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Division 5 A- Outline Specifications – Intelligent Transportation System (ITS)

Part-1 Toll Management System

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1. System Outline and Scope of Works

1.1 General

This Employer's Requirements Part 2: Toll Management System covers the design, manufacture and factory test, shipping to site, installation, testing and commissioning of the toll management system for the Mumbai Trans Harbour Link (MTHL), Mumbai, India.

This Employer's Requirements shall be read in conjunction with the Employer's Requirements Part 1: General, Part 3: Traffic Management System, and Part 4: Drawings.

1.2 Toll payment mode

Toll management system collects toll from MTHL users. The following four types of payment mode will be provided:

- Cash
- Wallet APP/QR code
- ETC (RFID)
- Credit and Debit Cards

In cash payment, user pays the toll amount in cash and toll collector hands over the receipt and change, if any, to the user.

In Wallet App/QR code payment, no cash transaction is made. Users are requested to have the Wallet App/QR code payment application in their smart phone. At the toll gate, user takes the photo of the QR code posted on the outside wall of tollbooth, input the toll amount shown on the user fare display and settle the payment. Receipt is issued upon confirmation from the E-Purse provider.

In ETC payment, Users are requested to have an RFID tag on the windshield of the vehicle. ETC antenna mounted above the toll lane reads the RFID tag and automatically settles the payment. No receipt is issued.

In Credit and Debit card methodology, the user can pay through credit or debit card of any accepted bank on the POS machine. Upon payment; the bank slip and toll receipt are issued.

1.2.1 Vehicle classification and toll rate

1.2.2 MTHL classification

Vehicles will be classified into seven (7) types by toll collector as well as automatic vehicle classifier as listed below. Toll management system software, database structure, display formats and print-outs will be designed to cater for these seven classes.

Table 1 : Vehicle Classification

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Class	Vehicle Type
1	Car, Jeep, Van or Light motor vehicle
2	Light commercial vehicle, Light good vehicle, or Mini bus
3	Bus or Truck
4	Up to 3 Axel Vehicle
5	4 to 6 Axel Vehicle
6	HCM / EME
7	Oversized vehicle (7 or more axles)

Vehicle classifications will be made based on the number of axles and other parameters as defined below. The definition allows automatic classification by equipment that measures these parameters.

Table 2 : Definition of Vehicle Classes

Class	Definition
1	**A car, jeep, van or light motor vehicle** is defined as any mechanical vehicle, the gross vehicle weight of which does not exceed seven thousand five hundred kilograms or the registered passenger carrying capability as specified in the certificate of registration issued under the motor vehicle act, 1988 does not exceed 12 excluding the driver.
2	**Light commercial vehicle or light good vehicle or mini bus** is defined as any mechanical vehicle, with the gross vehicle weight exceeding seven thousand five hundred kilograms but less than twelve thousand kilograms or the registered passenger carrying capability as specified in the certificate of registration issued under the motor vehicle act, 1988 exceeds twelve but does not exceed thirty-two excluding the driver.
3	**Truck or bus** is defined as any mechanical vehicle, with the gross vehicle weight exceeding twelve thousand kilograms but less than twenty thousand kilograms or the registered passenger carrying capability as specified in the certificate of registration issued under the motor vehicle act, 1988 exceeds twelve exceeds thirty-two excluding the driver.
4	**3 axle vehicle** means mechanical vehicle having 3 axels or vehicle with the gross weight exceeding twenty thousand kilograms but less than sixty thousand kilograms.
5	**4 to 6 axle Vehicle** means mechanical vehicle having 4 to 6 axels or vehicle with the gross weight exceeding twenty thousand kilograms but less than sixty thousand kilograms.
6	**HCM or EME** means heavy construction machinery of earth moving

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	equipment or mechanical vehicle having 4 to 6 axels or vehicle with the gross weight exceeding twenty thousand kilograms but less than sixty thousand kilograms.
7	**Oversized Vehicle** means mechanical vehicle having more than seven axels or vehicle with the gross weight exceeding sixty thousand kilograms.

1.2.3 FASTag classification

FASTag is proposed as RFID tag for ETC. FASTag adopts the vehicle classification in seven (7) categories as shown below. It does not define physical features of vehicle on which vehicle classifier can automatically classify the vehicle into proper vehicle class.

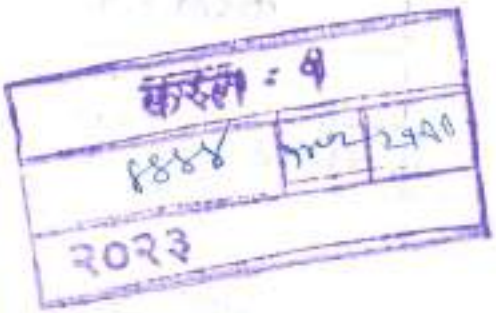
Table 3: Vehicle Classification of FASTag

Tag class	Description	Tag colour
4	Car / Jeep / Van	Violet
	TATA Ace and similar mini light commercial vehicle	Violet
5	Light commercial vehicle / Mini bus	Orange
6	Bus 3 Axle/Truck 3 Axle	Yellow
7	Bus 2 Axle / Truck 2 Axle	Green
12	Tractor / Tractor with trailer / Truck 4/ 5/ 6 Axle	Pink
15	Truck 7 Axle and above	Blue
16	Earth Moving / Heavy Construction Machinery	Black

The FASTag classification slightly differs from the classification proposed for MTHL. The FASTag classification will be converted to the MTHL classification as shown below.

Table 4 Conversion of FASTag to MTHL Classification

Tag class	Description	MTHL classification
4	Car / Jeep / Van	1
	TATA Ace and similar mini light commercial vehicle	2
5	Light commercial vehicle / Mini bus	2
6	Bus 3 Axle/Truck 3 Axle	4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7	Bus 2 Axle / Truck 2 Axle	3
12	Tractor / Tractor with trailer / Truck 4/ 5/ 6 Axle	5
15	Truck 7 Axle and above	7
16	Earth Moving / Heavy Construction Machinery	6

1.2.4 Toll rate

The toll rate for each vehicle class shall be system parameters and will be set when the system is put into operation. The system parameters will be modified when rate is revised.

Toll management centre system shall be provided with a toll rate setting function. When toll rate is revised, toll table in the system shall be updated and the new toll rates shall be sent automatically to toll plaza system and toll lane equipment upon the designated time for the change of rate of toll fees.

1.2.5 Toll exemption

Mechanical Vehicle as mentioned in "National Highways Fee (Determination of rates and collection) rules, 2008 [GSR 838(E) dated 5/12/2008 – point no 11" shall be exempted from payment of toll. The toll collector terminal shall be provided with a key for toll exempted vehicle. The toll exemption transaction at toll lane shall be same as cash payment operation except no cash is paid and data including snapshot of vehicle shall be taken for toll exempted transaction for verification purpose.

1.3 Location of tollgate

Toll plaza shall be established at two locations. Mainline toll plaza shall be setup at the section between Shivaji Nagar IC and SH54 IC, and another toll plaza shall be constructed at Shivaji Nagar Interchange with tollgate at all on/off ramps as shown in the Drawings.

It shall be noted that at Shivaji Nagar Interchange, tollgate is provided separately to the on/off ramp and each tollgate handles the vehicle along the specific route. On the other hand, vehicles from different entry IC or different destination IC are mixed at the mainline tollgate and they cannot be segregated. All lanes shall be equipped with manual, QR, Cr/Dr cards and ETC payment modes to allow the lanes to accept payment via all modes all the time.

Table 5: Location and Number of Tollbooth

Location	Toward	Type	# of Hybrid lanes	Location
Mainline Toll Plaza	Sewri	Mainline	8	KM 19+370
	Chirle	Mainline	8	

Shivaji	AP-Sewri	Entry 1	6	KM 17+480
	JNPT-Sewri	Entry 2	3	
	AP-Chirle	Entry 3	3	
	Sewri-AP	Exit 1	6	
	Sewri-JNPT	Exit 2	3	
	Chirle-Ap	Exit 3	3	
Total			40	

1.4 Toll collection location

Due to the location of tollgate, vehicles that travel between two ends of MTHL pass through tollgate one time at mainline tollgate between Sewri and Chirle. While the vehicles that travel between Shivaji Nagar and Chirle pass through the tollgate twice. In order to avoid double payment and underpayment, the toll is collected at the locations summarized in Table 6.

Table 6 : Toll Collection Location

From	To	Toll payment at	Tollgate type	Remarks
Sewri	Shivaji Nagar	Shivaji Nagar	Exit	
	Chirle	Mainline toll plaza	Mainline	
Shivaji Nagar	Sewri	Shivaji Nagar	Entry	
	Chirle	Shivaji Nagar	Entry	Need to surrender proof of payment at mainline toll plaza
Chirle	Shivaji Nagar	Mainline toll plaza	Mainline	Need to refund at exit tollgate
	Sewri	Mainline toll plaza	Mainline	

It shall be noted that no toll is collected from the vehicles that use the section between SH54 IC and Chirle IC.

In order to cope with the configuration of the toll system, the following measures shall be taken for the toll payment:

Payment by cash/QR code

1) The receipt for cash and QR code payment shall have a second part that carries a bar code indicating the date, time, interchange and other details of the payment made.

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2) Vehicle travelling from Shivaji Nagar to Chirle shall pay the toll in cash or QR code and receive a receipt upon entry at Shivaji Nagar. At the mainline toll plaza, the vehicle shall surrender the second part of receipt to the toll collector as a proof of entry at Sivaji Nagar and payment already made. The toll collector scans the bar code on the receipt and lets the vehicle to proceed. If no proof is shown, the vehicle is considered to have entered MTHL at Sewri and full amount of toll shall be charged.

3) Vehicles travelling from Chirle to Shivaji Nagar shall pay the full amount of toll at the mainline toll plaza. At the exit at Shivaji Nagar, vehicle shall surrender the second part of the receipt to the toll collector as a proof of payment at Mainline Toll Plaza. The toll collector scans the bar code to confirm the payment already made, refund the toll difference and lets the vehicle to proceed.

Payment by ETC

1) For all transactions being done by ETC; the entry and exit shall be detected by the RFID readers installed in the lanes.

2) For every ETC transaction; the blacklist as sent by the CCH (NPCI) shall be checked in the lane; and upon successful validation; the vehicle shall be allowed to proceed.

3) If the vehicle is found in the blacklist entry; user shall be required to pay the toll by other method of payment.

4) All the entry and exit pair transactions shall be sent to acquirer bank for further demand of the toll fee from the Issuer bank; with NPCI being the CCH.

Payment by credit / debit card

5) The receipt for credit/debit card payment shall have a second part that carries a bar code indicating the date, time, interchange and other details of the payment made.

6) For toll payment paid by credit/debit card; the refund required for the trip from Chirle to Shivaji Nagar shall be treated as a payment of negative amount and the transaction shall be sent to the acquirer bank as such.

1.5 Toll system configuration

Toll management system shall have three tiers of hierarchy consisting of Toll Management System at the top, Toll Plaza System at each toll plaza, and toll lane system at each tollgate as shown in Table 7. Toll management System shall supervise the entire toll management system. At the mainline toll plaza and Shivaji Nagar, toll plaza system shall be provided to monitor and control the toll lane system at the tollgate.

A toll management system centre will be established at the mainline toll plaza located between Shivaji Nagar IC and SH54 IC. There shall be two toll plaza systems, one at the same location as toll management System centre and another at Shivaji Nagar interchange.

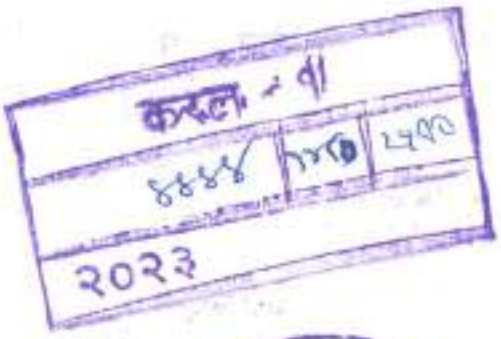
A set of toll lane equipment shall be installed in the tollbooth, on the toll island or its vicinity for toll collection operation. The operation of all lane equipment shall be controlled and monitored continuously by toll lane controller at each toll lane and toll plaza system (TPS). The toll plaza system shall also compile, audit and prepare the statistical data for print out and for display and onward transmission to the toll management system.

Table 7 : Toll System Configuration

Location	Shivaji Nagar				Mainline Toll Plaza	
Toll management centre system					Yes	
Toll plaza system	Yes				Yes	
	Entry		Exit		Eastbound	Westbound
Equipment	To Sewri	To Chirle	From Sewri	From Chirle		
Cash/QR code	Yes	Yes	Yes		Yes	Yes
ETC	Yes	Yes	Yes		Yes	Yes
Cash/QR refund				Yes		
ETC refund				Yes		

The toll plaza system shall also provide management facilities such as attendance recording of staff, reconciliation between declared and expected toll collection, control of cash and changes transferred between the toll plaza and the bank, reconciliation of the ETC revenue as sent to the acquirer bank and received from the issuer bank, settlement of payment made by credit / debit card, etc.

The toll plaza system shall operate as an autonomous system with no data communication between plaza and toll management system centre system being necessary. Likewise, the toll lane system shall operate normally even when data link with the toll plaza system is interrupted. During the interruption, toll lane system shall operate normally and keep the transaction data. Upon recovery of communication link with toll plaza system, toll lane system shall send all data stored during the interruption and the entire system shall operate as if there has be no interruption.



A data communication network via optic fibre cable shall be constructed as part of the scope of works of this contract. A complete data communication link from the toll lane controller to the Toll Plaza System and between Toll Plaza System and toll management system and all the necessary interfaces to the data communication network shall be provided under this contract.

1.6 Code system

In order to process all data and information related to the toll collection system efficiently, a code system shall be established for transaction, toll management system facilities, and the employees of toll collection operation organization. The Tenderer may propose the different code system from the system described below. In such case, advantages of the system that Tenderer proposes shall be described in his technical proposal.

1.6.1 Transaction

All transactions shall be identified uniquely with an ID as part of transaction data. They shall be checked for any error and irregularity at the toll management centre. If any irregularity is found in the transaction data, it shall be reported for further investigation.

The ID part of the transaction data shall consist of the following data:

7) Date and time of transaction
8) Toll plaza and toll lane ID
9) Sequential number assigned based on the data above

Each transaction data shall contain at least the following information:

10) Vehicle classification (by toll collector and by AVC)
11) Discrepancy in vehicle classification if any
12) Image and video for the transactions
13) ANPR Image and output
14) Toll collector ID
15) Toll amount collected
16) Method of Collection of Toll (Cash/QR/ETC/Cr or Dr cards)
17) Fine and other amount charged
18) Exceptional transaction (exemption, military convoy and other cases)

It shall be possible to search the transaction data with the keys consisting of any combination of the items listed above.

Date and time information shall be the date and time of the system clock. In the event the lane equipment operates in standalone mode due to interruption of data link between lane equipment and toll plaza server, the transaction time data shall be so marked. Upon restoration of data link between lane equipment and toll plaza server

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and transfer of data from lane equipment to toll plaza server, the server shall check the date and time data and difference with system clock if any shall be corrected.

1.6.2 Toll collection facilities

Each interchange shall be given a unique ID consisting of alphabetical characters and all lanes at each interchange shall have a unique ID for identification purpose. These codes shall be used in identification of the transaction and identification of toll collection facilities.

1.6.3 Staff ID

All employees and staff of the toll collection operation organization who are given an access to the toll plaza building shall have a unique ID. The ID shall be encoded into the ID card using the contactless IC card to be issued to the staff. For access control purpose, all ID card shall have an access privilege class. Different access level shall be defined to control the access to the facilities and the extent of the operation allowed to each access privilege class.

The staff ID of the person who has lost the access to the toll plaza building and toll collection facilities shall be so marked, and the same ID shall not be assigned to other persons.

1.7 Contractor's responsibility for design

The Contractor shall be entirely responsible for the design of all equipment, software, database and system to be provided under this contract and shall guarantee the correct and efficient operation of the same under the environmental conditions specified.

The Contractor shall be responsible for any discrepancies, errors or omissions in the drawings and information supplied by him, whether they have been approved by the Employer or not, provided that such discrepancies, errors and omissions are due to defective drawings or information furnished by the Employer.

The primary objectives of Contract shall be to ensure, using all the methods of payment available, correct tolls are collected and registered for all vehicles travelling on the MTHL, that all tolls collected are correctly brought to account, that all transactions are individually recorded for subsequent analysis at the toll management system, that all journeys for which payment are carefully controlled and that all resulting accounts, records, displays and other data are accurate and consistent. Performance of the system and equipment shall not be affected by the rate of traffic flow and all practicable means shall be incorporated to prevent incorrect collection, registration or recording.

1.8 Abbreviations and definitions

The following abbreviations shall refer to the words presented hereunder throughout this Employer's Requirements:

19) ALB Automatic Lane Barrier

20) AML Anti-money Laundering

21)	ASB	Amber Siren Beacon
22)	AVC	Automatic Vehicle Classifier
23)	BCR	Bar Code Reader
24)	CCTV	Closed Circuit Television
25)	CSC	Contactless Smart Card
26)	CSCRW	Contactless Smart Card Reader/Writer
27)	DDR	Dual Data Rate
28)	NVR	Network Video Recorder
29)	ECC	Error Correcting Code
30)	EDV	Exempt Document Viewer
31)	ETC	Electronic Toll Collection
32)	FPS	Finger Print Scanner
33)	FSW	Emergency Footswitch
34)	GBIC	Gigabit Interface Converter
35)	HHDR	Handheld RFID Reader
36)	HP&MC	High Personage & Military Convoy
37)	ICUM	Intercom Unit Master
38)	ICUS	Intercom Unit Slave
39)	IHMCL	Indian Highways Management Company Ltd.
40)	KYC	Know Your Customer
41)	LSDU	Lane Status Display Unit
42)	LTL	Lane Traffic Light
43)	MCBF	Mean Cycle Between Failures
44)	MCU	Master Communication Unit
45)	MLB	Manual Lane Barrier
46)	MTBF	Mean Time Between Failures
47)	MTHL	Mumbai Trans Harbour Link
48)	MTTR	Mean Time to Repair
49)	NHAI	National Highway Authority of India
50)	NPCC	Number Plate Capture Camera
51)	NPCI	National Payment Corporation of India

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52)	NVR	Network Video Recorder
53)	OBU	On Board Unit
54)	OHTL	Overhead Traffic Light
55)	PDB	Power Distribution Board
56)	POS	Point of Sales
57)	TPS	Plaza Server System
58)	QR code	Quick Response code
59)	RAID	Redundant Array of Inexpensive Disks
60)	RFID	Radio Frequency Identification
61)	RPR	Receipt Printer
62)	TBC	Toll Booth Camera
63)	TCD	Toll Collector Display
64)	TCK	Toll Collector Keyboard
65)	TCT	Toll Collector's Terminal
66)	TLC	Toll Lane Controller
67)	TMS	Toll management centre
68)	TOD	Tour of Duty
69)	TPS	Toll Plaza System
70)	UFD	User fare display
71)	UPS	Uninterrupted Power Supply

1.9 System components

1.9.1 Toll lane equipment

The lanes shall be of hybrid in nature, meaning having the capabilities of accepting cash/QR code payments, credit card and debit card payments and ETC payments. The toll lane shall be provided with the equipment listed below. Bar code reader (BCR) shall be provided in all exit lanes at mainline, and Shivajinagar interchanges.

Table 1.8 Composition of toll lane equipment

	Equipment	Abbreviation	Hybrid lane
Booth	Toll lane controller	TLC	✓
	Toll collector terminal	TCT	✓
	Receipt printer	RPR	✓
	Emergency foot switch	FSW	✓

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	Intercom unit slave	ICUS	✓
	Toll booth camera	TBC	✓
	Exempt Document Viewer	EDV	✓
	QR code board	QRC	✓
	Bar code reader	BCR	✓ (see note)
	Finger print scanner	FPS	✓
	Handheld RFID Reader	HHDR	✓
Lane	RFID antenna & reader	ANT	✓
	Manual lane barrier	MLB	✓
	Overhead traffic light	OHTL	✓
	Lane traffic light	LTL	✓
	User fare display	UFD	✓
	Automatic lane barrier	ALB	✓
	Amber siren beacon	ASB	✓
	Lane camera	LCM	✓
	Number Plate Capture Camera	NPCC	✓
	Automatic vehicle classifier	AVC	✓

Note: Bar cord reader shall be provided to eastbound toll lane at the mainline toll plaza and all exit toll lane at Shivaji Nagar to confirm the entry interchange.

1.9.2 Toll plaza system

The toll plaza system shall be a server system installed at mainline toll plaza and Shivaji Nagar Interchange to control and monitor the operation of toll lane equipment. The toll plaza system shall consist of the following equipment:

72) Toll plaza servers in Hot Standby Configuration

73) TPS Backup Server

74) Auditor's console

75) Lane status display unit (LSDU) workstation

76) Audit workstation

77) Snapshot image workstation

78) CCTV monitoring equipment

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79) Tour of duty workstation

80) Point of sales workstation

81) Networking system components

82) Printers

83) Intercom unit master

It shall be noted that auditor's console accommodates lane status display unit workstation, audit workstation, snapshot image workstation, CCTV monitoring workstation and master communication unit.

The Toll Plaza System (TPS) shall have the following three main functions:

84) Data acquisition from lane equipment and provision of real time monitoring facilities via visual display unit in the control room of the plaza building.

85) Data processing and plaza management via visual display units, printer terminals and data transfer facilities.

86) Sending and receiving the ETC related data and files as per NPCI latest ICD manual.

The TPS servers shall be configured in Hot Standby Configuration with TOR switches and SAN storage devices.

The TPS shall comprise various inter-linked software modules, some of which shall carry out real time functions, such as data communication with lane equipment and provision of detailed monitoring facilities.

Each TPS shall be interfaced, via optical fibre cable network to the TMS system. The TMS shall make available data files relating to plaza operations for transfer to the TMS system and shall receive data files such as operating parameters from TMS system.

Visual display units and printer terminals shall be provided for control, selection and data input and output. Back-up facilities shall be provided through use of appropriate external storage devices to ensure that no loss of data or restrictions on operation occurs as a result of failure of either the TPS or of the data transmission link with the TMS system.

1.9.3 Toll Management System (TMS)

The toll management centre system shall be a server system installed at the toll management system centre to be established at mainline toll plaza at KM 19+370. The system shall consist of the following equipment:

87) TMS Server in hot standby configuration

88) TMS backup server

89) TMS administration workstation

90) TMS reporting workstation

91) Financial management workstation

92) Snapshot image workstation

93) Video Wall and Video Storage devices

94) Networking system components

95) Printers

The TMS system shall have the following main functions: -

96) Data acquisition from TPS.

97) Data processing and validation via visual display units, printer terminals, and data/parameter transfer facilities.

98) Downloading of operational parameters to TPS.

99) Interfacing with backup TMS system for backup and standby operations.

The TMS servers shall be configured in hot standby configuration with top of rack (TOR) switches and storage area network (SAN) storage devices.

The TMS system shall be interfaced, via optical fibre cable network to the TPS. The TMS system shall make available operating parameters relating to plaza operations for transfer to the TPS and shall receive data files from the TPS.

Visual display units and printer terminals shall be provided for control, selection and data input and output.

1.10 Software

The Contractor shall provide a set of software to operate on the servers, workstations and computers of lane controller system, toll plaza system server, toll management system centre and other computers to be provided under the Contract. The software shall function as a system to provide end results required in the Employer's Requirements.

A high-level language for all programming shall be used in developing the software for the system. Details of the language to be used shall be stated in the Technical Proposal of the Tender. The copyright of the software specifically developed for the project shall remain with the Contractor.

The set of the software to be provided shall consist of those provided by third party and those specifically developed for the project. All third-party software shall be legally licensed and there shall be no restriction on the use in the toll management system. They shall be registered under the name of Employer and any supports and services provided by the software developer including update and revision shall be available to the Employer.

The software to be specifically developed for the Project shall be fully tested and shall be free from bugs. The Tenderer shall state in the Technical Proposal of the Tender the software quality assurance program that the tenderer intends to adopt in developing

the software.

The programming of the applications shall be arranged in such a way that maximum flexibility is afforded by the design to allow the Employer to implement modifications or additional facilities which may become available or desirable during the working life of the system. Such future modifications or changes shall not be the part of the current scope of the contract and shall be estimated and paid time to time by the Employer if required but comprehensive documentation of the software and source codes shall be provided under the Contract to allow such changes to be implemented by the Employer without relying on the recourse to the Contractor.

The Employer may wish to implement additional software packages to run concurrently with the software that necessary to meet the requirements of the Employer's Requirements. These packages may include but will not be limited to:

100) Leave planning

101) Tour of duty planning for staff

102) Programs allowing the Toll plaza system (TPS) and toll management system (TMS) to operate with other systems such as traffic management system interfaced to the data network and involving bi-directional transfer of files.

The Tenderer shall propose in the Technical Proposal of the Tender the feasibility and ease with which such applications might be implemented using the TPS proposed by him and shall advise the spare memory capacity and processing power which could be available, but not necessarily provided, within the proposed computer to allow such applications to be implemented.

1.11 Network equipment

The Contractor shall supply and install network equipment at all toll plazas to connect the Toll plaza system server with toll lane system, and the toll plaza system server with toll management system centre server.

Between interchange toll plaza system server and toll lane equipment, the Contractor shall supply and install all equipment, cables, connectors, terminals and other miscellaneous materials necessary to establish a working local area network connecting these two systems.

The network between the toll management system centre and toll plaza system shall use the optic fibre cable network to be installed as part of the contract and a data communication network shall be established using layer switch. The Contractor shall supply and install the network equipment suitable for the optic fibre network and establish a digital data link between them.

The requirements for the digital data communication system are presented in Volume 4 of the Employer's Requirements.

1.12 Power supply

Power supply rated at 440V, 3 phases will be made available at the essential supply

board of the interchange toll plaza building. This supply will be backed up by standby generators to be provided by others.

A power distribution board (PDB) as detailed in the drawing shall be supplied and installed under this Contract. The Contractor shall provide power distribution board at other locations where necessary, and the cost of such power distribution board shall be considered included in the Contract Price.

The Contractor shall supply and install UPS systems in the manner shown in the Drawings. All Toll Plaza System and all toll lane equipment shall be provided power through this UPS to make sure that the power is continuously available to all toll management system equipment during the interruption of commercial power.

All toll equipment shall operate at 240 volt, single-phase supply with 50 Hz.

Toll equipment load shall be arranged in the PDB in such manner as to give the best practicable balance over the three phases of supply.

Complete earthing network constructed using earthing rods and chambers of not more than one (1) ohm shall be provided for toll management system equipment.

1.13 Booth communication system

A booth communication system shall be provided at each interchange plaza building to allow voice communication between toll management staff in the building and toll collector at tollbooth.

The communication system shall be of the type that is capable of both one to one and one to many communication from the toll management room.

Additional facilities shall be provided to allow toll management staff to communicate with various locations in the plaza building such as communication between the toll management room and rest room, strong room and cash counting room, etc.

1.14 CCTV system

In addition to the video camera provided to each lane, The Contractor shall provide a CCTV system as specified herein under the Contract. The CCTV equipment is categorized as two types, CCTV for toll management systems and CCTV for security.

The CCTV for toll systems shall consist of:

103) Toll booth CCTV cameras installed inside the booth to observe the activities of the toll collector while doing the transactions.

104) Plaza surveillance CCTV cameras installed on a mast of sufficient height and are intended for general surveillance of the toll plaza and walkways.

The CCTV for security shall consist of under bridge surveillance camera and toll plaza building surveillance. The requirements for the security surveillance camera is described in Part 3: Traffic Management System.

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2. Design Requirements

2.1 General

All types of equipment comprising the toll management system, Highway Traffic Management System and data communication system to be installed under this Contract shall be capable of continuous, 24 hours a day, 7 days a week operation under the environmental conditions prevailing in Mumbai. Should the design require periodic replacement of any equipment or component, the replacement schedules of such equipment or component shall be described in the technical proposal and in the maintenance manual.

Toll management system, Highway Traffic Management System and data communication system shall have high reliability, accuracy and security in design. Stoppage of the total system shall not be allowed under any circumstances. Redundant hardware configuration shall be adopted for key components to ensure continuous operation of the systems. Data backup mechanism shall be used to prevent data loss. Operation log shall be kept to allow tracing of operation in case of any dubious transaction and irregularity in the operation of the system. Mechanism shall be incorporated in the system design to prevent illegal or fraudulent activities by toll collector and any user of the system.

The Contractor shall review the Employer's Requirements prepared by the Employer and the Contract Documents and execute the detailed design work as necessary at the Contractor's cost and time, so that the Contractor will supply and deliver the workable toll management system, Highway Traffic Management System and data communication system, all of which will suit the intended purpose when completed.

Unless stated otherwise in the Contract Documents, the Contract shall be for the whole Works as described in the Contract Documents. The Contractor shall quote for the entire system and facilities on a "single responsibility" basis such that the Contract Price covers all Contractor's obligations mentioned in or to be reasonably inferred from the Contract Documents in respect of the design, manufacture, procurement, construction, installation, commissioning and testing of the Works and remedying any defect during the contract period. This includes all requirements under the Contractor's responsibilities for testing and commissioning of the systems and facilities, and where required by the Contract Documents, the acquisition of all permits, approvals and license, the training services and such other items and services as may be specified in the Contract Documents.

2.1.1 Toll management system

A combination of open and closed toll system will be introduced to the MTHL, where toll plaza is placed on the mainline between Chirle IC and Shivaji Nagar IC at Gavan. In addition, tollgates are placed at all entry and exit ramps of Shivaji Nagar for the vehicles that use Shivaji Nagar IC.

Vehicles shall be classified into Seven (7) types based on vehicle height, number of axels and axel distance. The classification of vehicle shall be made by both toll

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collector visually and by automatic vehicle classification device.

Four types of toll payment method shall be provided, namely cash based manual collection, toll payment through QR code, credit / debit card, and electronic toll collection (ETC) system. ETC system shall be an RFID type complying with the National Highways Authority of India (NHAI) and Indian Highways Management Company Ltd (IHMCL) as per document H-25011/04/2011 P& P (Toll) Vol. VI dated 07.11.2017. Employer reserves the right to change the ETC technology; which shall be decided at the time of start of the design phase of the project.

2.1.2 Highway Traffic Management System

The Highway Traffic Management System to be introduced to the MTHL is a comprehensive Traffic Management System for the bridge having long stretch comprising the following various component systems:

a) Emergency call box (ECB) system,

b) Closed Circuit Television (CCTV) monitoring system,

c) Video Incident Detection System,

d) Automatic vehicle counting cum classification (ATCC) system,

e) Meteorological (MET) observation system, and

f) Variable Message Sign (VMS) system.

These systems shall function as a component system and, at the same time, cooperate each other by exchanging data between the systems to achieve the intended function of the total system.

2.1.3 Data communication system

A data communication system using optic fibre cable shall be established along the entire stretch of MTHL. The system shall be based on Internet protocol and will be used for the exchange of data and video signal for:

Toll management system: Data exchange between toll management centre and toll plaza system. Data exchange within toll plaza and interchange will be a separate system to be provided as part of toll management system.

Highway Traffic Management System: Data exchange between command control centre and road side equipment including ECB, ATCC, meteorological equipment, variable message sign, etc. In addition, video signal is transmitted from the traffic surveillance and security video camera and VIDS system.

The data communication system may be used by other systems such as in-house LAN network, and internal telephone system.

2.2 System requirements

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2.2.1 System capacity

The toll management system shall have a sufficient capacity in terms of response time, transaction processing speed, data transmission bandwidth, and storage capacity to process a maximum of two hundred thousand transactions per day and up to five million RFID accounts. Neither additional hardware nor replacement of the initially installed equipment shall be allowed to handle the transactions stated above and to perform the functions required as toll management system.

The Highway Traffic Management System shall have a sufficient capacity in terms of response time, data processing speed, data transmission bandwidth, and storage capacity to handle information that the system processes, monitor and control all equipment connected to the system. The system, hardware and software shall be designed to perform the required function without excessive delay, lack of storage space or any other critical limitations for the system with twice the number of toll terminal equipment to be supplied under the Contract.

The bidder shall state in his Technical Proposal that the proposed system will meet the requirements for the system capacity as stated above.

2.2.2 Reliability

The equipment and device comprising the toll management system, Highway Traffic Management System and data communication system shall have high reliability. They shall have the mean time between failures (MTBF) as specified for respective equipment in these Employer's Requirements. The bidder shall state in his Technical Proposal the expected MTBF of the equipment he will supply. The MTBF shall be either the calculated figure based on the reliability of components comprising the equipment, or the actual MTBF achieved by the same or similar equipment. For the off-the-shelf equipment supplied by a third party, the MTBF published by the manufacturer or supplier will be accepted.

The server system of toll management system shall have an availability of 100 % with redundant system configuration.

2.3 System design

2.3.1 Design briefing

Within 45 days of Commencement Date of the Works, the Contractor shall conduct a design briefing session in Mumbai. The design briefing shall cover all the system components included in the Contract. The main objective of the briefing is to acquaint the Engineer and EMPLOYER staff with the design concept and outlines of the proposed systems, and to allow them to examine whether or not the Contractor's design complies with the Contract.

2.3.2 Design review and approval

Within 60 days of the Commencement Date of the Works, the Contractor shall submit a System Design to the Engineer for his review and approval. The System Design shall provide detailed information of the proposed system, including system configuration,

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specification and functions of equipment, block diagrams, input and output, flow charts, interface, design calculation and manufacturer's specification sheets and shall cover all necessary hardware, software, database and operating procedures. The Contractor shall obtain the "Notice of No Objection" (NONO) from the Engineer with regard to the System Design within three (3) months of the Commencement date of the Works.

The submission of the system design shall be made in multiple timings to avoid the situation in which the total design approval is submitted in one time with many volumes of document. Individual submission shall be made in units of component system.

The Contractor shall not, without specific approval in writing by the Engineer, place any material, part or component on order, nor commence manufacturing of any equipment or software development until the System Design has been approved by the Engineer. The Contractor shall not implement any changes on the approved system design without prior written approval of the Engineer.

The approval of the System Design by the Engineer, however, does not relieve the Contractor from delivering a fully operational and reliable system.

2.3.3 Hardware system design

Hardware portion of the System Design shall include among others the following:

a) Functional and physical system block diagram of each component system.

b) Connection and interface between the blocks in the block diagram.

c) Functions, capacity, input, output, and method of operation.

d) Response time, delay, allowance, attenuation, loss and other figures as appropriate for applicable equipment.

e) Environmental and physical design specifications of the equipment. Manufacturer's product specification sheets may be accepted for standard products.

f) Power consumption of equipment.

g) Cable network diagram.

h) Cable work plan.

i) Conduit line plan.

j) Equipment layout in the rooms at the toll management centre, command control centre, and toll plaza office where system, communication and power supply devices are placed.

2.3.4 Software system design

Software portion of the System Design shall include, as a minimum, description of module, identification of tasks, priority level, execution schedule, input and output

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algorithms and parameters, database structure and contents, parameter update procedures, data flow, calling sequences, error detection, backup and recovery and programming languages.

Structure of software shall be simple and straightforward. Interdependency and interaction between modules shall be clear and kept to minimum to prevent a defect in one module from affecting many other modules. Data and parameters shall be separate from the program and kept in the database.

2.3.5 Operating procedures of toll management system

Two kinds of operating procedure of toll management system shall be defined and presented: toll system operation and toll collection operation.

Toll system operation shall cover the procedures that the system operator follows in monitoring, checking and diagnosing the system operation. The procedure shall include but not be limited to the monitoring of operating status of component devices, modification and updating of operation parameters, connection and disconnection of device, identifying the cause of failure, recovery of the system from failure, and display and printout of various reports.

Toll collection operation procedure is the procedure that toll collectors follow during their daily work. The procedure shall cover the start and end of duty procedure, normal cash transaction, and various abnormal cases of transaction such as discrepancy of vehicle classification made at exit point and impecunious user. Log-in, log-out of toll collector at tour of duty workstation and post-checking procedure by toll collection supervisor shall also be covered.

Fool-proof mechanism shall be incorporated as much as possible in the operation procedure to prevent any inadvertent mistake to cause serious damage to the system, toll road operation, toll collection and driver's safety. Frequently used operating sequences shall be described in a step-by-step manner.

2.4 Drawings furnished by the employer

The drawings of bridge, embankment section contained in the bid document are the latest drawing available at the time of bidding. The Employer will furnish the Contractor with the revised drawings as they become available. The Contractor shall examine these drawings and design the equipment layout, equipment installation method, cable route, cable installation method, and other works related to these facilities.

2.5 Local area network

It is required that the toll lane system, toll plaza system and toll management centre system employ an open network architecture consisting of several servers, workstations and central controllers connected through a standard local area network based on TCP/IP. To ensure a high level of reliability and operational flexibility, it is required that the workstations connected to the network shall be complementary to each other and shall not be dedicated to a specific function. Breakdown of a workstation or other device connected to the network shall not affect the normal

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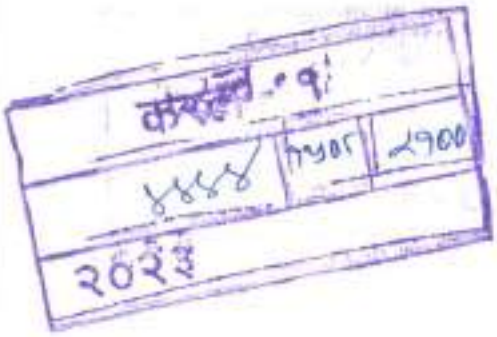

operation of the system and database in any aspect.

2.6 Power supply

The input power supply of any equipment shall not be connected to any electric components except arresters without connecting first through fuses, power switches and circuit breakers.

The power supply made available at toll management centre, command control centre and toll plaza building will be 440-volt three phase 4 wire 50 Hz. The Contractor shall supply an interruptible power supply at toll management centre, command control centre and toll plaza building of suitable capacity with the output of 230-volt single phase.

All equipment shall be provided with a clearly visible label indicating the input power supply type (AC or DC) and voltage. All equipment shall operate with the power supply of 230V plus or minus 10 percent, and 50 hertz plus or minus 3 percent. All solid equipment shall be designed to operate normally under instantaneous power supply interruption of 20 milli-second or shorter.

The power supply voltage available in the field will be 230V AC. Unless specified otherwise or unless approved by the Engineer, all field equipment shall be designed to operate directly on 230 V AC. The Contractor shall be responsible for arranging the terminal devices necessary to receive the power supply.

2.7 Design life

All components and materials used in this Contract, excluding consumable items shall be of a design life of 10 years or longer unless specifically stated otherwise in the Employer's Requirements. The bidder shall state in his Technical Proposal whether there is any equipment or component that do not have the design life as specified. The Engineer may approve them if they are easily replaceable and a 10-year design life is generally considered infeasible or uneconomical. The replacement of such equipment shall be possible without displacing other component.

2.8 Workmanship

All equipment and components shall be new and shall be designed and manufactured in the soundest manner, using materials most suited to the particular services. All materials shall comply with the latest relevant authorized standards for testing materials unless otherwise specified or permitted by the Engineer. For the design of all equipment, it shall be considered to enable to make ease of their maintenance work.

All workmanship shall be of the highest class throughout to ensure smooth and vibration free operation under all possible operating conditions, and the design, dimensions and materials of all parts shall be such that the stresses to which they may be subjected shall not render them liable to distortion, undue wear, or damage under the most severe conditions encountered in service.

All parts shall conform to the dimensions shown on and shall be built in accordance with approved drawings. All joints, datum surfaces, and mating components shall be

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machined, and all castings shall be spot faced for nuts. All machined finishes shall be shown on the approved drawings. All screws, bolts, studs & nuts and threads for pipe shall conform to the latest standards of the International Organization for Standardization covering these components and shall conform to the standards for metric sizes.

2.9 Nameplate and cable tag

All equipment supplied under the Contract shall have a nameplate. The nameplate shall indicate as a minimum, manufacturer's name, model, type or make, serial number, manufactured month and year. In addition, other information such as input voltage, current, frequency, and complying standards may be described. Information on the nameplate shall be printed or inscribed in indelible manner. The nameplate shall be firmly attached to the cabinet at the suitable position by screw, rivet or adhesive and shall not be easily removed.

All cables shall have a tag showing cable ID attached to them at suitable location. In addition, for optic fibre cable, the tag shall indicate such information as cable ID, cable type, source, destination, length, wavelength and attenuation for ease of maintenance.

2.10 Environmental conditions

2.10.1 General

All equipment shall be designed to operate properly under the environmental conditions normally encountered at the site of the equipment in Mumbai and shall conform to the minimum requirements specified herein. Particular attention shall be paid to the fact that MTHL is a bridge across Mumbai Bay and all outside equipment and cables are prone to the seawater damage.

The bidder shall describe in Technical Proposal the countermeasures against seawater damage that Contractor will adopt for the outdoor equipment and cables with the description of supporting examples of the countermeasures.

2.10.2 Environmental conditions

Unless specified otherwise, indoor equipment shall be designed to operate in the temperature range of 5 to 40 degree Celsius, and the relative humidity range of 5 to 85 percent, whereas outdoor equipment shall operate in the ambient temperature and relative humidity ranges of 5 to 60 degrees Celsius and 40 to 95 percent non-condensing humidity, respectively. Adequate protection from moisture condensation, fungus, rust, insects, rodents, and dust shall be provided.

All equipment shall be adequately treated to prevent rust and corrosion due to high humidity or moisture condensation. Unless otherwise specifically approved by the Engineer, all steel housing, pole, fittings, and conduit shall be galvanized, and paint finish shall not be accepted. All galvanized steel surface shall have a minimum plated zinc amount of 550 g/m2. Any signs of rust or corrosion occurring within the defect liability period shall be deemed a defect and the Contractor shall be responsible for correcting, at his own expense, the defect to the satisfaction of the Engineer.

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2.10.3 Wind

All outdoor equipment and their support, individually and fully assembled and installed as a whole, shall withstand an instantaneous wind velocity of at least 45 m/sec.

2.11 Protection against lightning

All outdoor equipment shall incorporate gap arresters or other suitable device approved by the Engineer to prevent lightning damages which may enter through input AC lines, communication cables, signal cables, feeder cables or other metallic elements exposed to the open air. Likewise, surge arrester or other suitable protection device against lighting shall be provided to the suitable points of the local area network and to the devices that could be subjected to the surge caused by the lightning.

Compensation for furnishing and installing lightning protection equipment shall be included in the Contract Price and no separate payment shall be made therefor.

2.12 Cabling

2.12.1 Type of cable

The Contractor shall provide all power supply cable, optical fibre cable, LAN cable, signal cable and communication cable to the equipment that he supplies. The cables shall be of suitable rating for the use. Optical cable connecting the toll plaza system with the toll lane system shall have six (6) cores or more regardless of the number of cores actually used.

All underground cable shall be placed inside steel, polyvinyl chloride (PVC) or high-density polyethylene (HDPE) conduit of suitable size and no direct burial cable shall be used.

2.12.2 Cable work design

No cable shall be exposed to open air. The installation of non-protected cables on any structure will not be permitted. All cables shall be placed in trunking or conduit. Flexible coupling, flexible pipe, elbow or other suitable part shall be used for the connection point of conduits where direction changes.

All trunking, conduit, cables, wiring and earth conductors shall (except when laid in trenches or in ducts), be secured throughout their length and shall be supported on cleats, hangers, trays or racks. No permanent cabling, wiring or conductors shall be left lying loose in or on any part of the structure or buildings. Cables shall be fixed to trays etc. by purpose made fixing clamps or similar device.

Under no circumstances, joints in cables shall be made. Cable terminations and joints shall be made by methods and with such materials as are recommended by the makers of the cables and approved by the Engineer.

The Contractor shall supply and erect cable trays, hangers, brackets and supports for all the cables inside buildings. Trays shall be made from sheet steel of adequate thickness and all trays, supports, clamps, etc., shall be hot dipped galvanized after manufacture. Lengths of tray shall be bolted together with approved fish plates and

webs. The arrangement of cables on trays shall avoid interference between power cables and communication or data cables.

Power cables shall be separated as necessary from control and communication cables by not less than 300 mm except where otherwise approved by the Engineer.

2.12.3 Cable delivery

Cables shall be of approved manufacture and chosen from Indian manufacturers in so far as is practicable. The cable shall be delivered to site with maker's seals intact and bearing the maker's original guarantee. Seals shall be retained for inspection and record in case of later faults. Short lengths of cable may be delivered cut to scale provided they are suitably packed, and the Engineer's approval is obtained beforehand.

Unless agreed by the Engineer, cables shall have been manufactured not more than 18 months before delivery to Site and the date of manufacture shall be indicated on all consignments. The permission of the Engineer shall be obtained before any cables are installed or wrappings removed. Manufacturer's test certificates shall be submitted for all cables.

All cables shall be chosen to suit the ambient conditions and rated for the conditions of installation. No cable of less than 1.5 square millimetre core section shall be used for power purposes. Cables laid in trunking and on trays shall be rated for multiple runs as appropriate.

All cables shall be delivered on robust cable drums with cable ends treated to form an effective seal. When a cable is cut from a drum the cable left on the drum shall be immediately sealed in an approved manner to prevent the ingress of moisture. All cables once they have been cut shall be either terminated in their final position immediately or effectively sealed in an approved manner.

No damaged or repaired sections of cable shall be used.

2.12.4 Cable burying

In all cases where cables are to be buried in the ground, the work of trenching, backfilling, supply and lying of protective tiles etc. will be carried out under the Contract. Trenches shall be excavated in accordance with the requirements of this Clause. The depth of trench shall be such that the cable has a minimum cover of 600 mm.

All buried cables shall be armoured and suitably served for the soil conditions and laid on a 75mm deep bed of sand or sifted earth and then covered by the same depth of the same material as per the standard BS EN 12613. Protective tiles complying with BS2484, or alternative to the approval of the Engineer, shall then be laid. During the back filling of all cable trenches, coloured polythene tapes 150 mm wide shall be laid at a depth of 150 mm in the trench for warning and cable tracing purposes. The tapes shall give identification by colour and legend, as appropriate, e.g., Yellow - "Power cable below" and Green - "Communications cable below" etc. Cables shall be laid at a minimum depth of 600 mm.

Immediately after backfilling, cable and joint markers shall be laid. These shall take the


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form of concrete slab markers or concrete marker.

Each cable run in open ground shall be marked at the point where it leaves the plinth, manhole, Sub-station, supply feeder pillar or similar and shall be marked at approximately every 100m along the cable run with an additional marker at each change of direction of the cable run. Slab cable markers shall be installed flat in the ground immediately above the cable with wording e.g., "LV CABLE" or "COMM CABLE" shall be impressed on each cable marker. Additional circuit symbols shall also by impressed as directed by the Engineer. The letters shall be approximately 25mm high and 6.35 mm (1/4 in.) deep. Heavy duty armoured cable shall comply with BS 6121.

2.12.5 Cable pulling

All proposals for winching cables into ducts shall be submitted to the Engineer for approval. A cable pulling eye shall be used in pulling the cable through conduit. Care shall be taken that no damaging stress shall occur to the cable sheaths.

2.12.6 Cable Installation

Arrangements for the routing etc., of all cable trunking and conduit runs shall be agreed by the Engineer before the commencement of installation. The installation shall be completed to the highest standard of neatness with respect to the visible runs and the arrangement and alignment of apparatus and fittings. Reference should be made to IEC 14763.

The positions of equipment are indicated generally in the Employer's Requirements and Drawings, but the exact locations shall be agreed with the Engineer before the commencement of installation.

Throughout the cable installation care shall be taken to avoid damage from sharp edges, if necessary either by smoothing the edges or by providing fixed liners.

Cables on horizontal and vertical trays and racks shall be secured at sufficiently close intervals to ensure that they lie flat, and without crossovers. Cables installed vertically shall be held at sufficiently close intervals to ensure that their weight is taken without excessive clamping pressure. Every cable shall be neatly run vertically horizontal or parallel to adjacent walls, beams or structural members. All cables shall be either fixed to walls, ceilings and building structures or run in ducts and trenches. All cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. Spacing of clips, saddles and cleats shall be such as to prevent sagging of the cables at all times during their installed life.

Cables shall not be installed with bend radius less than that laid down by the cable manufacturer.

Where a number of cables are terminated at any particular item of equipment, then special care shall be taken to ensure that the cables finally approach the equipment from a common direction and are individually terminated in an orderly and symmetrical fashion.

All cables shall be carefully unrolled in such a manner as to avoid loops and kinks and care shall be taken to avoid damage to outer sheaths by drawing over sharp obstacles, stones, etc.

Cables shall not normally be installed on external surfaces subject to direct solar radiation, but where this is necessary, suitable screens shall be provided to protect all such cables from the direct effect of the sun's radiation. These screens shall be of an approved design, and securely fixed to the structure.

Where it is necessary to remove the sheath of a cable, e.g., at a joint, the minimum length necessary shall be removed and the exposed conductor, sheath or armouring shall be adequately covered by tape, sleeve or other suitable means.

2.12.7 Trunking Systems

All cable trunking shall be made from mild steel sheet or rigid high impact heavy gauge PVC as approved by the Engineer, of adequate thickness and stiffened as necessary to prevent distortion. Barriers shall be of at least the same gauge as the trunking, with right angle flanges fixed to the trunking in an approved manner.

Trunking shall have turned edges fitted with screwed insert bushes to receive screws for the trunking cover and the cover shall have flanged edges to overlap the trunking body. Steel trunking shall have the pieces and angle connections properly designed and neatly made for electrical continuity, with full protection of cables. The erected trunking shall be properly aligned during erection, neat in appearance and all joints shall butt tightly together.

2.12.8 Conduit systems

Unless otherwise agreed, all conduit systems shall be galvanized steel, polyvinyl chloride (PVC) or high-density polyethylene (HDPE) of suitable size and rating. All fittings for steel conduit shall be galvanized.

The sizes of conduits used shall be determined by the number of cables to be drawn in and diameter of the cables, but in no case conduit smaller than 20 millimetres diameter shall be used.

Fixing to surfaces of walls shall be by means of spacer saddles securely fixed by screws. Where conduits are concealed or laid in construction floors, they shall be held in position with substantial fixings of make and pattern to be approved by the Engineer.

Where the conduit system terminates at any equipment requiring a non-rigid connection, a flexible conduit shall be installed of the PVC or PVC sheathed metallic type, fully watertight with purpose made connection adaptors as approved by the Engineer. Each flexible connection shall include not less than 400-millimetre length of flexible conduit and a separate earth conductor shall be run within the conduit. The flexible conduit shall not be used as an earth continuity conductor.

2.12.9 Cable tray and ladder

Cable trays, cable ladders and their supports shall be strong enough to meet the load

requirements of the cables including any future cable additions and any other additional loads applied to the system.

The cable tray design shall meet the following requirements:

a) Cable tray can safely support the loads being imposed upon it;

b) The proposed fixings to adjacent components are also sufficient for the intended load, and

c) Any declared deflection limits shall not be exceeded.

Cable tray and ladder systems that are electrically conductive shall have adequate electrical continuity to ensure equipotential bonding and connection to earth.

The Contractor shall obtain a prior approval by the Engineer if the cutting or drilling of structural members of the bridge is required for installation of cable tray.

2.12.10 Cable identification

Cable and wire ends shall be prepared using only approved means which avoid damage to conductors and shall be clearly and indelibly marked in accordance with relevant diagrams for wiring up and circuit checking. Each cable shall have an indelible label securely fixed near each end, giving its reference number in the cable 'As-Built' schedules.

Throughout the installation the arrangement of wire and terminal identities shall be consistently followed and shall be as agreed with the Engineer.

Any phase wires in power circuits used for distribution other than 230/440V shall have the phase voltage clearly marked at each end of the conductor.

2.12.11 Cable termination

All cables ends into enclosure shall be glanded and sealing boxes shall be supplied when necessary to complete the installation. All materials used in the manufacture of the glands etc., shall have no deleterious effect on the cable core or armouring and shall be non-corrodible. Glands shall be to BS 4121 or an equivalent specification. Spare gland holes shall be fitted with blanking plugs.

2.12.12 Terminals

Wiring entries into all enclosures shall be made through compression type glands with all wires neatly arranged, securely located, preventing the access of vermin to the enclosure and relieving all terminals of the weight of cables. Terminals shall be coded and identified according to the diagrams and the cable and wire marked to assist in correct marrying of all connections. Terminals shall be of the anti-vibration type, using non-tracking moulded insulation, made by specialist manufacturers and having current ratings not lower than that of the cable or wire which they will receive. Live metal shall be recessed or protected to avoid accidental contact. Terminals used in control, alarm and communication cubicles and in associated cable junction boxes shall be bolted or clipped to carrier rails to permit the addition of extra terminals at a later date.

All equipment and junction boxes shall have a separate terminal for each wire including spare cores. Link type terminals shall be provided at the ends of long control, alarm and communication cable runs to facilitate the testing of cables.

Jumper leads and transition terminals shall be provided to avoid long runs of cable tails within desks and cubicles. Flexible cable harnesses shall be properly located and protected from chafing, pinching, and tension where they pass from doors or other movable positions.

All connections between main switchboards, distribution boards, plant and accessories shall ensure that the correct sequence of phase colours is preserved throughout the system.

2.12.13 Earthing and bonding

All exposed metal work and metal not forming part of the electrical circuitry and including equipment enclosures and cable supports shall be bonded together and to earth in accordance with BS CP1013. This requirement shall apply irrespective of the operating voltage and purpose of the equipment. Particular care shall be taken where moving parts are involved that they are earthed in all normal positions. A suitable flexible connection shall be used so that hinges rollers or bearing surfaces are not used for continuity.

Substantial non- ferrous earthing lugs or studs shall be fitted for bonding to cable sheaths or other adjacent equipment. Where sections of cubicles are placed together to make a composite unit, a bonding strip shall be provided without break through the intermediate sections to provide bonding between all sections. Earthing and bonding connections shall be stud or clamp type.

The Contractor shall make all necessary arrangements and provide all necessary items for separate earthing for low level electric circuits if this is required by him. This equipotential grounding shall then be kept insulated from all other earthing or bonding work up to the point of connection to the earth ground electrode.

To minimize the induced voltages and currents created by a lightning strike in vicinity, the equipotential grounding and the normal earth rods must be buried as close as possible to each other without touching. All earth conductors shall leave the building on the same side wall but not in contact with each other except where bonded together.

Resistivity tests on supplementary earth electrodes and on earth conductors shall be made as the Engineer directs. Earthing network constructed using earthing rods and chambers for frame or equipment body earthing shall be not more than five (5) ohms. The results shall be reported in writing.

All cable sheaths, conduits, trunking, trays and the like shall be bonded together and to structural work and connected to adequate earth electrodes. Particular attention shall be paid to the correct bonding and earthing of single core cable sheaths.

The design of all plant and ancillaries shall include protection against all effects of stray current, lightning and faults in adjacent circuits which may cause damage or incorrect

performance of the equipment.

2.12.14 As built drawing

The As-Built drawings shall show the spacing, location and identification of each cable at all major sections of trays, racks and trunking.

2.12.15 Insulation resistance

Connection of insulated cable shall be made in such a way that the same insulation shall be achieved by winding insulation tape or applying insulation cover.

(a) Insulation resistance of the communication cable

Insulation resistance between conductors and between conductors and ground of communication cable installed indoor shall be 5 mega ohm or larger for a circuit or a system using 250 volt insulation resistance meter. The portion that is not suitable for the test may be removed.

Insulation resistance between conductors and between conductors and ground of underground and aerial communication cable shall be 5 mega ohm-km or larger for the section longer than 1 km and shall be 5 mega ohm for the section shorter than 1 km. The portion that is not suitable for the test may be removed.

(b) Insulation resistance and dielectric strength of power supply cable

Insulation resistance between conductors and between conductors and ground of low voltage power cable installed indoor, outdoor, aerial and underground shall be 5 mega ohm or larger for the cable section separated by switch. If device is connected to the cable, however, the minimum insulation resistance shall be 1 mega ohm. The measurement shall be made with the voltage shown in Table 2.1.

Table 2.1: Measurement Voltage of Insulation Resistance

Supply voltage	Measurement voltage	
	No equipment	Equipment connected
100 volt class	500 volt	125 volt
200 volt class		250 volt
400 volt class		500 volt

The voltage in the column of "equipment connected" shall be applied to the case in which damage to the equipment is expected by insulation resistance measurement.

2.13 Cabinets

All equipment cabinets for outdoor uses shall be of rainproof and rustproof construction with smooth exterior and adequate protection against moisture condensation. The special attention shall be paid to the environment in which the equipment, devices, terminals and cables operate. The Tenderer shall state in his Technical Proposal the

anti-corrosion measures to be taken against corrosive onslaught of waves and salt spray for the cabinet.

The cabinet shall be made of hot-rolled mild steel plate complying with JIS G 3131 or equivalent having thickness of 2.3 t, stainless steel plates or aluminium alloy of adequate thickness. Steel plate cabinets shall be treated with abrasive blasting before zinc thermal painting complying with JIS H 8300 or equivalent. Then two or more layers of coating of polyurethane resin enamels and varnishes shall be applied before the cabinet is painted in final colour.

Past experience has indicated that condensation may develop inside a completely enclosed outdoor cabinet connected with underground conduit due to breathing effect which is caused by a change in ambient temperature even when the conduit is sealed by foamed sealant. The bidder shall state in his Technical Proposal how he will overcome this problem

Cabinet doors shall permit complete access to the interior of the cabinet and shall encompass essentially the whole area of the front surface of the cabinet. All door hinge pins shall be of stainless-steel construction.

All outdoor equipment cabinets shall be equipped with a build-in lock. All cabinets for the same type of equipment shall have an identical lock. The specified number of keys for each type of cabinet shall be furnished to the Engineer.

2.14 Radio interference

All data processing and transmission equipment shall be designed to prevent radio interference with the satisfactory operation of other equipment regardless of whether the interference is due to radiation, induction or conduction.

Vehicle detector units shall be designed to operate normally in the presence of radio interferences.

2.15 Metering

All electrical and electronic equipment shall be provided with waveforms, voltage test points or voltage meters as necessary for indicating circuit conditions.

2.16 Unit of measurement

In all documentations, correspondences, technical schedules and drawings, metric units of measurement shall be employed. On drawings where other units have been used, the metric equivalent shall be marked in addition.

2.17 Brand name

If brand name, product or model number is mentioned for equipment in the Specifications, it shall be construed to include the brand, product or model having sane or equivalent specifications.

3. Toll Collection Operation Procedure

3.1 Type of toll collection procedure of manual and QR code system

MTHL adopts standard configuration for toll management system consisting of mainline tollgate at Gavan between Shivaji Nagar and Gavan interchanges, and ramp tollgate at Shivaji Nagar Interchange. Vehicles pass through one or two tollgates depending on their entry and exit points as presented in Section 1.4 of this Employer's Requirements. The toll management system shall be designed to cope with the configuration of the MTHL as shown in Table 3.1 Type of Toll Collection Procedure. Different toll collection procedure shall be adopted regardless of the payment method (cash/QR code/Card/ETC).

Table 3.1 Type of Toll Collection Procedure

Procedure	Location	Route		Remarks
		From	To	
Payment	Mainline westbound	Gavan	Shivaji Nagar Or Sewri	Pay full amount from Gavan to Sewri
	Shivaji Nagar	Airport Or JNPT	Sewri Or Gavan	Pay amount corresponding to destination
		Sewri	Shivaji Nagar	Pay amount corresponding to destination
	Mainline eastbound	Sewri	Gavan	Pay full amount from Gavan to Sewri
Refund	Shivaji Nagar Exits	Gavan	Shivaji Nagar	Surrender second part of receipt given at mainline toll gate and received Refund
Exit Pass	Mainline eastbound	Shivaji Nagar	Gavan	Exit passage on Bar code scan

3.2 Initial conditions

The operational procedures and the functions of various equipment and device are described below. Basic steps are given first, then the infringements and alternative procedures which can arise are presented. The descriptions assume that all power is correctly available, the lane equipment are switched on and ready for use, appropriate data has been downloaded from the Toll plaza system (TPS), and the lane is unidirectional and is initially not in use.

As the initial condition before the lane is opened, the following situation shall exist:

Table 3.2 Initial Conditions

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	Equipment		Status
1.	Manual lane barrier	MLB	Closed
2.	Overhead traffic light	OHTL	Red (closed)
3.	Lane traffic light	LTL	Red
4.	User fare display	UFD	Blank (off)
5.	Lane video camera	LCM	Off
6.	Booth video camera	BCM	Off
7.	Automatic lane barrier	ALB	Closed
8.	Amber siren beacon	ASB	Off
9.	Automatic vehicle classifier	AVC	Operational
10.	Vehicle detector	MD	Operational

Display on the TCT shall show that power is available, the lane is closed and the display shall show the current date and time assumed by the equipment.

All keys on the TCT shall be disabled expect for the toll collector login keys.

3.3 Log in and log out Procedure

3.3.1 Log in procedure

To commence his duty, the toll collector is expected to perform an attendance log-in at the TOD workstation before proceeding to the booth. The lane will be assigned to the toll collector randomly by the system without any requirement or possibility of human interference or manipulation. The collector will then unlock the booth, arrange the float, and then present the finger on the fingerprint reader for login. The collector shall not be allowed to log-in at the lane unless he has done the attendance log-in at the TOD Workstation. An override shall be included where the lane supervisor assisted log-in is employed should there be a failure in the link between the TOD and lane. Assuming the fingerprint is valid, the collector's identification number shall be shown on the TCT display for a period of approximately three seconds. Should the fingerprint input be invalid or unable to be read then an appropriate message shall be shown on the display and an alarm will be raised on LSDU in the Control Room of the Toll Plaza building. In case if the lane is offline, the lane alarm shall be raised to notify the supervisor and lane assistant that some unauthorized access is attempted in the lane. The UFD will also display appropriate message. Once the fingerprint input has been accepted by the equipment, the toll collector will be deemed to be 'logged-in' to the lane equipment.

3.3.2 Lane open procedure

The toll collector will open the Manual lane barrier and then operate the lane open control on the TCT. This action shall cause:

1) The lane closed aspect of the OHTL to be extinguished.

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1) The lane closed indication on the TCT to be cancelled.
2) The lane open aspect of the OHTL to be illuminated.
3) The lane open indication to be displayed on the TCT
4) Post the sign bearing QR code on the outside wall of tollbooth facing toll lane

The sequence of presenting finger to the fingerprint reader, opening of the manual lane barrier and operation of the lane open control may be performed in any order. The lane open condition shall be dependent on all conditions having been met.

3.3.3 Lane close procedure

The toll collector will operate the 'lane closed' control on the TCT which shall cause:

1) The lane open aspect on the OHTL to be extinguished
2) The lane closed aspect on the OHTL to be illuminated
3) The lane open display on the TCT to be extinguished
4) The lane closed display in the TCT to be illuminated
5) Remove the QR code sign

It shall be possible for the toll collector to process any vehicles still queuing for the lane whilst the OHTL is displaying the lane closed aspect provided that the toll collector is still logged in to the TCT. In addition to operating the lane closed control, the toll collector may also close the manual lane barrier to present a physical obstruction to vehicles trying to enter the lane.

3.3.4 Log out procedure

At the end of a duty, the toll collector will press the 'log out' key followed by the 'enter' key as confirmation. The lane equipment shall close the current duty for that toll collector and the lane equipment and TPS shall produce and store end of duty statistics.

After pressing the 'log out' key but before pressing the 'enter' key, the toll collector may press the 'cancel' key. In this case, the current duty shall not be terminated, and the toll collector may continue to operate the lane.

It shall be possible for the lane equipment to be left in the lane closed condition as above without the collector logging out. Subsequent operation of the lane open control, and manual lane barrier if appropriate, shall restore the lane open condition and allow continuation of the collector's duty.

3.4 Standard operation procedure for cash / QR code payment

3.4.1 Procedure for cash payment

A vehicle will arrive in the toll lane and stop adjacent to the toll booth. The ANPR camera shall detect the vehicle registration number plate automatically and shall display the output on the TCT. The toll collector will enter the appropriate vehicle classification and type of journey and will check the vehicle registration number. If the output of ANPR is correct, the transaction shall proceed or if there are any changes to be done, the same shall be done by the toll collector; and the transaction shall proceed further. This action shall cause the

selected classification and the amount of toll due to be shown on the display on the TCT and the UFD. It shall be noted that the toll collector may enter the classification prior to the vehicle arriving at the toll booth.

The motorist will offer the toll collector coins and/or notes as payment for the toll. The toll collector will take the amount tendered and provide change if any.

Having received full payment, the collector shall press the 'CASH' key whereupon:

1) The red aspect of traffic light shall be extinguished.
2) The green aspect of traffic light shall be illuminated.
3) A receipt shall be produced if demanded by motorist
4) The method of payment shall be shown on the TCT display and on the UFD.
5) Automatic lane barrier shall open

The toll collector will hand over the receipt to the motorist. Then the vehicle will move forward and enters the field of detection of the automatic vehicle classification equipment. Upon such event, the following shall occur:

1) The green aspect of traffic light shall be extinguished.
2) The red aspect of traffic light shall be illuminated.
3) The classification, toll amount due and method of payment displayed on the TCT shall be extinguished.
4) The equipment shall be ready to receive another classification input.
5) The classification, toll amount due and method of payment displayed on the UFD shall be extinguished.

The vehicle will move forward and, when it exits the field of detection of the vehicle exit detector the automatic lane barrier shall close.

As the vehicle leaves the lane, the classification shall be determined by the automatic vehicle classification system and shall be compared with that entered by the toll collector. The exit of vehicle from the AVC detection area shall trigger the incident capture camera installed in the lane to capture the Image and five (5) second video of the rear side of the passing vehicle. If there is any discrepancy in the class declared by the toll collector and the class detected by the AVC, the same shall be reported to the audit workstation in the Plaza Control Room along with the vehicle image and video taken by incident capture camera.

The lane equipment and the Toll Plaza System shall record separately the number of receipt issued by the equipment, and the number of vehicles detected as leaving the toll lane and as detected by the automatic vehicle classifier.

Automatic vehicle classifier shall communicate with LSDU on a separate data channel; and this channel should not be dependent on the toll lane controller.

3.4.2 Procedure for QR code payment

A vehicle will arrive in the toll lane and stop adjacent to the toll booth. The ANPR camera

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shall detect the vehicle registration number plate automatically and shall display the output on the TCT. The toll collector will enter the appropriate vehicle classification and type of journey and will check the vehicle registration number. If the output of ANPR is correct; the transaction shall proceed or if there are any changes to be done; the same shall be done by the toll collector; and the transaction shall proceed further. This action shall cause the selected classification and the amount of toll due to be shown on the display on the TCT and the UFD. It shall be noted that the toll collector may enter the classification prior to the vehicle arriving at the toll booth.

The motorist is required to take the following actions:

1) Start QR code payment application on his smart phone.
2) Scan the QR code posted on the outside wall of toll booth.
3) Enter the amount of toll indicated on UFD.
4) Enter the passcode, if required.
5) Press 'PAY' or appropriated key to pay the toll.
6) Present the smart phone screen to the toll collector to show the payment already made.

Upon confirming the payment, the collector shall press the 'QR Code' key whereupon the system shall enquire on the central database of QR payment for the payment receipt and upon receiving confirmation.

1) The red aspect of traffic light shall be extinguished.
2) The green aspect of traffic light shall be illuminated.
3) A receipt shall be produced if demanded by motorist
4) The method of payment shall be shown on the TCT display and on the UFD.
5) Automatic lane barrier shall open

The toll collector will hand over the receipt to the motorist. Then the vehicle will move forward and enters the field of detection of the automatic vehicle classification equipment. Upon such operation, the following shall occur:

1) The green aspect of traffic light shall be extinguished.
2) The red aspect of traffic light shall be illuminated.
3) The classification, toll amount due and method of payment displayed on the TCT shall be extinguished.
4) The equipment shall be ready to receive another classification input.
5) The classification, toll amount due and method of payment displayed on the UFD shall be extinguished.

The vehicle will move forward and, when it exits the field of detection of the vehicle exit detector; the automatic lane barrier shall close.

As the vehicle leaves the lane, the classification shall be determined by the automatic vehicle classification system and shall be compared with that entered by the collector. The

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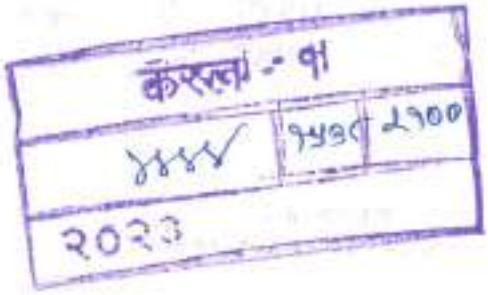
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exit of vehicle from the AVC detection area shall trigger the incident capture camera installed in the lane to capture the Image and five (5) second video of the rear side of the passing vehicle. If there is any discrepancy in the class declared by the toll collector and the class detected by the AVC, the same shall be reported to the Audit workstation in the Plaza Control Room along with the vehicle image and video taken by incident capture camera.

The lane equipment and the toll plaza system shall record separately the number of receipt issued by the equipment, and the number of vehicles detected as leaving the toll lane, and as detected by the automatic vehicle classifier.

Automatic vehicle classifier shall communicate with LSDU on a separate data channel, and this channel should not be dependent on the toll lane controller.

3.4.3 Procedure for credit/debit card payment

A vehicle will arrive in the toll lane and stop adjacent to the toll booth. The ANPR camera shall detect the vehicle registration number plate automatically and shall display the output on the TCT. The toll collector will enter the appropriate vehicle classification and type of journey and will check the vehicle registration number. If the output of ANPR is correct, the transaction shall proceed or if there are any changes to be done; the same shall be done by the toll collector; and the transaction shall proceed further. This action shall cause the selected classification and the amount of toll due to be shown on the display on the TCT and the UFD. It shall be noted that the toll collector may enter the classification prior to the vehicle arriving at the toll booth.

The motorist will inform the toll collector that he pays with credit / debit card the toll collector coins and/or notes as payment for the toll. The toll collector will take the amount tendered and provide change if any.

The payment by credit / debit card will take the following steps:

6) Motorist informs the toll collector that he wants to pay toll with credit / debit card and surrender the card.
7) Toll collector presses "CREDIT" button. The toll amount due is automatically sent to card reader and shown on it.
8) Toll collector inserts the card into card reader, or swipes the card through card reader.
9) Motorist is required to enter pass code if necessary to authorize payment by the bank
10) Upon acceptance of the card and confirmation of payment, the bank receipt is printed automatically.

Upon completion of transaction by credit / debit card:

11) The red aspect of traffic light shall be extinguished.
12) The green aspect of traffic light shall be illuminated.
13) A receipt shall be produced if demanded by motorist.
14) The method of payment shall be shown on the TCT display and on the UFD.
15) Automatic lane barrier shall open

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The toll collector will return the card and hand over the receipt to the motorist. Then the vehicle will move forward and enters the field of detection of the automatic vehicle classification equipment. Upon such operation, the following shall occur:

16) The green aspect of traffic light shall be extinguished.

17) The red aspect of traffic light shall be illuminated.

18) The classification, toll amount due and method of payment displayed on the TCT shall be extinguished.

19) The equipment shall be ready to receive another classification input.

20) The classification, toll amount due and method of payment displayed on the UFD shall be extinguished.

The vehicle will move forward and, when it exits the field of detection of the vehicle exit detector, the automatic lane barrier shall close.

As the vehicle leaves the lane, the classification shall be determined by the automatic vehicle classification system and shall be compared with that entered by the collector. The exit of vehicle from the AVC detection area shall trigger the incident capture camera installed in the lane to capture the Image and five (5) second video of the rear side of the passing vehicle. If there is any discrepancy in the class declared by the toll collector and the class detected by the AVC, the same shall be reported to the Audit workstation in the Plaza Control Room along with the vehicle image and video taken by incident capture camera.

The lane equipment and the toll plaza system shall record separately the number of receipt issued by the equipment, and the number of vehicles detected as leaving the toll lane and as detected by the automatic vehicle classifier.

Automatic vehicle classifier shall communicate with LSDU on a separate data channel; and this channel should not be dependent on the toll lane controller.

3.4.4 Procedure for refund

Receipt check shall be conducted at the Shivajinagar Interchange exit lanes to determine the entry interchange of vehicles. The following procedure shall be taken instead of the standard procedure stipulated in Sections 3.4.1 and 3.4.2.

For the vehicles coming from Chirle and exiting at Shivaji Nagar tollgate;

1) The driver is required to surrender the receipt of toll with barcode issued at mainline tollgate,

2) Toll collector shall read the receipt with the bar code reader to confirm that vehicle has entered MTHL at Chirle.

3) Relevant information recorded on the receipt in bar code shall be displayed on TCT and 'REFUND' shall be displayed on UFD.

4) The toll collector shall refund the toll difference to the driver, issue a new receipt and collect the receipt issued at mainline tollgate.

Upon pressing "REFUND" button by the toll collector, automatic lane barrier shall open and

driver may proceed.

3.4.5 Correction

At any time during the transaction up to the selection of 'CASH', 'QR Code', 'Credit / Debit', 'PAID' or 'REFUND', the toll collector may use the 'correction' key to abort the current transaction and the start the transaction procedure again. On pressing 'CORRECTION' key:

1) The information on the TCT display and UFD relating to the previous classification shall be cancelled.

The keyboard shall be ready to accept a further classification input.

3.4.6 Violation

A violation shall be signalled if a vehicle is detected as entering the fields of detection of the AVC when the red aspect is displayed on the traffic lights. This shall be independent of the toll collector being logged on to the equipment.

On detecting a violation, the entry lane equipment shall raise an alarm in the Control Room of the Plaza building and shall cause the amber siren for that lane to be energized. The siren alarm shall be cancelled either on acknowledgment of the alarm by the lane supervisor or on expiry of the violation alarm time-out period currently in force.

Incidents shall be recorded by the lane equipment and the plaza server system. In the lane, the incident capture camera shall take a picture of the incident. The Toll Plaza system shall have a mechanism to record and input details of the incident.

3.4.7 Exempt transactions

Certain vehicles, such as police patrol vehicles, ambulance, fire brigade trucks, etc. as per the government notification or operating rules of MTHL are exempted from paying toll. These vehicles shall be classified by the collector in the same manner as all other vehicles and the payment will be registered by the toll collector pressing the 'EXEMPT' key. The exempt transactions shall be authorized electronically and remotely by the auditor sitting in the control room; upon checking the validity of the exempt transaction. No receipt shall be issued. The ALB shall not open if the auditor does not authorize the exempted passage of the vehicle. The transaction shall proceed in a similar manner to that outlined above for cash payments.

3.4.8 HP & MC convoy sequence

High personage's convoys and military convoys are exempted from paying toll by Government legislation. These vehicles shall be registered by the toll collector by pressing the 'HPMC' key. The HPMC transactions shall be authorized electronically and remotely by the auditor sitting in the control room; upon checking the validity of the exempt transaction. No receipt shall be issued. When the 'HPMC' key is pressed the following shall occur:

1) The toll due for the selected classification displayed on the UFD and TCT shall be blanked.

2) The red aspect traffic lights shall be extinguished, and the green aspect traffic lights

shall be illuminated.

3) No receipt shall be issued.

4) The automatic lane barrier shall remain continuously in open position till the end of the convoy.

5) All and every vehicle that passes through the lane during a HPMC activation shall be registered as a HPMC transaction.

6) The vehicle class is not entered by the toll collector, while the class determined by the AVC for each vehicle shall be recorded.

The HP & MC sequence shall be terminated by pressing the 'HPMC' key followed by the 'ACCEPT' key when the last vehicle arrives at the level of the toll collector. The system shall close the rising barrier after the passage of the last vehicle. Upon termination of the HP & MC sequence the green aspect traffic lights shall be extinguished and the red aspect traffic lights shall be illuminated.

3.5 Lost receipt

Should a motorist who is entitled to refund but has lost the receipt, shall pay the full applicable toll at the respective tollgate location.

3.6 Excessive journey time

In processing the receipt check and refund, the toll lane equipment shall calculate the time taken for the journey and shall check it against that allowed by the system for any journey. In the event of the actual journey, time being greater than the allowed, refund shall not be paid.

3.7 Violation

A violation will be deemed to have occurred if a vehicle enters the field of detection of the automatic vehicle classification equipment before the toll collector or the equipment has registered a valid payment as having been made. This shall apply to the cases where the vehicle passes through the lane without completing transaction or when no toll collector is 'logged-on' to the toll lane equipment. Details of all such 'transactions' shall be recorded by the lane equipment; and alarms shall be raised and reported in the audit & LSDU workstation in the toll management room.

3.8 Receipt printing

Receipts shall be issued automatically for each transaction, except those 'EXEMPT', 'HPMC', 'EMERGENCY', and 'ETC' is used in lieu of payment on the registration of completed payment.

Spaces shall be incorporated into the printing to assist in easy interpretation of the receipt. In addition, bar code indicating the details of transaction shall be printed on the receipt. The receipt shall be printed by the equipment and presented to the toll collector after tearing off from the printer cutter.

The receipt shall have barcode, which shall be used for refund at Shivaji Nagar and no

payment at mainline tollgate for eastbound vehicle coming from Shivaji Nagar.

3.9 Maintenance mode

3.9.1 General

Maintenance mode shall be provided for the lane equipment which shall allow full operation of the equipment with the OHTL status showing "lane closed," irrespective of the status of the various controls and interlocks. The maintenance mode shall be entered with the authorized identity identification, similar to those used by the toll collectors but having a unique range of numbers, which shall be used to enable the equipment for maintenance mode.

Details of all transactions performed in maintenance mode shall not be included in summary data files produced by the Toll Plaza System but "end of shift" files, clearly identified as relating to maintenance mode, shall be available in respects of each period of operation. All monitoring and alarm facilities shall be available in maintenance mode.

3.9.2 Test functions

Once maintenance mode has been entered, special test facilities shall be available that shall assist in routine testing or fault diagnosis. These facilities shall allow verification of correct operation of the following as a minimum:

1) full functioning of the lane as a whole
2) operation of the TCT and its various sub-parts
3) operations of the AVC
4) operations of the loop detector
5) operations of bar code reader
6) operations of RFID antenna
7) output interfaces for all equipment,
8) data communication with TPS,
9) Input from and output to as the case may be for all the lane equipment

These tests shall be initiated using either the portable laptop computer with appropriate software in place of lane controller or using the existing lane controller with the keyboard (TCK) and display (TCD) forming part of the TCT. It shall be possible for each of the functions to be checked separately and independently.

4. Functional Requirements for ETC System

4.1 General

The ETC system shall be the system based on the FASTag proposed by National Highway Authority of India (NHAI), implemented and operated by Indian Highway Management Company Limited (IHMCL), and managed by National Payment Corporation of India (NPCI). The requirements for and operating procedure of the system shall comply with the Procedural Guidelines of NETC - ICD manual version 2.5 release on 29 August 2017.

The Ministry of Road Transport specifies the functional and physical specifications of FASTag and Highways Resolution dated 7 November 2017.

The tag and marks specification are specified by the specification of "NETC Tag and Marks specifications Version – 1.1" issued by National Payments Corporation of India.

The ETC equipment operation shall include two (2) component parts; ground equipment or the RFID antennas and readers installed in ETC lanes and the RFID tag fixed on the windshield of the vehicles from inside.

The ETC system shall be capable of detecting, reading the data and completing the transaction with the vehicle running the toll lane at 60 km/h or below. The accuracy of the system shall exceed 99.4% (normal operation of 994 out of 1,000 transactions) of the transactions between the RFID tag and the ETC lane equipment. The ETC lane equipment shall include adequate protection against cross lane transactions. The Contractor shall demonstrate in the Technical Design and Proposal of the Tender as how he intends to achieve the required transaction speed and accuracy using the past experience of usage of the same technology.

Measures shall be taken to prevent occurrence of double deduction in all circumstance or exceptional events. It is expected that the ETC lane system shall be capable of preventing double deduction and operate continuously as normal in the following events in the lane at the minimum:

1) Violation
2) Two or more RFID tags in the detection lobe at the same time

RFID antenna shall be installed above the toll lane to communicate with RFID tag to realize nonstop operation. No handheld RFID reader shall be used except as backup measure when the RFID antenna fails to read RFID tag.

The ETC system required to be implemented is as on tender date based on the RFID technology; but in case the Government of India, finalizes any other technology for the implementation of ETC in future at the time of commissioning; the same shall have to be considered in the offer without any extra cost to the employer for the same.

4.2 General specifications RFID tag

Supply of RFID tag is not included in the scope of works for toll management system. Specification of RFID tag is provided for reference only.

Particular	Specifications


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Standard	Class 1 Gen 2 Passive UHF RFID transponder
Power	Passive
Frequency	UHF860 MHz to 960 MHz
Data transfer rate	At least 512 kbps under ideal condition and 64 to 512 kbps under field conditions
Protocol	EPC Gen 2, ISO 18000-6C
Tag ID printing	QR code as per ISO/IEC 18004:2015 standard
Tag read range	6 m minimum for RFID tag fixed on vehicle windshield from inside in open air

Memory specification

Particular	Specifications
Tag memory	Unique TID: 96 bits, EPC memory: 96 bits User: 512 bits
Data retention	10 years minimum with UV protection for normal sunlight exposure and ambient temperature of 45° C

Environmental conditions

Particular	Specifications
Operating temperature	-20° C to 80° C
Storage temperature	-40° C to 100° C
Relative humidity	Up to 95% non-condensing

4.3 ETC lane operation

4.3.1 Normal operation

Because the type of lanes to be implemented at MTHL are hybrid in nature; all lanes shall be equipped with ETC facilities. No invalid tag ejection lane is required. The layout and positioning of all the ETC lane equipment is as per the ETC lane layout drawing in the Drawings section.

The operation procedure of ETC lanes shall be as presented below.

1) At the entry of a vehicle into the ETC lane, the RFID antenna shall check and detect the presence of the RFID tag in the vehicle.
2) The RFID antenna shall read RFID tag ID and vehicle classification. Lane video camera shall take the photo and video of vehicle number plate.
3) The ETC lane controller shall check the ID against the blacklist.

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If the vehicle is not found in the Latest Blacklist,

1) At the toll lane the user fare display shall display the Valid Tag message along with the Registration number plate set in RFID tag
2) The Lane traffic light shall turn green and automatic lane barrier shall open.
3) Automatic vehicle classifier shall classify the vehicle and send the classification result to the lane controller.
4) Upon detection of the vehicle leaving the detection area of the barrier, the barrier shall close automatically, The ETC lane transaction for the vehicle shall be complete.
5) Thee lane shall be ready for next vehicle.
6) AT the TPS sever; the system shall send the data of ETC transactions to the acquirer bank for further processing by NPCI.

4.3.2 Error and invalid RFID tag

If the RFID antenna fails to read RDID tag correctly, the following sequence shall be followed.

1) Lane traffic light shall stay red and automatic lane barrier shall stay closed.
2) An alarm shall be issued to the toll collector terminal and the auditor's console of the Toll plaza server system.
3) Toll collector present at tollbooth shall read the RFID tag with the handheld RFID reader provided to toll collector terminal.
4) If the handheld RFID reader is able to read RFID tag correctly, then normal operation shall be resumed as if the Tag is read by the Overhead antennae and reader.
5) If the handheld RFID reader fails to read the RFID tag, RFID tag shall be judged to be defective. The toll collector shall inform the driver that the RFID tag is defective, and the vehicle shall be required to pay the toll with penalty in cash, QR code or credit/debit card.
6) Once toll is paid, normal operation shall resume.

If the RFID tag is judged invalid, the following sequence shall be taken:

1) Lane traffic light stay in red and automatic lane barrier stay closed.
2) An alarm shall be issued to the toll collector terminal and the auditor's console of the plaza server system.
3) Toll collector present at tollbooth shall inform the driver that the RFID tag is invalid and the vehicle shall be required to pay the toll and penalty in cash, QR code or credit/debit card.
4) Once toll is paid, normal operation shall resume.

4.4 Exception lists

The system shall obtain and update the exception list from NETC CCH through acquirer Bank. The exception list consists of three list, namely blacklist, low balance list and

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exemption list.

The blacklist of invalid FASTag maintained by the clearing house operated by NPCI shall be used and applied to scrutinize the vehicles at ETC lane. The master list shall be retrieved from the clearing house once a day at the specified time and the differential list shall be obtained within the specified interval by the NETC CCH. The blacklist shall be maintained in the toll lane computer and updated without delay when the master list is updated. It shall be protected and shall not be possible to alter the list manually by anyone who has access to the toll management system.

Likewise, the Toll Plaza system shall obtain the low balance list form the acquirer at regular interval and timing specified by the NETC system and implement it in the lane controller as soon as possible and not later than 10 minutes of the receipt by the plaza server. In case a FASTag is in the exception list, the vehicle shall not be allowed to pass through ETC lane. The notification of low balance will be issued to the customer by the issuer bank.

The system shall maintain the exemption list that specifies the vehicle class for toll exemption. Examples of vehicle exempted from toll payment are VIP convoy, ambulance, fire bridge, and police vehicle.

4.5 Toll lane controller function

4.5.1 General

The hybrid toll lane controller provided at all the lanes shall handle the ETC transactions with the help of all the lane equipment installed in lane except the manual lane barrier.

All items necessary for the autonomous operation of the ETC lane equipment as required shall be accommodated within hybrid toll lane controller cabinet. All data relating to the duties, transactions and alarms shall be kept in the toll lane controller for a minimum of thirty (30) days.

The lane controller shall have a user interface for access by maintenance personnel. The access shall be protected to a sufficient level.

4.5.2 Data exchange with RFID

The RFID antenna shall be used to broadcast and receive signals from RFID tag and shall have symmetrical read pattern which confines the coverage area to a single lane width. Vehicle with valid RFID tag shall encounter the RFID antenna and on reading the valid RFID, the ALB shall open for passage of vehicle. Information read from Tag shall include but not limited to the following:

1) Tag ID
2) EPC Memory details and information stored in the same

No data shall be written to the RFID Tag in lane at the time of reading for toll transaction.

4.5.3 Data exchange with plaza server system

Other than the requirements specified above the toll lane controller shall:

1) Receive configuration data from the Toll Plaza System at start-up.

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2) Receive blacklist and reload data from the Toll Plaza System at start-up, and the blacklist and reload list shall be updated whenever the Toll Plaza System sends data to the ETC lane controller.

4.5.4 Equipment monitoring function.

ETC Toll lane controller shall be provided with the following monitoring functions and shall report the abnormality or malfunction of the equipment to the plaza server system:

1) Regularly check the status of itself and the lane equipment.
2) Upon receipt of an alarm from any equipment in the lane,
3) Vehicle detection status of any of the vehicle detector kept for the period longer than pre-set time; and
4) Automatic lane barrier kept at open status for the period longer that pre-set duration.

4.5.5 RFID tag

The RFID tag used for the system shall be FASTag complying with the specifications issued by NCPI and issued by one of the authorized FASTag issuing banks.

4.5.6 RFID antenna

The RFID antennae shall be installed at the suitable location along the toll lane for data communication with the RFID tag fixed inside the windscreen of the passing vehicles.

The RFID antenna shall communicate with the RFID tag using radio frequency waves of specified frequency in the range of 860 MHz to 870 MHz complying with the standards and specifications set forth in the Employer's Requirements.

4.6 RFID tag

RFID tag shall be the product of the manufacturer accredited by NPCI and comply with the specifications below.

Particular	Specifications
Standard	Class 1 Gen 2 Passive UHF RFID transponder
Power	Passive
Frequency	UHF860 MHz to 960 MHz
Data transfer rate	At least 512 kbps under ideal condition and 64 to 512 kbps under field conditions
Protocol	EPC Gen 2, ISO 18000-6C
Tag ID printing	QR code as per ISO/IEC 18004:2015 standard
Tag read range	6 m minimum for RFID tag fixed on vehicle windshield from inside in open air

Memory specification

Particular	Specifications

Tag memory	Unique TID: 96 bits, EPC memory: 96 bits User: 512 bits
Data retention	10 years minimum with UV protection for normal sunlight exposure and ambient temperature of 45°C

Environmental conditions

Particular	Specifications
Operating temperature	-20°C to 80°C
Storage temperature	-40°C to 100°C
Relative humidity	Up to 95% non-condensing

5. Data Communication

5.1 Type of data communication

There shall be three (3) types of data communications in the toll management system. They are

1) Between lane controller and toll plaza system
2) Between toll plaza system and toll management centre system
3) Between toll management centre system and acquire bank

All toll lane controllers shall be interfaced to the Toll Plaza System (TPS) installed in the plaza building at each interchange plaza building via a local area network (LAN). Data shall be transmitted from and stored by the lane equipment at various times for transaction recording, surveillance data transmission, operation parameter updating, and equipment operation monitoring. The toll lane controller system shall be designed in such a way that interruption of the data communication link between Toll Plaza System and toll lane controller shall not stop the toll collection operation and normal operation of toll lane shall be possible.

The Toll Plaza System shall send the toll collection operation data of normal operation to toll management centre system at the interval not longer than 5 minutes. Incident data including insufficient balance, unreadable RFID tag, detection of blacklisted RFID tag, vehicle class discrepancy, and exempted vehicle shall be sent immediately to the traffic management centre system.

The Toll Plaza System shall receive blacklist, exception list and other operating data and parameter immediately as they are updated.

The toll management centre system shall communicate with the acquirer bank to obtain the system parameters including but not limited to blacklist, and exception list and process toll payment made by ETC system. The communication shall be encrypted to prevent eavesdropping and other malicious attempts by unauthorized organizations or persons.

5.2 Data communication between lane controller and plaza server

5.2.1 Data from toll lane controller to TPS

The following information shall be both stored by the lane equipment on an individual event basis and transferred to the TPS in real time under normal operating conditions:

1) Log in and log out of toll collector.
2) Individual transaction details
3) System status and operational status
4) Lane opening and closing events.
5) Operating shift statistics.
6) Images of incidents

The following data shall be transferred to the TPS in real time but need not be stored on

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an individual event basis by the lane equipment:

1) Alarms and incidents
2) On demand messages

5.2.2 Data transfer mode

It shall be possible for toll lane controller to send to the TPS in batch mode, and the batch timing shall be a settable parameter in the setup parameters in the toll management system software. The polling shall be done from the TPS server side and shall not be done from the lane controller side.

It is recognized that there will be occasions when either the TPS system is off-line or data communication between one or more lane equipment and the TPS is interrupted. Under these conditions, the lane equipment shall continue to store data for a minimum of seven (7) days operation for later transmission to the TPS.

5.2.3 Data from TPS to toll lane controller.

The lane equipment shall also receive data relating to operational parameters from the TPS.

1) Current and future fare tables for each vehicle classification with date and time of implementation for future tables.
2) List of authorized collector, lane supervisor, auditor and maintenance personnel with ID.
3) Violation alarm time out period.
4) Blacklist of RFID tags.
5) Parameter values for equipment alarms.
6) All toll plaza codes and lane codes included in the network.
7) Codes to be used when manual log-on of collector is necessary.

Downloading of all operational parameters shall be completed within 10 seconds under all circumstances.

Operating parameters received from the TPS shall be stored in non-volatile storage device of the lane controller in a secured way.

Fare tables giving toll rates for each possible journey for each classification shall be held in the form of two tables, one current and one future, together with a date and time for implementation of the future table. In the event of no future rates being defined both tables shall contain the same data for security. Routines in the lane equipment shall ensure that once a change in toll rates has been implemented, data relating to previous rates is marked as deleted from memory.

The violation alarm time out period shall be started at the determination of a violation by the lane equipment and shall be the period for which the alarm signal is given before being automatically reset. In the event of the alarm being acknowledged by input to the monitoring console of the TPS within this period, the alarm shall be cancelled immediately.

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All alarms whether terminated by acknowledgment or time out shall be recorded by the LSDU.

5.2.4 System time

The lane equipment shall include an internal real time clock which shall receive data and time synchronization form the TPS on a regular basis and on any event no less than once every hour. The equipment shall use data from its real time clock to drive the clock display on the TCT and for time flagging of events and data. In the event of TPS failure, the lane controller shall continue to update its own internal clock from the last synchronization data received. The accuracy of the lane equipment clock under such conditions shall be within 15 second per month. When data communication with the TPS is restored, the lane equipment shall assume the date and time next advised by the TPS. Means shall be provided to allow authorized personnel to set up and adjust the time assumed by the lane controller in the event of data communication with the TPS not being possible. Also, an alarm shall be generated if any gap is found between the lane controller and the TPS server after the communication is restored.

6. Toll Plaza System Functions

6.1 System outline

6.1.1 System functions

A Toll Plaza System (TPS) shall be installed in the plaza building at mainline toll plaza, and Shivaji Nagar Interchange. The TPS shall perform supervisory functions but shall exert no direct control over the operation of the associated lane equipment.

The principal functions of the TPS shall be to:

1) provide real time monitoring facilities.
2) correlate data from lane equipment into audit and statistical reports and files at interchange level;
3) serve as an alarm monitoring and acknowledgement system.
4) transmit operational data to the toll management centre System (TMS);
5) receive from the TMS system, and download to lane equipment, parameters relating to operation of that plaza.
6) serve as a time recording system for the attendance of toll personnel at site.
7) provide traffic data to the TMS system;
8) allow input of bank-in data; and
9) produce back-up files for security and for further off-line processing.

6.1.2 Design requirements

The TPS shall support multi-task, multi-operations functions so that the various requirements of the system can be carried out simultaneously with no perceivable delay to persons making inputs to the system.

In the event of power failure, the system shall restart automatically on restoration of power without the need for intervention with no loss of data or reduction in security.

Diagnostic software, in a suitable format for immediate loading and running, shall be provided to allow tests to be performed on all TPS system equipment, interfaces and peripherals. Such tests shall be performed with the systems off-line and shall have no adverse effects on the operation of the toll lane equipment.

Any fault of one software module of the server shall be recorded and alarmed by the system. A watchdog facility shall be included as part of the processor system with an alarm being given at the LSDU console in the event of any fault of the TPS.

The TPS shall process the data received from lane equipment into the files for storage and further processing these to achieve the operating requirements of the system as detailed in the Employer's Requirements. Details of all print outs, toll collector duty records, revenue data, incident reports and the like that are compiled by the TPS shall be similarly stored as uniquely identified files as well as being made available for transfer to the TMS system. Sufficient storage capacity shall be provided within the TPS to allow all such files to be stored for a minimum of 5 years operation under the design criteria specified.

6.1.2.1 CPU time loading

The loading of the central processors of TPS shall be of the order of 50% at the maximum when all scheduled tasks are concurrently executed and transactions are being made at all toll lanes connected to the TPS. The Contractor shall provide a resident program to measure the CPU time loading. The Contractor shall indicate in the Technical Proposal of the Tender the means by which he proposes to demonstrate that this requirement is met.

6.1.2.2 Disk capacity

The disk capacity of the TPS shall be calculated considering of the need to store the operating system, the application software and other software packages necessary for operation of the system, and the data generated by the system to meet the requirements of the Employer's Requirements and to adhere to the manufacturer's recommendations on usable disk capacity for efficient running of programs.

In the calculation of the disk capacity, it shall be assumed that all transaction record shall be kept for five years in the disk connected with TPS on-line. In addition, snapshot image of incident shall be kept for the same period for the manual transaction and image of all vehicles that have used QR code or ETC shall be all kept for 5 years.

6.1.2.3 System time

The TPS shall have an integral real time clock that shall be used for the timing of all reports, printouts, data transfer and the like. The real time shall be automatically synchronized with the real time clock of the toll management centre server. It shall be possible for authorized personnel to set the current date and time. Once set the clock shall remain accurate to within 15 second in one calendar month. In the event of power failure to the TPS, the real time clock shall be maintained to the same degree of accuracy for a period of not less than a week.

The TPS shall send, it's currently assumed date and time to the lane controller and the lane controller shall use this data for their time synchronization purposes.

6.1.2.4 Database management system

A relational database management system shall be provided to toll plaza server. The database shall be the product of the reputable software developer and provided by the authorized dealer. The software shall be registered in the name of the Employer. The custom-made or free license database management system shall not be accepted.

6.1.2.5 Human machine interface

The various functions available from the consoles shall be selected from menu type displays through use of cursor controls, programmable function keys, mouse and track ball or similar pointing device as per the approval of the Engineer.

It shall be possible for any combination of functions to be made available to any level of staff and for this combination to be readily changed by keyboard input to the workstation by the persons having the highest access level. Passwords for each level shall be considered as operating parameters of the system and shall be downloaded from the TMS system as part of the system parameter. It shall not be necessary to differentiate between display and print of a particular function for the purposes of access control to that function.

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Where a function contains too much data for display on a single screen, it shall be possible to use cursor and page control keys to scroll, both vertically and horizontally, the display until the desired data is shown.

6.1.3 Failure of TPS

If the TPS server has failed, implementation of attendance recording, cash transferred to bank and start and end of tour of duty procedures will require staff to make manual records of all relevant data on the special forms provided. Means shall be provided to input the manually recorded data into the TPS server when it recovers without loss or duplication of the data.

If the required workstation has failed, it shall be possible to perform the tasks at an alternative workstation which is connected to the network. Operation thereafter shall be the same as under normal operating conditions.

6.2 Auditor's console

An auditor's console shall be provided and shall be installed in the toll control room in such a position to allow an auditor seated at the console having the best possible view of the toll plaza at the mainline toll plaza.

The auditor's console shall encompass the following:

1) Lane status display workstation
2) Audit workstation
3) Snapshot image and incident video workstation
4) CCTV monitoring workstation
5) Booth intercom system
6) Alarm buzzer and indicator

The auditor's console shall be placed in the toll control room at mainline toll plaza and Shivaji Nagar toll interchange. It shall be laid out ergonomically and shall employ high quality materials. The overall design of the toll control room furniture shall be to a high standard and each item shall be compatible to give a pleasant appearance. The console shall also include cable management designs to ensure cabling are organized neatly and shall not be exposed. The Contractor shall submit the design of the auditor's console for approval by the Engineer prior to manufacturing. The console shall also include security alarm buzzers and indicators such as alarms from the plaza generator set, UPS equipment, etc.

6.3 Lane status display Unit workstation

The lane status display unit workstation shall be interfaced to all lane equipment and shall receive from them details of transactions, collector actions and equipment status in real time so as to allow monitoring to be performed by staff in the control room of the plaza building.

6.3.1 Status display

The lane status display workstation shall be designed to produce the colour graphic

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screens that are easily interpreted and that draw attention to exceptional items and alarm conditions. Use of inverse video and blinking of displays shall also be included where appropriate. The displays shall, in particular, ensure that meaningful information is given. Use of different colours or momentary cancelling of displays will be an acceptable method of achieving this.

The lane status display unit workstation shall display the following as a minimum for the plaza status display:

No	Task	Details
1	status of each lane	open, closed, failed, maintenance, no data communication, etc.
2	collector identity	Staff ID number of collector currently logged on to TCT in each lane.
3	classification	all classifications entered by the collector
4	method of payment	as recorded for each transaction
5	AVC classification	class of vehicle as detected by the AVC equipment
6	Exceptional items	violation, discrepancy, force reset, etc. when these conditions arise
7	Correction	when collector corrects a classification input
8	Toll booth emergency	When emergency footswitch in the toll booth is pressed.

It shall be possible for the auditor to check the current and previous status of the lane simultaneously on one screen.

It shall be possible to select, by keyboard input or use of mouse, any individual lane for detailed monitoring. Once such a selection has been made, the relevant details from the plaza status display for that lane shall be shown together with more particular information relating to the equipment within that lane in real-time. This information shall include:

1) traffic lights — Red or green
2) RFID antenna — Working or Failure.
3) AVC equipment — Operational or failure of any or all modules
4) toll lane controller — Operational or Failure of module or units
5) footswitch — Activation and release
6) Toll Collector Console — Details of all equipment whether operational or failure
7) user fare display — Contents being displayed.
8) automatic lane barrier — Open, close or error

The Contractor shall propose a process to meet such requirements.

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6.3.2 Equipment alarm

Current alarms shall be displayed on the lane status display unit workstation. Alarms shall be shown in chronological order of the condition arising and shall be scrolled so that the most recent information is shown. The console bell tone shall be used to attract the auditor's attention each time a new alarm item is raised. Alarms to be raised shall include:

1) exceptional items
2) RFID antenna failure or read error.
3) AVC failure including identification of failed element.
4) other lane equipment alarm/failures
5) toll booth emergency
6) receipt printer out of paper
7) printer failure
8) communication link failure/recovery
9) Cabinet Security Alarm for all Electrical Cabinets in the ITS Systems

All alarms shall include date and time of occurrence, lane number and toll collector identity number where appropriate.

It shall be possible to set parameter values in respect of those alarms that may occur without affecting overall operation of system. The alarm condition shall only be signalled when the frequency of occurrence of the event exceeds the parameter value. The parameter values shall be independent for each alarm of this type and shall be considered as operating parameters of the system.

6.3.3 Panic alarm

When emergency footswitch is activated and a panic alarm is raised in a toll booth, it shall be indicated on the lane status display unit workstation and the bell tone shall sound. The auditor shall be required to acknowledge the alarm by way of keyboard input and the bell tone shall only be cancelled when this has been done.

6.4 Audit workstation

The audit workstation shall allow authorized staff to access various traffic, revenue and management related data, including operational data in the form of equipment and operating parameters, both in real time and from archive data files.

Use of the audit workstation shall require the auditor to log on by entering his identity number and a password. The identity number shall be verified as being one included in the Staff ID number table downloaded from the TMS system as part of the operating parameters and the password shall be checked as being correct for the allocated access level. Only those functions that are available to the access level of the person currently logged on to the console shall be shown in the menu displays.

All operations at the audit workstation shall be logged together with the operator's ID in the TPS system.

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6.4.1 Functions and screen menu

The following screens shall be available on the audit workstation:

No	Main Menu	Activity
1	Traffic menu	Traffic volume by location (lane, plaza, interchange), time base (hour, day, month), direction (in, out), direction (eastbound, westbound),
		Graphical presentation of above
2	Plaza activity menu	Current toll collector assigned
		Toll collector assignment schedule
		Transactions
		Lane events reports
		TOD reports
3	Revenue menu	Revenue by vehicle class
		Revenue report
		Collector revenue
		Bag bank transfer
		Return bank slip
		Revenue updating
4	Maintenance menu	Alarm criteria
		Alarm log
		Alarm summary
		Fault history
		Accuracy of the AVC per class
5	System menu	Backup TPS data
		Restore data
		Backup parameters
		Restore parameter
6	Incident menu	Incident notice
		Incident acknowledgment

It is expected that once an auditor has logged on the console, he will be presented with an initial menu, also identified as scrolling menu, containing each of the six groups identified above together with a log out option. When a group is selected, a second level menu showing each of the available functions and an option to return to the initial menu shall be displayed. For all groups apart from the system functions there shall also be an option to

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request for a print out of data without the data being displayed.

Once an item has been selected for display or print, the auditor will enter information such as date, lane number, toll collector ID or any relevant combination of these to define the selection criteria which are to be displayed or printed. A simple input screen that prompts the auditor to confirm as to the required information may be provided. When a request for display of data has been completed, the first or only screen of data shall be prompt up and there shall be no perceivable delay when paging or scrolling the data to view the data that is not currently shown. In the event that no data is available for the requested item, a message shall be displayed to that effect.

All data display screens shall include both the current date and time assumed by the TPS and the time period for the data which is being displayed. The displayed data shall be frozen at time of request and shall not be updated in real time on screen. The display, and any requested printouts of the data, shall be highlighted to indicate the period of data and information it covers.

The auditor shall be able to request display or print of the traffic volume data for any completed period in a similar manner to other data retained by the TPS. It shall not be necessary for the start time to be entered to the input screen following selection of the traffic screens from the second level menu.

Hourly traffic volume data for both plaza and individual lanes shall be compiled on the basis of calendar days and shall be available from the TPS following input of the required date. Formats for all displays shall be subject to approval of the Engineer. Functions available will depend on the privileges given to the auditor. The auditor will manage the lanes to open duty, close duty, and toggle the status of overhead traffic light (red and green).

6.4.2 Revenue reconciliation

The daily collected revenue is the corresponding sum of the toll paid by each of the various methods of payment of ETC, QR code, credit/debit card and manual options. Cash is collected only through manual payment.

The cash collection and cash collection discrepancy shall be compiled for each toll collector. The tours of duty (TOD) of a collector shall be closed when end of shift report is consistent and all discrepancies due to exceptional transactions have been duly acknowledged by the auditor and there is no outstanding transaction that requires auditor's acknowledgement.

6.5 Snapshot image & Video workstation

The snapshot image & Video workstation shall be used to monitor and store the incident image and video of the vehicle. The snapshot image and video shall be taken for all vehicles that have passed the toll lane. The image & video of the vehicle that has caused an incident shall be kept for one year and the snapshot & Video of the vehicle without any incident shall be kept for one week.

The workstation shall have two main functions namely:

1) Real-time viewing of image & Video
2) Search and retrieval of images & Video from archive


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If an incident occurs, snapshot image & Video shall be sent immediately and shown on the display in a new window irrespective of the operation being executed on the workstation provided that the workstation is powered on. The image & Video shall be attached with date, time, interchange name, lane ID. For the image & Video of the vehicle class discrepancy, category input by the toll collector and category judged by the automatic vehicle classification system shall also be attached. There shall be no limit on the number of windows for this purpose.

All snapshot images & Videos shall be stored in the storage device of the workstation and at the same time it shall be sent to the toll management centre system. Provision shall be made to attach additional data such as plate number manually input through the workstation. It shall be not possible to delete the snapshot image at the Toll Plaza System level.

The workstation shall be provided with a function to search and retrieve the image & Video from the archive. Search shall be made using several keys including, date, time, toll lane, plate number and other attributes. It shall be possible to specify a range for date and time.

6.6 CCTV monitoring workstation

The CCTV monitoring workstation shall be used to monitor the toll lane, toll booth, toll plaza and interchange premises. The requirement for the CCTV monitoring workstation is presented in the section for CCTV monitoring system.

6.7 Tour of duty (TOD) workstation

TOD workstations shall be provided in cash room at each toll plaza for the purposes of attendance recording and input of cash collection data by toll collectors following completion of a toll collection duty using manual lane equipment. A contactless card reader/writer of a desktop type shall be provided and installed adjacent to each TOD workstation. Staff will present their identification cards to these readers as a means of identification when using the workstations.

All operations at the TOD workstation shall be logged together with the operator's ID in the TPS system protected by encryption.

6.7.1 Operation

Operation of the TOD workstations shall be especially straightforward and shall require the minimum of input via the keyboard since it is unlikely that persons using them will be computer literate. It is envisaged that the required function will be selected from a simple menu and the person shall be instructed to select one of the options. Only those options that are selectable shall be displayed.

Means shall be provided to allow a re-try operation in the event of incorrect keyboard input or incorrect reading of the ID card.

6.7.2 Sign on and sign off

Toll collector is required to select either sign on or sign off from the menu options displayed followed by presenting the Thumb ID to the fingerprint reader.

The TOD workstation shall display the identification number of the user as per the

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fingerprint reader, together with an indication of whether the action is for arrival or departure, and the name of the person. A message shall be shown to confirm the display to complete the processing.

Any fraudulent attempt to sign on a person who is already registered as signed on, or to sign off a person who was not recorded as having previously signed on shall be detected and an alarm shall be issued.

In the event of failure of the TOD Workstation, it will not be possible for staff to use the TOD workstations for attendance recording purposes. In this case, the required task may be implemented in any other available workstation connected to the same network. In the case of full server failure, the toll control room will record in an appropriate form details of staff arriving and departing. A facility shall be provided which allows these details to be entered manually to the TPS after it has been restored to an on-line condition.

It shall be possible, following appropriate keyboard input, for the identity of all staff currently "signed on" to be displayed on the audit workstation and, following a further request, to be printed on the operations printer. A facility shall be provided to allow authorized staff to "sign out" staff who may have omitted to do so or who have left the plaza at a time when the TPS was off-line.

The Toll Plaza System shall compile attendance records and shall make these records available for transfer to the TMS system together with other data.

6.7.3 Cash reporting

At the end of his duty the toll collector shall use the TOD workstation to enter details of cash collected. The collector will select the "enter cash collected" item from the menu shown on the TOD workstations and present his thumb to the associated fingerprint reader. The screen shall then show a "Cash Declaration Menu" which includes details of the relevant duty and a separate field for each denomination of note and each value of coin. The collector will enter the number of each type of coin and note which is to be banked. The TOD workstation shall calculate the total for each denomination and overall total and shall display these. Means shall also be provided to allow the collector to enter a bag or seal identification number which shall be used as part of the "cash transferred to bank" facility. The collector will acknowledge correct input or amend incorrect entries by simple keyboard input that does not involve re-entering all data.

After the "Cash Declaration" form has been filled in, the supervisor will display to toll collector the cash up report which shows the declared and the computerized revenues, the debt of the toll collector for positive discrepancy with the link to the corresponding incident picture. The toll collector shall acknowledge the printed cash report. To be valid, the end of duty report shall be consistent which means that the system has checked all incident notices corresponding to the duty and the auditor has acknowledged all incidents which came up in the lane during the duty turn.

A facility shall be provided whereby if the amount entered by the collector differs from the "computed" amount, a warning to this effect is given to the collector and he is given an opportunity to recheck his declaration and amend previous data entries. The "computed" amount calculated by the TPS shall not be displayed to the collector and the "allowable variance" shall form an operational parameter of the system.

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Once the collector has acknowledged that all data entered by him is correct, a printout of the "cash for banking" containing all details entered by the collector shall be produced on the tour of duty printer on a new fold of paper. This print out shall include space for both collector and auditor to sign.

6.8 Data exchange

Data exchange with toll lane equipment, toll management centre system and the peripherals attached to TPS shall be arranged in such a way that failure of any one device or communication link does not render any other data exchange inoperative.

6.8.1 Data exchange with toll management centre system

The TPS shall be interfaced via digital data communication system for data communication with toll management centre system. The data communication shall use the digital data transmission system to be established along MTHL under this Contract.

All data transmission shall be validated and errors occurring during data transmission shall be automatically detected and retransmitted. Under no circumstance, the integrity of data being exchanged between TPS and the TMS system shall be affected.

Separate files shall be provided for data transmission from TPS to TMS system and operating parameter files from TMS system to TPS. The Contractor shall propose the kinds of data exchanged for the approval by the Engineer. They shall include the data listed below as a minimum.

Data sent from toll management centre system to TPS shall be as minimum,

Data	Contents
Operating parameter table	Valid interchange and lane codes, access control password, alarm setting
Staff ID number table	ID number, name, access level
Vehicle classification table	Vehicle classification parameter, number of vehicle classes
Fare table	Current, future, date and time of implementation
Blacklist	Complete blacklist and differential blacklist

Data sent from TPS to toll management centre system shall be as minimum,

Data	Contents
Lane operation	Time open and time closed, etc.
Traffic data	Lane traffic volume by class, etc.
Transaction	Date and time, interchange, lane, vehicle class, toll collector class, payment Method (manual, QR code, credit/debit card and ETC), amount of toll collected, exemption, etc.
Snapshot image & Video	Image & Video of vehicle taken by incident capture camera together with date and time, lane

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Alarm	Date and time of alarm, etc.
Revenue	Revenue by payment mode (manual, QR code, credit/debit card and ETC), by toll collector, bank-in amount with date and time, etc.
Toll collector	Time reported, time sign in, time sign off, time left, etc.
Equipment malfunction	Date and time occurred, date and time recovered, etc.

In case of communication failure with the toll management centre system, operating parameters data shall also be able to be transferred on a separate removable media or USB drive and facilities shall be provided to allow them to be loaded into the TPS. It shall be possible for implementation of amended inputs to be included and for the data to be checked for correct configuration before execution in sequence.

It shall be possible for any file to be transmitted from the TPS to the toll management centre system on receipt of a request from the latter as a means of further cross checking. The Contractor shall include details of the proposed arrangement and labelling of files in the first draft of the Software System Design to be submitted as part of the design approval process. These initial proposals shall be discussed and agreed with the Engineer as part of the approval of the Software System Design.

6.8.2 Data collection from lane controller

All data generated by lane equipment and stored by the TPS shall be totally secured against failure of the lane equipment, failure of the TPS, breakdown of the data communication link between the lane and the TPS or the TPS and the TMS system, and failure of the TMS system itself.

All the data sent from the lane equipment to the TPS shall contain an identification number. This number shall be supplemented by the plaza code and lane number so that the source of the message may be readily traced.

All incident notice shall be individually stored by the lane controller which shall have sufficient capacity to store data for all equipment for a period of seven (30) days. This throughput and duration shall only be used for design purposes and the limit of the available memory shall be the determining factor of the time for the actual data storage achieved.

The TPS shall monitor all the data received and the mechanism to detect the loss of data shall be implemented along with the automatic recovery of the lost data.

On restoration of data communications between the TPS and a lane equipment or disk capacity becoming available at the TPS, all essential data messages stored by lane equipment that have not been previously transferred to the TPS and acknowledged as being correctly received shall be transferred automatically to the TPS.

The received data shall be processed by the TPS in a similar manner to that received in real time and once this has been completed, display and print out of the data shall be available.

The data communication protocol and the sequence of bringing lane controller back into communication with the TPS shall take due account of the fact that there may be large amounts of data to be transferred. The primary aim of the system is to ensure that all reports and data files are correctly compiled, data is available for print out, display and files are available for transfer to the TMS system and that no data is lost.

Portable external storage drive shall be provided under the Contract for the purpose of extracting data stored by the lane equipment under conditions of TPS failure. Such equipment will be used when the limit of available data storage in the lane equipment is being reached and the intention is to provide a means of continuing operation of the system with no long-term loss of audit and statistical data.

6.9 Printer and printing functions

Two printers shall be provided for toll plaza system for production of hard copy. The printers shall produce operating logs, alarm messages, traffic statistics and details of shift reports or the shift closing activities as required.

All printouts including alarms and audit reports shall be programmable and configured to control the manner of printing either by on demand, automatically or suppressed.

On demand prints shall take priority over automatically produced printouts. In the event of an on-demand print being requested while automatic prints are pending, on demand printing shall commence after all pages of automatic prints have been output.

The precise format and content of all print outs shall be agreed with the Engineer during the design stage.

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7. Toll Management Centre System (TMS) Function

7.1 System outline

7.1.1 System functions

The TMS system shall be provided in the traffic management centre to monitor and supervise the operation of both the TPS at Mainline toll and at Shivajinagar Interchange and to provide audit control and statistical data relating to the toll collection operation at each toll plaza.

The system shall be designed in such a way that comprehensive facilities will be available, but that operation shall be straight forward and should be easily understood by suitably trained, non-technical personnel. In the event of power failure, the system shall auto reboot on restoration of power without need for operator intervention, other than a log-on operation.

The principle functions of the TMS system shall include but not limited to the following:

1) Receive transaction data, incident data, operation monitoring data and equipment monitoring data from all TPS systems.
2) Correlate transaction data from TPS and bank-in into summary and statistical reports and files.
3) Process traffic data and produce statistical summary.
4) Process incident data and prepare blacklist to be added and send it to central clearing house.
5) Produce archive disks containing data files that may be further processed off-line.
6) Receive blacklist of FASTag from the acquirer bank portal or in turn from central clearing house and download them to the TPS.
7) Update and revise operation parameters and download them to TPS.
8) Search FASTag data of vehicles, find a pair of data of the same FASTag unit and adjust the net amount to be charged.

TMS system shall comprise but not limited to the followings equipment:

1) TMS server
2) TMS administration workstation
3) TMS reporting workstation
4) Financial management workstation
5) Snapshot image & Video workstation
6) CCTV monitoring workstation
7) Networking system components
8) Printers


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7.1.2 Cluster configuration

The TMS Server shall be configured as a two-node high availability cluster with a primary and a standby node (where only one node will be active at any given time). The primary node shall be located at the main toll management centre at the mainline toll plaza and the secondary node shall be located at the sub toll management centre at Sewri Interchange. The currently active node will host the toll administration processes. In the event of a serious hardware or software problem on the primary node, the clusters will failover to the secondary node, whereby the secondary node will become the active node. The changeover of the system shall not cause any loss of the data or irregular operation of the toll management system and its components. After the restoration of primary node, the cluster shall return back to the primary node from the secondary node.

The Contractor shall describe the detailed procedure of failover between the primary and secondary node including the process of how the data loss is prevented and how data is updated or synchronized at the time of recovery.

7.1.3 RAID system

The RAID with hot-swap capability shall be used in the configuration of storage system. The RAID system shall be any of the levels 5, 10 and 50 and to expand storage to multiple terabytes in a variety of computing environments.

7.2 Design requirements

The TMS systems shall support multi-task, multi-operations functions so that the various requirements of the system can be carried out simultaneously with no perceivable delay to persons making inputs to the system.

7.2.1 CPU time loading

The loading of the central processors of TMS server shall be of the order of 50% at the maximum when all scheduled tasks are concurrently executed. The Contractor shall provide a resident program to measure the CPU time loading. The Contractor shall indicate in the Technical Proposal of the Tender the means by which he proposes to demonstrate that this requirement is met.

7.2.2 Hard disk capacity

The disk capacity of the TMS server shall be calculated considering the need to store the operating system, the application software and other software packages necessary for operation of the system, and the data generated by the system to meet the requirements for the toll management system and to adhere to the manufacturer's recommendations on usable disk capacity for efficient execution of programs.

In the calculation of the disk capacity, it shall be assumed that all transaction record shall be kept for five years in the disk connected with TMS server on-line. In addition, snapshot image & video of incident shall be kept for the same period for all types of transaction and image of all vehicles that have passed through toll lane without any incident shall be kept for three (3) months regardless of the payment mode. The Contractor shall indicate in the Technical Proposal of the Tender the calculations by which the hard disk capacity is chosen.

7.2.3 System time

The TMS server shall have an integral real time clock that shall be used for the timing of all reports, printouts, data transfer and the like. The real time shall be used to automatically synchronize the real time clock of the Toll plaza server system. It shall be possible for authorized personnel to set the current date and time. Once set the clock shall remain accurate to within two (2) sec in one calendar month. In the event of power failure to the TMS server, the real time clock shall be maintained to the same degree of accuracy for a period of not less than 48 hours.

7.2.4 Database management system

A relational database management system shall be provided to TMS server. The database shall be the same product and organized in a same manner as provided to the toll plaza system and shall be the product of the reputable software developer. The custom-made database management system shall not be accepted.

7.2.5 Human machine interface

The various functions available from the consoles shall be selected from menu type displays through use of cursor controls, programmable function keys, mouse and track ball or similar graphical user interface to the approval of the Engineer.

It shall be possible for any combination of functions to be made available to any level of staff and for this combination to be readily changed by keyboard input to the workstation by the persons having the highest access level. Passwords for each level shall be considered as operating parameters of the system. It shall not be necessary to differentiate between display and print of a particular function for the purposes of access control to that function.

Where a function contains too much data for display on a single screen, it shall be possible to use cursor and page control keys to scroll, both vertically and horizontally, the display until the desired data is shown.

7.3 Workstations

Toll management centre system shall consist of several workstations as required herein. Each workstation shall have its own functions and perform the tasks assigned to it under normal conditions. In the event of unavailability of a workstation due to malfunction or maintenance, however, it shall be possible that any other workstations work as substitution to perform same functions. Access privilege control shall be applied in the same manner with the workstation being replaced.

The assignment of the functions to each workstation shall be as shown below.

	Workstation	Main functions
1	TMS administration workstation	Parameter management
2	TMS reporting workstation	Generating the TMS system reports
3	Financial management workstation	Managing the revenue activities


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4	Snapshot image & video workstation	To observe the vehicle images & video
5	CCTV monitoring workstation	To observer the CCTV at plazas

7.4 Functional requirement

The TMS system application shall consist of the following modules:

1) Parameter management
2) Traffic management
3) TMS activity
4) Revenue statistics
5) System administration
6) Report generation
7) Organization of data
8) Transaction matching and pairing

7.4.1 Parameter management

The minimum functions available in this module shall be:

1) Enquiry/reporting
2) Maintenance of parameter tables

The minimum parameter tables managed under this module are:

1) Access level setup
2) Automatic print out
3) System constants
4) Exemption criteria listing (such as ambulance, police, government vehicle, etc.)
5) Staff list
6) Fare tables
7) Versions (in case of change of tables such as changed toll fare table, etc.)
8) AVC parameters
9) Acceptable bank for bank-in transactions (list of banks for bank-in processes)
10) Parameters related to Blacklist Management
11) Remarks (optional)

Maintenance function allows the addition and editing of the parameter tables. The versions of the tables shall be automatically defined by the respective parameter counters and shall increment in a single step. Editing of parameter table version numbers shall be prohibited.

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Revision number table is generated automatically by the system when any of the tables is modified and subsequently downloaded.

Each plaza shall have its unique set of parameter tables.

Overwriting of a revision previously downloaded/transferred shall not be allowed. Instead, a new revision shall be available for editing.

Enquiry/reporting function shall allow the display/printing of parameter table for the selected range of dates and revision number.

7.4.2 Traffic data management

The system shall collect the traffic volume data at mainline toll plaza and Shivaji Nagar Interchange from the Toll Plaza System and process them into the summary form. Traffic volume data and OD data shall be produced.

1) Traffic volume at section and on/off ramp statistics
2) Origin – destination (OD) traffic volume statistics

Traffic volume data shall be the summary of traffic volume produced by plaza server system. In addition, traffic volume at each section of the MHTL in the form of monthly total, daily average, and day of the week average shall be calculated. At the beginning of a new calendar year, annual summary that contains traffic volume on an annual basis shall be made.

Traffic data management shall process the transaction data and produce OD table showing the traffic volume between all interchange pairs. The data shall be processed separately for each type of vehicle classification and aggregate of all types of vehicles. The time base of OD data shall be monthly total, daily average and day of the week average. The processing of transaction may be carried out by the toll plaza computer server and the toll management centre system may compile the data from each Toll Plaza System into overall data covering the entire MTHL.

7.4.3 TPS activity management

The minimum primary functions available in this module shall be:

1) Enquiry/reporting
2) Audit reporting of maintenance activities
3) Status

Enquiry/reporting function performs the display and printing of the following: -

1) List of toll collectors on duty
2) List of toll collectors who has finished his duty in a day
3) Details of transactions specified
4) Criteria for filtering transactions for display including the discrepancy types
5) Plaza revenue summary
6) Plaza TOD summary

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7) Plaza traffic volume summary

8) Collection performance summary for a specified period (with both text and graphics)

9) Exceptional transaction summary

The display of end of duty for lane shall include the possibility to zoom into the individual transactions of the same duty or to the list of duty where another duty can be selected.

Enquiry/reporting function allows the display/printing for selected date, plaza, lane, duty, bag no, transaction number, transaction time, where applicable.

The plaza activity display selection screen shall provide additional selection filters for the lane individual transaction screen. The additional selection filters shall be based on two criteria namely the observation of events at lanes and payment type. The logical control between the two criteria may also be specified as an 'OR' or 'AND' function. The logical control between the three categories under observation of events namely payment monitoring, sequence and passage shall be an 'OR' function.

7.4.4 Revenue statistics

The functions available in this module shall be:

1) Revenue by vehicle class
2) Revenue by Payment Method type (Cash/QR/Card/ETC)
3) Period wise revenue
4) Revenue summary computed by the system
5) Revenue summary declared through TOD
6) Cash reconciliation (difference in computed and declared)
7) Bank-in history
8) Bank-in reconciliation
9) Revenue recovered/refunded.
10) Miscellaneous revenue

The entry of data for bank-in reconciliation shall consist of the following:

1) Data entry of bank-in slip/total bank-in for a collection date
2) Zooming into cash collection facility
3) Zooming into plaza TOD declaration

The following data are to be entered:

4) Daily amount of bank-in by the bank for each collector
5) The total bank-in per bank-in slip

If discrepancy occurs between declared and bank-in, an option window shall be prompted and there shall be an option to proceed or abort. If the auditor proceeds, there is a remark column that has to be filled to indicate the reason for discrepancy.

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The revenue outstanding amount recovered/refunded screen shall provide a facility to record and print revenue recovered or refunded during operation of the toll management system. The data entered, deleted or edited shall not affect all other reports or screens provided in the TMS system.

The miscellaneous revenue screen shall provide a facility to record and print other sources of revenue from other services such as towing, and repairing other than collection of toll. The data entered, deleted or edited shall not affect all other reports or screens provided in the TMS system.

7.4.5 System administration

This module shall allow the auditor to administer the TMS system through management of data and parameter including verification of data. It is expected that the TMS system shall receive data via digital data transmission system periodically and on an ad hoc basis from all plazas and provide completed statistical data at the end of every operational day.

This module shall have the following functions:

1) Copy parameter for TPS
2) Load TPS data to TMS system
3) Parameters for ETC Communication with Acquirer Bank
4) Backup TMS data
5) Restore TMS data
6) Backup TMS parameters
7) Restore TMS parameters
8) Data upload verification
9) System data verification

It is envisaged that under unforeseen circumstances the digital data transmission system may fail to allow transmission of data. Under such circumstances, the 'Copy parameter for TPS' function shall enable the auditor to transmit manually via removable media the new parameters for every TPS. Similarly, the "Load TPS data to TMS system" function shall enable the auditor to load data from every TPS to the TMS system.

The "Copy parameter for TPS" and "Load TPS data to TMS system" functions shall not in all circumstances result in deletion or duplication of TMS system data and TPS data. The TPS and TMS systems shall be capable of segregating and distinguishing newly inserted data from other data already located in the database and files to avoid duplication or deletion of data.

The "System data upload verification" screen shall provide a means for the TMS auditor to check and verify the status of data uploaded at the TMS. The information on this screen shall be updated automatically at least once daily on every operational day.

The number of duties for lane shall be determined at plaza level and shall be transmitted as "data" to the TMS system.

The "System data verification" screen shall provide the TMS auditor/clerk a checking facility to verify the status of summary data at the TPS and at the TMS. The information on this screen shall be updated automatically at least once a day on every operational day.

The summary data shall be determined at plaza level and shall be transmitted as processed data to the TMS system. It shall not be a value calculated at the TMS.

7.4.6 Reports generation

This function shall provide facilities to generate printouts for reports under a specified selection criteria. All information entered and generated by this module shall be independent from other module.

7.4.7 Organization of database

Data files to be organized with a RDBMS at the TMS shall be such to enable:

1) Efficient retrieval of information for display and production of reports
2) Identical RDBMS table as TPS
3) Methodical storage space management

With retrieval of data by various selection criteria including any combination of at least the following:

1) Range of dates
2) Range of payment modes
3) Range of plaza
4) Range of duty number
5) Range of lanes

8. Specifications for Toll Lane Equipment

8.1 Toll lane controller (TLC)

This specification lays down the general, functional and technical requirements for toll lane controller to be used as a sub-system in integrated toll management system at the toll plazas.

Contractor has to consider total 40 lanes of MTHL while designing the Toll Lane Controllers.

The specifications mentioned herein are minimum. The contractor shall design the Equipment as per the latest configuration available at the time of implementation.

The toll lane controller shall be used to control and monitor all the sub systems and peripheral equipment at the toll lane. The TLC shall be provided to each toll lane and located in the tunnel at the Mainline toll plaza and at tollbooth in Shivajinagar Interchange. It shall house the lane computer, interface to various equipment connected to it, and power supply unit. It shall monitor and control all equipment connected to it and acquire the operation data and record and transmit to the TPS in real time.

The TLC shall be connected to the TPS, via network cable, and shall be required to transmit all transactions, incidents as well as other control information to the TPS in real time. The Contractor shall ensure that a suitable transaction load test is done to simulate the transactions being sent to the TPS during the factory acceptance test. All lanes shall be connected to the TPS server for this test. The LSDU shall be able to monitor each activity that takes place in each lane in real time.

The TLC shall be able to track and store in an accurate and fully auditable manner all lane and AVC transactions in a manner as to ensure the system and data integrity is not compromised in any way. The Contractor shall provide a comprehensive test methodology for this activity.

8.1.1 System configuration

The toll lane controller shall be placed at the toll booth or in tunnel and shall consist of the following:

1) Industrial lane computer
2) Redundant power supply
3) Data communication ports
4) Digital I/O ports
5) 8-Port PoE industrial grade rugged managed switch with 2 additional SFP ports
6) Power distribution panel with surge and lightning protection circuit
7) Terminal blocks
8) Relays
9) Thermostat
10) Surge protection devices

11) IP 55 enclosure with high security Biometric locking mechanism

The TLC shall be of modular construction and each part shall be easily accessed, checked and maintained without affecting other part. The dimensions shall not exceed 1000 mm x 1000 mm x 300 mm.

8.1.2 Technical specifications

No.	Descriptions	Remarks
1.	Make	Vendor Specific
2.	Dimension	1000mm (H) x 1000mm (W) x 300mm (D) max.
3.	Weight	Less than 35 KG
4.	Installation and fixing details	Mounted on the booth floor/wall
5.	Cables	Power cable / data cable from all peripherals / LAN
6.	Material of cabinet	Steel/stainless steel
7.	Colour	SS Glossy Finish
8.	Power supply requirement	Single Phase 240 V AC, 50 H z
9.	Access for maintenance, modularity of construction	Access through cabinet door with cables well identified and terminated
10.	Environmental considerations	Ambient temperature 0°C to 50°C Relative humidity: up to 90 % non-condensing
12.	Reliability and maintainability	MTBF: 30,000 hrs MTTR: 1 hrs

8.1.3 Lane computer (LC)

Lane computer shall be a component of the toll lane controller. It shall be fitted inside the toll lane controller. It shall acquire all the data from the lane peripherals, process them, control peripherals and transmits data to the TPS in real time.

The specifications mentioned herein are minimum. The contractor shall design the Equipment as per the latest configuration available at the time of implementation.

Descriptions	Specification
Type	Industrial grade fan-less compact embedded computer
Installation	DIN-rail mounting inside the Toll Lane Controller
Cables	Power Cable, UTP cable, data cables
Material and Finishes	Aluminium housing, as per manufacturer's specifications

Dimensions	80mm (H) x 300mm (W) x 150mm (D) max
Colour	Manufacturer's original colour
Power Supply	Operating: 12V, 50 Hz. With power adaptor, 15W max. Power consumption
Access for maintenance, modularity of construction	Minimal maintenance, off-the-shelf product
Environmental Considerations	-20° C to 65° C operating temperature, 95% @ 40° C (non- condensing)
Design Criteria	**8th Generation Intel® Core™ i5-8559U (NUC8v5PN)** 1.6 GHz to 4.1 GHz Turbo, 4 Core, 8 Thread 6MB Cache, **25W Intel® UHD Graphics 620**, 300 MHz – 1.10 GHz (1 X 16 GB) DDR4 Synchronous Dynamic RAM 1TB SSD HDD Supports CompactFlash socket for type I/II CompactFlash disk Mini PCIe expansion for communication module i.e. HSDPA, WLAN Dual display and supports for wide screen with high resolution 2 x Gb Ethernet, 6 x USB 2.0 and 4 x COMs ports Serial port support RS-485 auto flow control 2 X Ethernet RJ-45 network port, 10/100/1000 Mbps Ethernet controller, support Wake On LAN 8-bit DIO Audio Line-in, Line-out, Mic-in Operating System: Linux or Windows 10 or Embedded Application Software: Lane Software, Antivirus Software (Client) link to Server CALS
Reliability and maintainability	Overall MTBF: 30,000 hrs. Overall MTTR: 0.5 hrs. – 1 hrs.

8.1.4 8-Port PoE Industrial grade rugged Switch with 2 Fibre Port

This device shall have the capability to provide adequate continuous power to each PoE equipment to meet the required performance, quality and reliability requirements.

1) Switch shall have minimum 8 nos. 10/100Base-T (with minimum 6 PoE ports with power budget of 60W) ports and additional 2 numbers of SFP uplink ports loaded with MMF Modules.

2) Shall have to be IP30 rated and shall work on up to 60°C temp in a sealed enclosure and should be DIN Rail mountable.

3) Switch shall be IEC 60068-2-6, IEC 60068-2-27, IEC 60068-2-47, IEC 60068-2-64, IEC 61000-4-5 and NEMA TS-2 compliant.

8.2 Toll collector terminal (TCT)

This specification lays down the general, functional and technical requirements for the toll collector terminal to be used as a sub-system in the toll lane equipment at all the toll lanes.

The specifications mentioned herein are minimum. The contractor shall design the Equipment as per the latest configuration available at the time of implementation.

Contractor has to consider total 40 lanes of MTHL while designing the Toll Collector Terminal.

The toll collector terminal shall consist of following equipment as minimum.

1) Toll Collector Touchscreen Display (TCD),
2) Toll Collector Keyboard (TCK)
3) Barcode Reader (BCR)
4) Biometric Fingerprint Reader
5) Receipt Printer (RPR)
6) Fake Note Detector
7) ID Scanner
8) Integrated Cash Drawer (ICD)

The Toll Collector terminal shall be the interface between the system and the toll collector. With the TCT the collector shall be able to input the data in the system and the TCD and RPR shall output the data from the TLC to the collector.

8.2.1 Toll collector display

The Toll Collector Display (TCD) shall be located on the Toll Collector's desktop and shall be screwed or bolted through the countertop, the position of the TCT shall be finalized with the Engineer at time of installation. Suitable mounting brackets manufactured from Stainless steel shall be provided to fix the screen to the desktop. All nuts and bolts are used to secure the TCT to the booth countertop shall be stainless steel. It shall be the system's interface to the Toll Collector, to display the status of transactions and status of the lane peripherals.

The technical specifications mentioned hereunder are minimum guidelines. The Contractor shall not deviate materially from the specifications specified.

Descriptions	Specifications
Display Type	Industrial grade Touchscreen TFT with Diagonal Size of 18.5" Minimum

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Installation and Fixing Details	Installed and screwed on the Toll Collector desk
Cables	Power Cable 1 x VGA Cable (15- pin HD D – Sub)
Cable routes	Power cable is terminated at the Lane Controller power distribution block via booth ducting VGA Cable is terminated to the SVGA Port at the TLC via booth ducting

8.2.2 Toll collector keyboard (TCK)

The keyboard on the Toll Collector terminal for Registration of toll operations shall be a programmable Industrial Grade keyboard. The industrial grade keyboard shall be fully programmable; this however must be approved by the Engineer before supply. These keys will be used to enter data of:

1) Staff Id number
2) Vehicle Classification
3) Type of Transaction
4) Accept/Cancel Transaction
5) Method of payments Selection
6) Numeric Keypad with backspace button for numeric corrections
7) Class Cancel
8) Bleed-off button
9) Violation Cancel/Accept Button
10) Simulation Button (Only for use during Maintenance Mode)
11) Alpha Numeric Keys in QWERTY format

Programmable keyboard features and specification shall be as follows:

- Shall have Powerful programming capability.
- Programming under DOS and Windows, multiple page, multiple level, whole range key content, time delay, position sense answer back code, etc.
- True spill-resistant design
- Optional blank key, double key for alternative key group layout
- Magnetic Card Reader
- 70 programming keys + 6 position control key
- Key top size: 18 mm x 22 mm for single key
- Interface: PS/2 or USB

- Dimension: Suitable for operation in the booth and placement on the work top / table

8.2.3 Contactless Smart Card Reader/Writer

The SC Reader is used to process read and write to the Contact less Smart card. The distance which the SC reader can access the smart card is approximately 5-10 cm.

Technical Specifications:

No.	Item	Specifications
2.	Installation and Fixing Details	Mounted on the toll booth panel
3.	Cables	USB cable (Power Through USB) Antenna cable: RG174 AU, 50 ohms
4.	Cable routes	USB cable is connected to the TCC via booth ducting. The Reader's antenna is built into the Reader housing.
5.	Material and finishes	PVC sheet with Epoxy painted
6.	Colour	Grey/Black
7.	Power Supply Requirement	5V DC
8.	Access for maintenance, modularity of construction	Modular design. Minor maintenance required
9.	Operating Temperature	-10°C to 70°C with heat dissipation of < 3.5 W
10.	Relative Humidity	5 % to 90 %
11.	Design Criteria	-Data Transmission Between MFGPR2: 106Kbaud -Card Operating Distance: 5-10 cm -Reading, calculating and writing operations: 200ms -Interface Protocol: According to KENT interface -Security Feature: According to KENT security Standards -MTBF: 30,000 hrs -MTTR: 0.25 hrs

8.2.4 Receipt printer (RPR)

The thermal receipt printer (RPR) shall be used to print receipts in the lanes. The printer shall be provided with the automatic advance function of the paper after printing so that the space for the first line of printing is aligned under the print head thus reducing the time

taken to produce a receipt. For design purpose it shall be assumed that receipts will be approximately 70mm in length. The Employer and project/plaza information will occupy space on the top. The area under this shall be used for printed data. The Contractor shall take the approval from the Engineer for the format of the receipt.

Technical specifications for the RPR shall be as follows:

Descriptions	Specifications
Installation and Fixing Details	Installed and fixed on the Toll Collector desk
Cables	- Power cable
	- Serial RS232C/ Parallel /USB
Cable routes	Power cable is terminated to the LC Termination Block via booth ducting. Data cable is connected to the LC
Access for maintenance, modularity of construction	The cover can be opened for maintenance. It also has paper sensors. Off-the-shelf product
Design Criteria	Print Speed: 47 LPS Print font: 9x17/12x24 Print column capacity: 56/42 columns
	Character size (mm): 0.99(W) x 2.4 (H) / 1.41 (W) x 3.4 (H) Paper dimension (mm): 79.5 + 0.5 (W) x 83 (diameter) Paper thickness: 0.06-0.07 mm Auto cutter life: 1.5 million cuts Real-time printer status: Auto status back (ASB) messages MCBF: 60 million lines MTBF: 360,000 hours, Overall MTTR: 0.25 hrs

8.2.5 Barcode reader

Desktop mounted fixed Barcode reader shall be installed in the toll booth on the TC worktop in lanes.

The motorists upon reaching the pay-axis of the lane will produce the entry receipt/return/ daily pass ticket he had collected from the TC at the first entry lane. The TC will place the ticket on the barcode reader which will read the 2D barcode printed on the ticket. The TLC will get the transit details from the barcode which are required to validate the validity of the ticket and authenticate based on the vehicle class (already selected by the TC while the vehicle was approaching) for processing of the transaction.

Contractor shall note that handheld/handy barcode scanner/readers will not be allowed in any case, even if the same is provided with the stand. Only desktop mounted BCR shall be supplied.

BCR Features and Specification shall be as follows:

- BCR shall be a High performance 2D omnidirectional laser scanner
- Shall have Programmable sleep mode; Reactivated by simple push of a button
- BCR shall perform Fully automatic scanning operation
- Depth of Field: 300 mm (EAN 0.33 mm / 13 mil, PCS = 90%)
- Scan Patten: 7 directions of scan field, 24 scan lines
- Scan Rate: 2400 scans/sec for omnidirectional scanning
- Interface: USB or Serial

8.2.6 Integrated Cash Drawer

Cash Drawer Integrated with TCT shall be installed on the TC worktop. The actual location of installation shall be decided and approved by the Engineer.

The cash drawer shall open as soon as the transaction is completed and receipt is generated by the TC after collecting cash from the user. The TC on receipt of cash from the user will press the receipt key on the keyboard. This action shall automatically open the cash drawer so that TC can place the money collected in the cash drawer and Bid the change.

Features

- Printer driven, powered by printer or CR port, support 12V/24V voltage range
- Heavy-duty cash drawer with Screw less design
- Ruggedized with reinforced steel and anti-scratch painting
- Large ball bearings design for smooth drawer slide
- Precision mechanical fitting to assure wobble-free operation
- Three position lock to ensure maximum security
- Receipt slot for revoked transaction
- Additional tray cover with lock
- Dimension: Suitable for operation in the booth and placement on the work top / table

8.2.7 Fake Note Detector

A fake note detector shall be installed in the booth on the toll collector worktop to enable the toll collector to check fake currency notes.

All bank notes (currency) have some security features that can be checked to stop counterfeiting and forgery.

To check the authenticity of the bank notes the toll collector should be familiar with their security features. Some security fibres, printing and threads are visible only under UV light.

The fake note detector shall be capable of checking banknotes of Indian Currency and shall have following features:

- Ultraviolet Detection

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- Water Mark Detection
- Magnetic Ink Detection

Description	Specifications
Dimensions	Suitable for mounting on the desk
Weight	OEM specific, light weight preferred
Power Supply	AC220V / 50Hz
Power Consumption	OEM Specific
UV Wavelength	345 - 400nM

8.2.8 Panic alarm system

The panic alarm system shall consist of foot switch in the toll booth, siren at the top of the toll booth and indicator at the toll plaza office. The system will be used by the toll collector to inform the toll office staff of the emergency.

The emergency footswitch is located in each toll booth under the toll collector's desk. Pressing the footswitch causes an alarm to be given to the auditor via the LSDU and siren. The siren is fitted on the top of the booth. The siren also is triggered by the incidents like violation and exceptional cases.

The specifications of footswitch shall be as specified below.

Descriptions	Remarks
Installation and Fixing Details	Mounted on the floor inside the tollbooth
Cables	- Power cable - Signal cable
Cable routes	- The power cable is laid inside the booth manhole before terminating to the TLC Termination Block. - Data cable is connected to the toll lane controller through the termination block
Material and finishes	Steel
Colour	Manufacturer's Original colour
Power Supply Requirement	220~240 V AC 50-60Hz with 10 A
Access for maintenance, modularity of construction	Modular Design, only plug and replace when failed
Operating temperature	10°C to 50°C
Reliability and maintainability	MCBF: 100,000 operations MTTR: 0.5 hrs

The specifications of siren shall be as specified below.

Descriptions	Remarks
Technology	Motor driven
Audible rating	112 dB at 1 meter
Environmental	Designed to meet IP54

8.2.9 Manual Booth Controller

In case of malfunctioning of toll lane controller, the manual booth controller is used to control the lane traffic manually.

It is normally in a locked mode and can be unlocked using key switch, when required. To operate the lane in a manual mode, manual booth controller needs to be unlocked.

The following equipment are controlled by the MBC:

- Overhead lane status display
- Automatic lane barrier
- Amber siren alarm

It shall be custom designed by the Contractor and the design shall be submitted in the technical evaluation of the bid.

8.3 Exempt Document Viewer Camera (EDV)

This specification lays down the general, functional and technical requirements of Exempt Document Viewer Camera to be used as a sub-system in the TMS at the Plaza.

Contractor has to consider total 40 lanes of MTHL while designing the EDV.

In case if any user of the toll road informs about the Exemption allowed to him owing to any office position in the government; the toll collector shall request for the ID card of the user; and shall present the same to the EDV.

EDV image shall be transmitted to the Audit room; and upon verification of the ID; the auditor shall allow the vehicle to pass from the lane without payment.

EDV image for verification shall be attached to the exempt transaction and shall be stored in the database for future audit.

8.3.1.1 Technical Specification

Descriptions	Remarks
Camera	2 Megapixel CMOS Alarm Pro Cube Camera
Image Sensor	1/2.8" Progressive Scan CMOS
Min. Illumination	0.01Lux @(F1.2,AGC ON), 0 Lux with IR 0.028Lux @(F2.0,AGC ON), 0 Lux with IR
Shutter Speed	1/3 s to 1/100,000 s
Lens	4mm@ F2.0, Angle of view: 85°

	(2.8mm, 6mm optional)
Lens Mount	M12
Day &Night	IR cut filter with auto switch
Digital Noise Reduction	3D Digital Noise Reduction
WDR	Digital WDR
Video Compression	H.264 / MJPEG
H.264 encoding level	Main Profile
Video Bit Rate	32Kbps~8Mbps
Audio Compression	G.711/G.722.1/G.726/MP2L2
Audio Bit Rate	64Kbps(G.711) /16Kbps(G.722.1)/16Kbps(G.726) /32-128Kbps(MP2L2)
Max. Resolution	1920 x 1080
Frame Rate	50Hz: 25fps(1920 × 1080), 25fps (1280 × 960), 25fps (1280 × 720) 60Hz: 30fps(1920 × 1080), 30fps (1280 × 960), 30fps (1280 × 720)
Image Settings	Rotate mode, Saturation, Brightness, Contrast adjustable by client software or web browser
Backlight compensation	Yes, zone optional
ROI	Support
Network Storage	Local storage: Built-in Micro SD/SDHC/SDXC card slot, up to 128 GB. NAS (Support NFS,SMB/CIFS)
Alarm Trigger	Intrusion detection, Line crossing detection, Motion detection, Dynamic analysis, Tampering alarm, Network disconnect , IP address conflict, Storage exception
Protocols	TCP/IP,ICMP,HTTP,HTTPS,FTP,DHCP,DNS,DDNS,RTP,RTSP,RTCP, PPPoE,NTP,UPnP,SMTP,SNMP,IGMP,802.1X,QoS,IPv6,Bonjour
General	One-key reset, Flash-prevention, dual stream, heartbeat, mirror, password protection, privacy mask, watermark, IP address filtering, Anonymous access
Standard	ONVIF, PSIA, CGI, ISAPI
Communication Interface	1 RJ45 10M/100M Ethernet interface
Alarm input	1

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Alarm output	1
Operating Conditions	-30 °C – 60 °C (-22 °F – 140 °F) Humidity 95% or less (non-condensing)
Power Supply	DC12V/PoE(802.3af)
Power Consumption	5.5W MAX.
PIR	Angle: 80°
Range: 10m	
IR Range	10 meters
Dimensions (mm)	72.3×89.9×131.3
Weight	400g(0.88lbs)

8.4 Toll Booth Camera

The Dome Camera fitted inside the booth is used for observing and/or recording the Toll collector Activities while performing the duty in the booth. This camera is installed in such a way that it clearly shows the Cash Transaction happening between the toll collector, the Vehicle Driver and shows the minor details of the vehicle being transacted.

Contractor has to consider total 40 lanes of MTHL while designing the Toll Booth Camera.

Technical Specifications

Descriptions	**Remarks**
Image Sensor	1/2.7" Progressive Scan CMOS
Min. Illumination	Color: 0.01 Lux @ (F1.2, AGC ON), 0.028 lux @(F2.0, AGC ON), 0 lux with IR
Shutter Speed	1/3 s to 1/100,000 s
Slow Shutter	Yes
Day & Night	IR Cut Filter
Digital Noise Reduction	3D DNR
WDR	120dB
3-Axis Adjustment	Pan: -30° to +30°, tilt: 0° to 75°, rotate: 0° to 360°
Lens	
Focal length	2.8, 4, 6 mm
Aperture	F2.0
FOV	2.8 mm: Horizontal field of view: 114°, Vertical field of view: 62°, Diagonal field of view: 135° 4 mm: Horizontal field of view: 86°, Vertical field of

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Descriptions	Remarks
	view: 46°, Diagonal field of view: 182° 6 mm: Horizontal field of view: 54°, Vertical field of view: 30°, Diagonal field of view: 62°
Lens Mount	M12
IR	
IR Range	Up to 10 m
Wavelength	850nm
Compression Standard	
Video Compression	Main stream: H.265/H.264 Sub stream: H.265/H.264 /MJPEG Third stream: H.265/H.264
H.264 Type	Main Profile/High Profile
H.264+	Yes
H.265 Type	Main Profile
H.265+	Yes
Video Bit Rate	32 Kbps to 16 Mbps
Audio Compression	G722.1/G711ulaw/G711alaw/G726/MP2L2/PCM
Audio Bit Rate	64Kbps(G.711)/16Kbps(G.722.1)/16Kbps(G.726)/32-192Kbps(MP2L2)
Smart Feature-set	
Behavior Analysis	Line crossing detection, intrusion detection
Face Detection	Yes
Region of Interest	Support 1 fixed region for main stream and sub-stream separately
Image	
Max. Resolution	1920 × 1080
Main Stream	50Hz:25fps (1920 × 1080, 1280 × 960, 1280 × 720) 60Hz: 30fps (1920 × 1080, 1280 × 960, 1280 × 720)
Sub Stream	50Hz: 25fps (640 × 480, 640 × 360, 320 × 240) 60Hz: 30fps (640 × 480, 640 × 360, 320 × 240)
Third Stream	50Hz: 25fps (1920 × 1080, 1280 × 720, 640 × 360, 352 × 288) 60Hz: 30fps (1920 × 1080, 1280 × 720, 640 × 360, 352 × 240)

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Descriptions	Remarks
Image Settings	Rotate mode, saturation, brightness, contrast, sharpness adjustable by client software or web browser
Image Enhancement	BLC/3D DNR
Day/Night Switch	Auto/Schedule/Day/Night/Triggered by Alarm In (-S model)
Network	
Network Storage	Support Micro SD/SDHC/SDXC card (128G), local storage and NAS (NFS,SMB/CIFS), ANR
Alarm Trigger	Motion detection, video tampering, network disconnected, IP address conflict, HDD full, HDD error, illegal login
Protocols	TCP/IP, ICMP, HTTP, HTTPS, FTP, DHCP, DNS, DDNS, RTP, RTSP, RTCP, PPPoE, NTP, UPnP™, SMTP, SNMP, IGMP, QoS, IPv6
General Function	One-key reset, anti-flicker, three streams, heartbeat, mirror, password protection, privacy mask, watermark, IP address filter
API	ONVIF (PROFILE S, PROFILE G), ISAPI
Simultaneous Live View	Up to 6 channels
User/Host	Up to 32 users 3 levels: Administrator, Operator and User
Client	iVMS-4200, Hik-Connect, iVMS-5200, iVMS-4500
Web Browser	IE8+, Chrome 31.0-44, Firefox 30.0-51, Safari 8.0+
Interface	
Audio (-S model)	2 Inputs: line in (3.5 mm) or mic in (built-in microphone), 1 Output: line out (3.5 mm), mono sound
Alarm (-S model)	1 Input: Alarm in (3.5mm) 1 Output: Alarm out (3.5mm)
Communication Interface	1 RJ45 10M/100M self-adaptive Ethernet port
On-board storage	Built-in MicroSD/SDHC/SDXC slot, up to 128G
SVC	Support H.264 and H.265 encoding
Audio (-S model)	
Environment Noise Filtering	Yes

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Descriptions	Remarks
Audio Sampling Rate	16 kHz, 32kHz, 44.1kHz, 48kHz
General	
Operating Conditions	-30 °C to +60 °C (-22 °F to +140 °F), Humidity 95% or less (non-condensing)
Power Supply	12 VDC ± 25%, PoE (802.3af, class 3)
Power Consumption and Current	12 VDC, 0.7 A, max. 8.5W, Φ 5.5mm coaxial plug power PoE (802.3af, 36V to 57V), 0.3 A to 0.1 A, max. 10W
Protection Level	IK08, IP66
Material	Front cover: plastic, Bottom base: metal
Dimensions	Φ110 mm × 56.4 mm (Φ4.3" × 2.2")
Weight	Camera: Approx. 400 g (0.9 lb.)

8.5 ETC Handheld Terminal

The ETC Handheld terminal shall be used to read and process the FASTag/Local Tag in the lanes only in case the respective lane ETC overhead reader is offline/down.

Contractor has to consider total 40 lanes of MTHL while designing the ETC Handheld Terminal. Justification shall be submitted for the quantity considered by the contractor along with the technical proposal.

The specifications of the ETC Handheld Terminal (EHT) shall be as follows:

Description	Specifications
Physical	Handheld Terminal suitable for single hand operation
Interface	USB, Wi-Fi and Bluetooth
Capabilities	UHF and Liner Barcode Scanning
Memory Storage	Minimum 2 GB
Environmental	IP 65
Alerts	Buzzer on Tags and barcode reads
RF Out put	up to 30 dBm
Frequency	UHF 865 to 867 MHz, WPC Approved
Power	Battery Lithium, suitable to operate the EHT for 4 hours
key Pad	Alpha Numeric / touch
Drop test	1.2 meters concrete drop tested

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Weight	Not more than 300 gm Suitable for single hand operation for long shifts
Battery Standby Time	12 Hours
Read range	2 meters or higher for Fastag / Local tag (Installed)
Accessories	Charger, Interface Cable and Carry Case (Waist Mount for field usage)

The handheld shall have in-built barcode reader. Portable pocket (waist mount) thermal receipt printer shall be connected with the handheld through Bluetooth or USB.

8.6 Fingerprint Scanner for Login

The fingerprint scanner shall be used at the TCT to authenticate the login of the toll collector.

Contractor has to consider total 40 lanes of MTHL while designing the Finger Print Scanner for login.

The Scanner shall be connected to the TCL; which shall verify the finger print signatures with the central or the local database

Description	Remarks
Optical Sensor	OPP06
Size (mm)	54 x 74 x 82.6 (With Stand) 27.4 x 40.5 x 73.7(Without Stand)
Image Size	248 x 292 pixels
Resolution	500 DPI
Interface	USB 1.1/2.0 High/Full Speed
Image acquisition time	Full Speed: Avg. 500 msec. High Speed: Avg. 300 msec.
Operating Temperature	-20~60 ℃
Operating Humidity	< RH 90%
Power Source	USB BUS Power
OS	Windows2000 or higher, Windows Server 2003/2008, Linux Kernel 2.6.x
Certificated	KC, UL, CE, FCC

8.7 ETC RFID Reader/ETC Transceiver

The lanes equipment shall have one ETC Transceiver reader and antenna. The ETC

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Transceiver shall be mounted on the canopy or on a pole in the island. In case of canopy, the reader shall be mounted at least 5.5 meters above the finished road level. The Contractor shall provide cantilever pole (if required), brackets, fixtures and other accessories necessary for the installation of the readers. The design of cantilever poles, brackets etc. shall be approved by the Engineer before the supply.

Contractor has to consider total 40 lanes of MTHL while designing the ETC RFID Readers.

The specifications for the ETC Transceiver (ET) shall be as follows:

Description	Specifications
RF / Radio:	
Frequency	UHF, 865 to 867 MHz (applicable certification from WPC)
RF Power	1 Watt maximum
Reading Zone	Optimum for single lane operation, with no cross reading across and along the lanes (CRITICAL)
Antenna	Liner polarized, with maximum 40 x 40 Degree.
Protocol	EPC Gen 2, EPC Gen 2 V2.0 and ISO 18000-6C, 63
Compliances	ETA (WPC) HCC, ETSI, WEE and ROHS
Hardware & Software:	
FLASH / RAM	2 GB / 1 GB or Higher
Visual Status Indicators:	Power, Transmit/Fault, Tag read and Receiver Fault or Configurable
RF Operations	Designed to keep always on / Transmitting mode.
Environmental	IP 65 or Better
Functional Characteristics:	
Air Interface & Adaptive Noise	The Transceiver technology employed should have the capability to optimize read rates for the vehicle identification application and adapt to instantaneous noise and interference level
Features	
Application capability	1. Should have read reliability exceeding 99.5% in the standard scenario.
	2. Diagnostic and Reporting Tools
Upgradeability	The firmware should be upgradable to support future protocols.
Transaction Capability	Reading of Tag & EPC memory for at least 2 Tags per second for a moving vehicle with a speed limit of 80 km/h.

8.8 Overhead traffic light (OHTL)

The overhead traffic light (OHTL) shall be mounted on the leading edge of the canopy covering the toll lanes above the centre of the lane. The purpose of the OHTL is to indicate

to the user whether the toll lane is open or closed for the processing of vehicles. A red cross aspect shall be used to signal that the lane is closed, whilst a green arrow aspect shall be used to indicate that the lane is open to traffic.

Contractor has to consider total 40 lanes of MTHL while designing the OHTL.

The overhead traffic light shall meet the following requirements:

1) The peak minimum luminous intensity of the red aspect shall be at least 250 cd and for green aspect shall be at least 300 cd.
2) Signs shall be sufficiently bright and directed to indicate to a motorist approaching the toll plaza, at a distance of 300m on a bright cloud free day that toll lanes are available for use.
3) The aspects shall be at least 300mm in height.
4) The sign shall be fitted with a sun-hood to screen the effect of the sunlight.
5) The enclosure of the OHTL shall be constructed from a corrosion resistant material. The enclosure shall have the environmental protection of IP65.
6) The system shall have night dimming function.
7) It should be possible to control OHTL from LSDU even if the lane computer is not working or power off and when the lane is connected to the network.

Technical Specifications:

Descriptions	Remarks
Dimension	Approx. 740mm x 540mm x370mm
Weight	Shall be less than 20 kg
Installation and Fixing Details	Fixed mounting on toll canopy
Cables	Power cable
Cable routes	Power cable is laid inside the duct at toll Pillars. The cable is then laid inside the booth manhole before terminating to the Termination Block.
Material and finishes	Polycarbonate
Lens Colour	Red and Green with black cover
Power Supply Requirement	230/240Vac 50/60 Hz single phase
Operating Temperature	0° C to 50° C
Relative Humidity	5%-90%
Power Consumption	10 W typical at 25°C
Protection against the effects of lightning	Covered under LC Surge Protection
Reliability and maintainability	MTBF: 30,000 hrs

	MTTR: 0.25 hrs - 0.75 hrs

8.9 User fare display (UFD)

The User Fare Display (UFD) shall be a LED display panel controlled automatically by the lane computer. It shall indicate to the road user the category of the vehicle and the amount payable/ balance in prepaid amount, low balance warning, public relations and seasonal messages.

Contractor has to consider total 40 lanes of MTHL while designing the UFD.

The user fare display shall be of LED type. The detailed technical specifications shall be as per the specifications below.

Descriptions	Remarks
Display lines	2 lines with 13 Characters each
Character height	120 mm minimum
Weight	Shall be less than 5.0 kg
Type of protection	IP55
Environmental	Temperature: 0°C to 65°C
Power Supply Requirement	240VAC at 20W max.
LED type	Ultra-bright AlInGaP LEDs 8000mcd at 20mA, 300 viewing angle Suitable for outdoor condition under bright sunlight
Communication Interface	RS232, USB or standard interface protocol
Reliability and maintainability	MBTF: 30,000 hours MTTR: 0.25 hrs
Installation	Self-standing on pedestal Cables inside pedestal

The user fare display unit shall be installed at the suitable location on the toll island and the face shall be directed towards the position of driver. UFD shall be able to give the health feedback for diagnosis in real time.

8.10 Lane traffic light (LTL)

Lane traffic light is the LED based traffic signal installed on the toll island towards the exit side. It shall be connected to the lane controller. The traffic light shall have two aspects of red and green. The red indicates that the motorist has to stop and pay the toll. After successful processing of transaction, the traffic light turns green and indicates the motorists to proceed towards the exit of the lane. Once the exit of the vehicle is confirmed by the detector of AVC or other device, the traffic light shall turn red for the next vehicle.

Contractor has to consider total 40 lanes of MTHL while designing the LTL.

The traffic light system shall work in synchronization with the boom barrier.

Lane traffic light shall meet the following technical specifications:

Descriptions	Remarks
Size of the traffic light	Approx. 200 mm diameter with sun visor
Light source	LED
Aspect colour	Green and red
Housing Material	Corrosion resistant material
Environmental protection	IP65
Intensity	70 CD min.
Environmental	Operating Temperature: 0°C to 65°C Humidity: 5 % to 95 % non-condensing
Power Supply	230 +/- 10% V AC

8.11 Automatic lane barrier (ALB)

This specification lays down the general, functional and technical requirements of automatic lane barrier to be used as a sub-system in the toll management system at the Toll Plaza.

Contractor has to consider total 40 lanes of MTHL while designing the ALB.

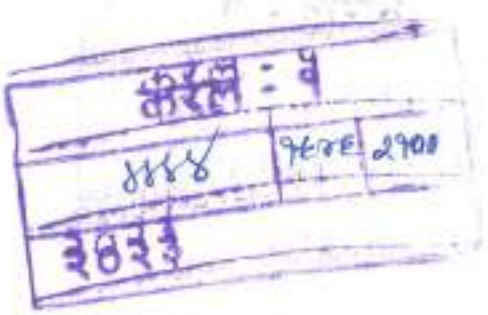
The barrier shall be used to control the traffic through the lane. The operation of barrier is linked to the LC-IPC. It allows the vehicle to pass through after a successful transaction has happened at the lane.

The system consists of a fixed housing and a movable arm with a high impact breakaway device or provision. The housing shall contain the motor and control units along with the integrated metal detectors for vehicle detection purpose.

The housing shall be installed on the right side of the traffic direction, after the booth on a concrete base as per the drawings included in the Employer's Requirement Part D: Drawings.

The automatic lane barrier shall meet the following technical specifications:

Descriptions	Remarks
Dimension	Max 400 mm (L) x 400 mm (W) x 1100mm (H)
Weight	Max 60 kg (without boom)
Installation and Fixing Details	Fixed mounted on the toll island
Cables	- Power Cable - Data Cable
Cable routes	- Power cable is terminated to the Termination Block via island ducting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	- Data cable is connected from the termination block to the ALB Controller.
Boom Length	3000 mm
Boom Attachment	Collapsible
Duty Cycle	100%
Open and Close Time	0.6 Sec
Colour	Boom: Red and white Housing: Vendor Specific
Power Supply Requirement	240VAC 50/60Hz single phase
Operating Temperature	-20° C to 50° C
Relative Humidity	5%-90%
Reliability and maintainability	- MTBF: 2 Million Cycles or 2 years excluding barrier arm holder - MTTR: 0.25 hrs - 0.75 hrs

The Barrier shall be such that it can be stalled & reversed at any position and programmed to avoid bouncing & swinging out at end positions.

8.12 Incident capture & License Plate Capture Camera for lanes

The incident capture camera shall be installed at the suitable location on the toll island directed to the lane. It shall be used to capture the image and video of the vehicle on the lane from behind in case of incident.

Contractor has to consider total 40 lanes of MTHL while designing the Incident capture & License Plate Capture Cameras.

The camera shall be used to capture images and video clips of the vehicles in the following incidents.

1) In case of class discrepancy between the classes detected by the AVC and that entered by the toll collector.
2) Exempt users: all transaction of vehicles with exemption privilege.
3) Offending vehicles / violations
4) When the toll collector activates the panic alarm footswitch.
5) Vehicles with cashless payment or FASTag.
6) All transactions with alarms

License plate capture camera shall be used to capture images of the vehicle registration plate. The installation shall be suitable to capture the plates for the small vehicle like car and also for the bigger vehicles like trucks and buses. This camera shall be triggered by the vehicle presence loop detector installed at the Payment Axis.

The cameras shall be installed inside the housing at the suitable height above the surface of the lane to be decided by the Engineer on a pole. The IC camera shall capture images and record videos of the incidents and LPR camera shall capture clear images of the license plate. The vehicle IC images & Video captured shall be of the backside portion of the vehicle and LPR shall capture the images from the front side of the vehicle.

General requirements:

1) The housing will be equipped with a hood to protect the camera under direct sunlight.
2) Protection: IP65.
3) The stand of the lane camera shall be made of steel that shall not swing or twist under gutter speed of strong wind. The stand will be protected from corrosive environmental conditions.
4) The LPR camera shall not focus on Light during nighttime; and shall be able to capture LPR images clearly at both day light and night time also.
5) IR Illuminators: Removable IR-cut filter for day & night function shall be used.
6) LPR Camera should have Varifocal Lens.

The stand for the IC and LPR cameras shall be made of steel that shall not swing or twist under gutter speed of strong wind. The stand shall be protected from corrosive environmental conditions.

Technical Specifications:

Item	Specifications
Camera	
Image Sensor	1/2.8" Progressive Scan CMOS
Min. Illumination Colour	0.01 Lux @(F1.2, AGC ON), 0.028Lux @(F2.0, AGC ON), 0 Lux with IR
Shutter Speed	1/3 s to 1/100,000 s
Slow Shutter	Yes
Auto-Iris	No
Day & Night	IR Cut Filter
Digital Noise Reduction	3D DNR
Wide Dynamic Range	120 dB
Angle of adjustment	Pan: 0° to 360°, tilt: 0° to 100°, rotation: 0° to 360°
Lens	
Focal Length	2.8 to 12 mm

Item	Specifications
Aperture	F2.0
Focus	-Z: Auto Without –Z: Manual
FOV	Horizontal FOV: 99.6° to 35°, vertical FOV: 53.5° to 20°, diagonal FOV: 118.6° to 40.2°
Lens Mount	Φ14
IR	
IR Range	Up to 30 m
Wavelength	850nm
Compression Standard	
Video Compression	Main stream: H.265/H.264 Sub-stream: H.265/H.264/MJPEG
H.264 Type	Baseline Profile/Main Profile/High Profile
H.264+	Main stream supports
H.265 Type	Main Profile
H.265+	Main stream supports
Video Bit Rate	32 Kbps to 8 Mbps
Audio Compression (-S)	G.711/G.722.1/G.726/MP2L2/PCM
Audio Bit Rate (-S)	64Kbps(G.711)/16Kbps(G.722.1)/16Kbps(G.726)/32-192Kbps(MP2L2)
Smart Feature-set	
Behaviour Analysis	Line crossing detection, intrusion detection
Face Detection	Yes
Region of Interest	1 fixed region for main stream
Image	
Max. Resolution	1920 × 1080
Main Stream	50Hz: 25fps (1920 × 1080, 1280 × 960, 1280 × 720) 60Hz: 30fps (1920 × 1080, 1280 × 960, 1280 × 720)
Sub-Stream	50Hz: 25fps (640 × 480, 640 × 360, 320 × 240) 60Hz: 30fps (640 × 480, 640 × 360, 320 × 240)
Image Enhancement	BLC/3D DNR
Image Settings	Rotate mode, saturation, brightness, contrast, sharpness adjustable by client software or web browser

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Item	Specifications
Target Cropping	No
Day/Night Switch	Day/Night/Auto/Schedule/Triggered by alarm in (-S)
Network	
Network Storage	Support built-in microSD/SDHC/SDXC card (128G), local storage and NAS (NFS,SMB/CIFS), ANR
Alarm Trigger	Motion detection, video tampering, network disconnected, IP address conflict, illegal login, HDD full, HDD error
Protocols	TCP/IP, ICMP, HTTP, HTTPS, FTP, DHCP, DNS, DDNS, RTP, RTSP, RTCP, PPPoE, NTP, UPnP™, SMTP, SNMP, IGMP, 802.1X, QoS, IPv6, Bonjour
General Function	One-key reset, anti-flicker, heartbeat, mirror, password protection, privacy mask, watermark, IP address filter
Firmware Version	V5.5.6
API	ONVIF (PROFILE S, PROFILE G), ISAPI
Simultaneous Live View	Up to 6 channels
User/Host	Up to 32 users 3 levels: Administrator, Operator and User
Client	iVMS-4200, Hik-Connect, iVMS-5200, iVMS-4500
Web Browser	IE8+, Chrome 31.0-44, Firefox 30.0-51, Safari 8.0+
Interface	
Audio (-S)	1 input (line in), 1 output (line out), mono sound
Communication Interface	1 RJ45 10M/100M self-adaptive Ethernet port
Alarm (-S)	2 inputs, 2 outputs
Video Output (-S)	CVBS
On-board Storage	Built-in micro SD/SDHC/SDXC slot, up to 128 GB
SVC	H.264 and H.265 encoding support
Reset Button	Yes
General	
Operating Conditions	-30 °C to +60 °C (22 °F to +140 °F), humidity 95% or less (non-condensing)
Power Supply	12 VDC ± 25%, Φ 5.5 mm coaxial plug power PoE (802.3af, class 3)
Power Consumption and Current	-Z: 12 VDC, 0.9 A, max. 11 W PoE: (802.3af, 36V-57V), 0.4 A to 0.2 A, max. 12.9 W Without –Z: 12

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Item	Specifications
	VDC, 0.6 A, max. 7W PoE: (802.3af, 36V-57V), 0.3 A to 0.1 A, max. 9 W
Protection Level	IP67
Material	Metal
Dimensions	Φ 105 × 294.5 mm (Φ 4.1" × 11.6")
Weight	Camera: approx. 1050 g (2.3 lb.) With package: approx. 1500 g (3.3 lb.)

8.13 Manual lane barrier (MLB)

This specification lays down the general, functional and technical requirements of Manual Lane Barrier (MLB) unit to be used to manually control the entry to the toll lane.

Contractor has to consider total 40 lanes of MTHL while designing the MLB.

A manually operated lane barrier (MLB) shall be provided at the entrance to all entry and exit lanes to reinforce the display of the Overhead Traffic Light (OHTL) when the lane is closed.

The MLB shall comprise a pedestal unit mounted on the raised island between the toll lanes, a horizontally swinging arm painted in the specified colours carrying and a 450mm diameter reflective "no entry" sign.

When in the "closed" position, the barrier shall present a physical obstruction across the entire width of the lane.

The barrier shall be robustly constructed with good access to the mechanism for maintenance. The mechanism shall be properly protected from weather, spray and water from hoses which will be used for lane and booth cleaning.

All maintenance covers shall be removable by special key. The barrier arm shall not lose its shape in case of any damage by any wayward vehicle.

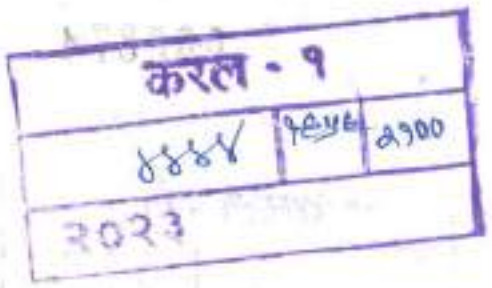
The barrier shall have end of travel buffers to prevent the frangible joint from breaking when the barrier is opened or closed roughly.

The barrier shall be properly counterbalanced to allow easy operation, for example by female connectors, and shall incorporate a locking device or other means of retaining the barrier in the fully open and fully closed condition. With such locking devices, the barrier shall not move in a windy weather condition.

Barrier arms for 3.5-meter-wide toll lanes shall be 4000 mm long and those for 5.5 meter wide lanes at each plaza shall be 6000 mm long. Mounting pedestals and pivots for all lanes shall be identical and interchangeable.

8.14 Flashing light

A flashing light shall be provided at the nose of island to be used to prevent vehicles from hitting the island under adverse weather conditions.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Contractor has to consider total 40 lanes of MTHL while designing the Flashing Lights.

The flashing light shall meet the following requirements:

Item	Specifications
Colour	Yellow
Aspect Size	At least 300 mm
Flashing mechanism	Rotation or flashing of bulb
Flashing rate	Approx. 160 times / min
Control	Manual

8.15 Automatic vehicle classification system (AVC)

This specification lays down the general, functional and technical requirements of Automatic Vehicle Classifier (AVC) System to be used as a sub-system in the toll management system.

Contractor has to consider total 40 lanes of MTHL while designing the AVC.

The specifications mentioned herein are minimum. The contractor shall design the Equipment as per the latest configuration available at the time of implementation.

The AVC system shall be able to distinguish between classes as defined by Employer. This class information shall be transmitted to the lane computer, and simultaneously to the Lane Status Display Unit database system, on completion of the post AVC classification. The lane computer shall check that this information matches the classification entered by the toll collector. If there is a discrepancy between the two classifications, the incident capture camera shall be triggered to capture a digital image and 5 second video of the vehicle. The digital image and discrepancy information shall be communicated to the audit workstation for further processing by the toll supervision staff.

The classification sensors shall be the combination of the following types:

1) Laser Profiler
2) Inductive loops

The use of in Road sensors as treadles shall not be accepted.

The AVC shall have the following accuracy for the standard vehicles:

1) For vehicle counting: 99.5 %
2) For vehicle classification: 98.0 %

The minimum specifications for Laser Profiler shall be as follows,

1) The laser profiler shall be canopy / island mounted and one device shall cover one lane.
2) The device shall be low weight to enable easy mounting in the canopy / island

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3) Rugged housing with enclosure rating of IP 67
4) Object blanking shall be possible, and Contour of surroundings shall be used as a reference.
5) All outputs shall be potential-free (like relay contacts)
6) It shall be possible to parametrize the Measurement output (time stamp etc.)

Technical Specifications

Item	Specifications
Technology:	laser scanner, time-of-flight measurement
Sensor range:	max 65 m 10 m @ 2% remission factor, 30 m @ 10% remission factor
Number of planes:	LZR®-U920: max. 4*
Number of points/plane:	Max. 274*
Angular resolution:	Max. 0.3516 °*
Angular coverage:	Max. 96 °*
Rotating speed:	900 turns/min
Scanning frequency:	LZR®-U920: 15 Hz
Remission factor:	> 2 %
Laser emission characteristics:	Wavelength 905 nm; max. output pulse power 75 W (CLASS 1) Wavelength 650 nm; max. output CW power 3 mW (CLASS 3R)
Supply voltage	10-35 V DC @ sensor side
Power consumption:	< 5 W
Peak current at power-on:	1.8 A (max. 80 ms @ 35 V)
Serial communication: Type Interface Communication mode Transmission speed Topology Symbol coding File type	 asynchronous RS 485 half-duplex 460800 bit/sec (max: 921600 bit/sec) point to point 1 start bit, 1stop bit, no parity bit 8 bits
Cable length:	+/- 160 mm
Connector:	M12 male, 8 poles

Item	Specifications
Input: Max. contact voltage: Voltage threshold:	1 opto-coupler (galvanic isolated - polarity free) 30 V DC (over-voltage protected) Log. H: >8 V DC; Log. L: <3 V DC
LED-signal:	2 bi-coloured LEDs: function status; 1 blue LED: power-on status; 1 orange LED: error status
Dimensions:	125 mm (D) x 93 mm (W) x 76 mm (H)
Protection degree:	IP65
Temperature range:	-30 °C to +60 °C if powered; -10 °C to +60 °C unpowered
Humidity:	0-95 % non-condensing
Vibrations:	< 2 G

Each lane shall be equipped with a dedicated AVC controller that interfaces to classification sensors.

AVC Controller Specifications:

Descriptions	Specification
TYPE	Industrial grade fan-less Compact Embedded Computer
Installation	DIN-rail mounting inside the Toll Lane Controller
Cables	Power Cable, UTP cable
Material and Finishes	Aluminum housing, As per manufacturer's specifications
Dimensions	80mm (H) x 300mm (W) x 150mm (D) max
Colour	Manufacturer's Original Colour
Power Supply	Operating: 12V, 50 Hz. With power adaptor, 15W max. Power consumption
Access for maintenance, modularity of construction	Minimal maintenance, off-the-shelf product
Environmental Considerations	-20° C to 60° C Operating Temperature, 95% @ 40° C (non- condensing)
Design Criteria	**8th Generation Intel® Core™ i5-8365U (NUC8v5PN)** 1.6 GHz to 4.1 GHz Turbo, 4 Core, 8 Thread 6MB Cache, **25W Intel® UHD Graphics 620**, 300 MHz – 1.10 GHz (1 X 8 GB) DDR4 Synchronous Dynamic RAM 500 GB SDD HDD Supports CompactFlash socket for type I/II CompactFlash disk

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	Mini PCIe expansion for communication module, i.e. HSDPA, WLAN Dual display and supports for wide screen with high resolution 2 x GbE, 6 x USB 2.0 and 4 x COMs ports Serial port support RS-485 auto flow control 2 X Ethernet RJ-45 network port, 10/100/1000 Mbps Ethernet controller, support Wake On LAN 8-bit DIO Audio Line-in, Line-out, Mic-in Operating System: Linux or Windows 7 or Embedded Service Pack 2 or better Application Software: Lane Software, Antivirus Software (Client) link to Server CALS
Reliability and maintainability	Overall MTBF: 30,000 hrs. Overall MTTR: 0.5 hrs. – 1 hrs.

In case of network failure, the AVC system shall function independently and store all data locally on a storage device. The data shall be sent to the independent database system via a separate data communication link which is different from the Toll Lane Controller.

The system shall be able to detect a vehicle moving in wrong direction.

AVC processing unit

1) Shall be a real-time processing unit
2) Shall be the trigger source for Incident Capture Lane Camera system
3) Shall have a local storage device capable of storing data for a period of at least 7 days.
4) Shall have a standby power supply capable of operations for a period of at least 7 hours

8.16 RFID tag for ETC

The functional and physical specifications of FASTag are amended by the Gazette of India: Extraordinary issued on 7th November, 2017. The amended specification is cited below as reference.

Contractor has to consider total 1000 Tags or MTHL project while designing the system.

Descriptions	Remarks
Power	Tags are passive
Frequency	UHF 869 MHz to 960 MHz as per EPC Gen 2 standards
Data transfer rate	At least 512 kbps under ideal conditions and 64 to 512 kbps under field conditions
Protocol	EPC Gen 2. ISO 18000-6C

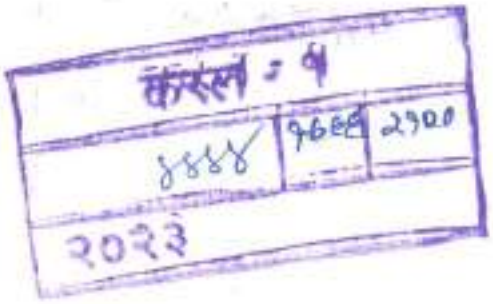
Descriptions	Remarks
Dimensions (including the substrate/backing)	Tag dimensions as per individual Automobile Manufactures' current size, maximum are occupied on the windshield shall be 50 Sq. cm till new update direction issued.
Material	Printed or etched
Physical printing of Tag ID on the Tag	Need to print QR Code as per ISO/IEC18004:2015 standard. Also, the Tag ID shall be physically printed on the Tag using the Hexadecimal numbering system and shall be adequately clear for easy visual recognition. The details regarding contents embedded within the QR Code shall be provided by National Highway Authority of India (NHAI) and may be updated on a regular basis.
Tamper Proof RFID Label	The tags should be RFID Tamper Proof Label specially designed for tagging directly to a surface, such as Glass (windshield) of an automobile. Any attempt to tip or tamper the label (tag) should result in disabling the functionality of the tags to insure a unique one to one relationship between the tag and the vehicle thereby preventing unauthorized tag removal and transfers. Such features of the RFID label should result in following actions: - Destroy Damage the Antenna Break the chip-antenna connection. The manufacturing process, construction of tags and associated materials should ensure reliable tamper indication even when sophisticated tamper methods of Mechanical attack (e.g. Razor Blades, Knives etc.), Chemical Attack (using Corrosives, Solvents etc.) and Thermal attacks are employed
Tag Read Range	6m (min) RFID Tag (max tag size 50sq. cm) fixed on Vehicle Windshield
Printing & Design	As defined by NHAI from time to time.

8.17 Vehicle Separator with loop detector system

The Vehicle Separator with loop coil system shall be used to detect the queuing of the vehicle at entry locations in the ETC lane. Two Vehicle Separator shall be installed on one side island of the ETC lane at a proper distance apart, to detect the direction and separation of vehicles.

A loop coil shall be installed in the lane along the Vehicle Separator and the inductive loop detector shall be installed in the ETC lane controller.

Contractor has to consider total 40 lanes of MTHL while designing the Vehicle separator and Loop Detector system.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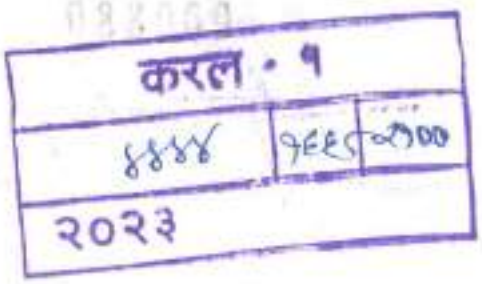
The presence of vehicle shall be detected by the loop coil and the exit of the vehicle shall be detected by the Vehicle Separator. Both components shall complement each other for the overall output of the sub-system.

Technical specifications for the Vehicle Separator shall be as follows:

Descriptions	Remarks
Technology	LASER scanner, time-of-flight measurement
Max. detection range	Max. 5.5m*5.5m (4m@5% reflectivity)
Opening angle	900
Angular resolution	0.23° (400 spots within 90°)
Protection degree	IP66 (EN 60529)
Temperature range	-30°C to +60°C if powered
Humidity	0-95% non-condensing
Norm conformity	IEC 60825-1; EN 60950-1; EN 61000-6-2; EN 61000-6-3; EN 60529; EN 50121-3-2

Technical specifications for the inductive loop detector shall be as follows:

Descriptions	Remarks
Detection method	Change in inductance
Sensitivity	Constant on the entire inductance range
Loop inductance	Min = 15 µH Max = 1500 µH
Mode	Omni-directional
Reaction time	Constant on the entire inductance range, independent from frequency. Typically 45 msec.
Power requirement	< 1.5 VA
Temperature range	Stock: -50°C to +80°C Use: -30°C to +70°C.
Protection	IP 40
Adjustments	Sensitivity and frequency
Output	Detection / Error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9. Weigh in Motion System

9.1 Medium Speed Weigh in Motion System (MSWIM)

The Medium Speed **Weigh-in-Motion System** shall be provided at each entry lane of MTHL.

Total of 20 lanes shall be installed with WIM functionality.

The **Weighing** Platform shall be heavy duty and robust. It should be suitable for **Indian** conditions as heavy overloading is observed on the highways in India.

Below specifications shall be used only for reference; and the contractor shall propose the latest technology for WIM functionality at the time of implementation of the MTHL Project.

WIM system shall be installed along with Vehicle Separator in the form of sensors and Loop detector of to form a queuing system at the time of toll collection.

9.2 Specifications of MSWIM

No	Item	Specifications
1	Bending Plate Size	1500mm X 700mm (For Normal Lane)
2	Bending Plate thickness	32mm
3	Number of Bending Plates per lane	2 Nos. (For Standard 3m wide lane or 3.5m extra wide lane)
4	Capacity of the platform	30 Ton/Axle
5	In Motion Accuracy	± 10% FSR up to speed 50 Km/h
6	Capacity of Bending Plate	15t
7	Bending Plate mV Output	0.7+/-0.1mV/V
8	Safe Overload - Bending	120%
9	Protection class for Bending	IP 68

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No	Item	Specifications
10	Protection class for	IP 67
11	Load Cell Junction Box	Aluminum Die cast enclosure with IP 66
12	Communication	TCP/IP (Built-in Ethernet Port)
13	Calibration	Factory calibrated
14	Re- calibration/Stamping &	Every 12 months

9.3 Static Weigh Bridge

The Static Weigh Bridge shall be provided at each entry lane canopy of MTHL.

Total of 4 Static Weigh Bridges shall be installed.

In case if the user does not agree to the Weight obtained by the WIM installed in the lanes; to solve the dispute; the vehicle shall be diverted to the Static Weighbridges for the resolution.

Upon weighing the vehicle at the Static Weighbridge; if the weight is found more than the preset limit; penalty shall be collected from the user.

If the weight at the static weighbridge is found to be in limits allowed, the vehicle shall be allowed to pass without penalty; and after collecting the proper toll from the same vehicle.

Contractor shall propose along with his design; the type of Static weighbridge proposed whether with pit or pitless and also shall obtain the approval from the engineer prior to construction phase.

9.4 Specifications of Static Weigh Bridge

Below specifications shall be used only for reference; and the contractor shall propose the latest technology for Static Weighbridge functionality at the time of implementation of the MTHL Project.

No.	Descriptions	Remarks
1	Capacity	120MT
2	Resolution	± 10 Kgs
3	Platform dimensions	18mtr x3mtr
4	Load Cells	/ 6 Nos. in case of Composite platform
	Load Cell	
5	Make	Flintec- RC3
6	Weighing Capacity	40T

No.	Descriptions	Remarks
7	Housing Material	Stainless Steel 17-4 PH (1.4548)
8	Type	Compression
9	Rated Output	2+0.1 % mV/V
10	Non –Linearity	< +0.0166% RO
11	Combined error	< +0.0200% RO
12	Hysteresis	<+0.0400
13	Maximum usable load without	200% Emax
14	Creep after 30 minutes	< + 0.0166 % RO
15	Protection Class	IP 68 (up to 2m water depth) / IP 69K
16	Insulation Resistance (100	> 5000Ω
17	Compensated temperature	-10...0+40°C
18	Operating temperature range	-40.....+80 (ATEX -40.....+80°C
19	Sealing	Complete hermetic sealing ;cable entry by
20	Mandatory approval	OIML ,NTEP
21	Environmental	Dust and splash proof
	Digital Weight Indicator	
22	Load Cell Excitation	15VDC
23	Load Current	350mA. (6 x 350 Load cells or (12 x 700 Load
24	Interconnection Cable	6 Wire Shielded cable (Long distance
25	Analog Signal Input Range	3mV to 40mV
26	Analog Signal Sensitivity	0.6µV/division
27	A/D Counts	700000 Counts
28	Conversion Rate	50/ Second typical
29	Calibration Mode	Software Calibration through Keypad
30	Display Increments	1/2/5/10/20/50/100
31	Display Cycle	100mS
32	Gain Drift	6PPM/°C
33	Zero Drift	10PPM/°C
34	Display	Digit Fluorescent green color Display
35	Keyboard	20 keys (10 of which are compoundly used

No.	Descriptions	Remarks
36	Serial Communication	RS232C Baud Rate (Selectable):
37	Clock	In-built RTC
38	Security	Password Protection for Calibration
39	Work- Environment	Power Supply: 180-240 VAC, 49-
40	Dimension	310x195x186(mm). Aluminum Die cast dust
41	Weight	3 Kg Approx.

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10. Specification for Toll Plaza Equipment

10.1 Toll Plaza System (TPS) server

10.1.1 General

This specification lays down the general, functional and technical requirements of Toll Plaza System Server to be used as a sub-system in toll management system.

Contractor has to consider two TPS locations of MTHL while designing the system.

The specifications mentioned herein are minimum. The contractor shall design the Equipment as per the latest configuration available at the time of implementation.

The TPS which is a Logical name shall physically consist of High Availability configuration having 2 servers in HA mode and the backup server. All these three physical servers shall follow same specifications as mentioned below and any configuration equivalent or better than the mentioned shall be supplied. In no case, any inferior configuration shall be offered by the contractor.

The server system is placed at each of the interchange plaza building at the server room. The plaza server shall be connected to the control room workstations and the lane computers through a local area network.

The computer hardware including printers and display terminals shall be readily available in India. Full maintenance support services and ready availability of consumable, spare parts or replacement units shall be assured from a third party, based in India, who is not connected with the Contractor, his agent or Sub- Contractor. The Contractor shall include the third-party support certificate in the Technical Proposal of the Tender for this hardware equipment.

10.1.2 Technical specifications:

The server shall be a microprocessor-based system with components and circuit boards supplied by manufacturers of international repute. Custom built or non-standard equipment shall not be acceptable to the Employer.

The technical specifications mentioned hereunder are minimum requirements. The Contractor shall not deviate materially from the specifications specified and shall obtain the approval for the TPS server from the Engineer.

Description	Specifications
Chassis	2 U Rack Mountable
CPU	Four numbers of latest generation Intel Xeon 14-Core processor 2.2 GHz, 19.25 MB Cache, 105W
Memory	256 GB RAM using 32GB Module scalable to at least up to 1.5TB, using DDR4 2666MHz DIMM (RDIMM) memory modules.
HDD Bays	4* 1.6 TB SSD with each SSD having minimum endurance of 3 DPWD

Optical drive Bay	One optical drive DVD-RW
Controller	Server should have RAID controller with 4GB battery backed write cache (on-board or in a PCI Express slot)
Networking	Server should support networking cards with below features: 1Gb 2-port network adaptor supporting advanced features 10Gb 2-port with dual SFP+
HBA	Dual 16GB single port PCIe Fibre Channel Host Bus Adapter with Optical Module
PCI Slots	Minimum 6 PCIe Gen 3.0 x4 Slots
Power Supply	Redundant 1500W Platinum hot plug power supply
Fans	Redundant hot-plug system fans
Display Controller	Should support VGA
Management and Maintenance	The server should be provided along with the out-of-band remote management and maintenance capability. Remote management should be possible by using API and Web based GUI
Warranty	5 year on site OEM Warranty with 24X7 support and Next Business Day (NBD) resolution
Operating System	Require this server with Two x MS Windows 2012 Standard 64Bit Operating System

10.2 Backup Tape Drive

This specification lays down the general, functional and technical requirements of Backup Tape Drive to be used as a sub-system in toll management system.

Contractor has to consider all the TPS servers of MTHL while designing the backup tape drives of the system.

The backup shall be done on the tape drive on daily one TD basis. Total 10 tapes shall be supplied and shall be reused for backup on every 11th day.

Technical Specifications

Descriptions	Remarks
Recording technology	LTO-7 Ultrium 15000
Capacity	15 TB Compressed 2.5:1
Host interface	6 Gb/s SAS
Transfer rate	300 MB/s native
Encryption capability	AES 256-bit

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Descriptions	Remarks
Form factor	5.25 inch half-height
Product dimensions (H x W x	7.7 x 22.3 x 29.5 cm
Weight	4.65 kg

10.3 TOR Switch

Contractor has to consider all the HA servers of MTHL while designing the TOR switches of system.

The following table lists the TOR Switch system specifications.

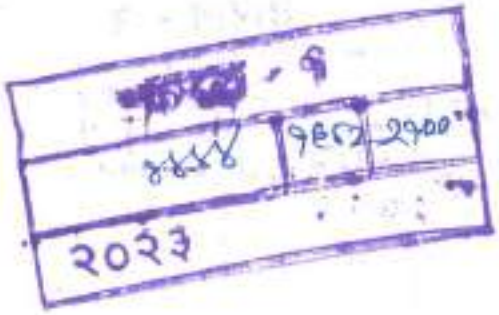
Descriptions	Remarks
Form factor	1U rack mount
Interface Options	24 × 1 GbE (24 RJ-45), 4 × 10 GbE SFP+
Dimensions	17.3 inches wide, 15 inches deep, 1 RU high
Weight	5.3 kg (11.68 lb)
Temperature Ambient	0° C to 40° C
Altitude Operating	1,800 m (6,000 ft)
Acoustic Noise	Less than 65 dB
Heat Dissipation	155 BTU/hour
Mean Time Between Failures (MTBF)	128,407 hours with ambient operating temperature of 40° C
Airflow	Rear-to-front cooling

10.4 SAN Storage

Contractor has to consider all the HA servers of TPS of MTHL while designing the SAN storage of the system.

The brief technical specifications are as follows:

S/N	Specification
1	Unified Storage Solution should be IP Based/iSCSI/FC/FCOE/NFS/CIFS as per the application requirement
2	Controllers shall be active-active so that a single logical unit can be shared across all offered Severs. The storage should have no single point of failure on components like controllers, disks, cache memory, I/O Ports, Power supply, Fan, etc.
3	Storage solution should comprise of Active-Active Load Balancing Storage Controllers with 64GB Cache from day one. If cache is provided in additional

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	hardware for the storage solution, then cache must be over and above 64 GB. The storage solution should be scalable up to 256GB Cache.
4	The storage array must have complete cache protection mechanism either by de-staging data to disk or providing complete cache data protection with battery backup for minimum 48 hours
5	Storage Capacity: Two storage pools, one with 30 TB (in RAID 5 Configuration) applications using SAS-SSD Disks and another pool of minimum 150TB for backup using NL-SAS/SATA Disk. Bidder is free to offer more capacity as per his solution requirement
6	Disks should be of 600 GB/ 900 GB/ 1 TB or more 12 Gbps SSD drives
7	Storage should support all industry standard RAID type like RAID 0, 1, 10, 5,6 & 50
8	The proposed Storage should support 6/12 Gbps Drives. it should support SSD, SAS & NL-SAS all type of Drives.
9	The overall storage solution should scalable up to 2 times of current usable disk space Storage without addition of controllers.
10	The offered Storage solution shall be supplied with at least 8 nos. of 10G IP Ports/ 16 Gbps FC ports (Depending upon the connectivity planned) and 4 Nos of 1GE iSCSI ports.
11	Modular design to support controllers and disk drives expansion
12	Should be Rack Mountable
13	The controllers / Storage nodes should be upgradable without any disruptions / downtime
14	Licenses for the storage management software should include disc capacity/count of the complete solution and any additional disks to be plugged in the future, up to max capacity of the existing controller/units.
15	Should be able to manage from Web and Command Line console for entire storage system.
16	Dual SAN Switch with desired no of ports activated as per the server count

10.5 Server Rack with Front Glass Door

The maximum dimension of the rack should be 600W X 42U X 1000D (mm) The Server Rack shall be provided with KVM console.

Contractor has to consider all the TPS locations of MTHL while designing the Racks.

10.5.1 Technical Specifications

Descriptions	Specifications
Make	Rittal or equivalent

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Basic Structure	Frame of sturdy 1.5mm frame section construction consisting of multi folded rolled hollow frame section punched in 25 mm DIN pitch pattern. All profile edges are radiuses. The corners are stiffened with welded zinc die cast corner connectors, gland plates in 3 parts, which are removable and interchangeable.
Doors	1.5mm sheet steel perforated with foamed seal polyurethane gasket, square section tabular frame, with punching in DIN pitch pattern, rod type 3 point lock system and double bit inserts to DIN 43656 (with single door: hinge fitting r/h or l/h freely selectable on site) Hinges with captive hinge pins, door opening angel 130 to VDI, can be retrofitted for 180 . Enclosure fitted with 2 sets of 15° angles, pair of depth rails (73 x 23 mm rails) fitted with swivel spring load lock handles.
Rear Door	1.5mm sheet steel perforated Door.
Roof Panel	With foamed -on seal, removable. Vented roof plate with option of having cable entry provision from top.
Load Carrying Capacity	500 KG Static load, Seismic Rated zone - 4 certified.
Surface Finish	Sheets cleaned, Degreased, Phosphate, Electro -Dip coat primed and electro statically power coated with textured Polyester paint
Required Accessories	Floor standing rack, Front and rear perforated doors, screw fixed side panels, top and bottom covers with cable entry Swivel handles on front and rear doors
Standard Mounting	Caster wheels (2 with Brake & 2 without Brake)
Ventilation	The rack shall have proper exhaust / ventilation using at least 4 fans housing units on top of the rack
Mounting Kit	Should have Six pkt of 20 nos. each Hardware mounting kit
Earthing Kit	Should have Rack Ground Kit
Cable manager	Four nos. of 01U Horizontal covered PVC Cable manager
Power Distribution	Two nos. of PDU 12 Point (5/15 amp) with MCB
Rack Trays	Two nos. of Fixed Hardware Shelf
KVM Console	Integrated KVM console with 17" LCD monitor – in a rack mountable housing

10.6 TPS workstations

The Contractor shall provide the workstations as listed hereunder.

Contractor has to consider all the TPS Locations of MTHL while calculating the quantities of the workstations of the system.

The workstations shall be the same model and shall have the same configurations.

1) Audit workstation
2) Lane status display workstation
3) Snapshot image workstation
4) CCTV monitor workstation
5) Tour of Duty (TOD) workstation

Audit workstation, lane status display workstation, snapshot image workstation and CCTV monitor workstation shall be accommodated in the auditor's console. A desk and a chair of the suitable design shall be provided to TOD workstation to accommodate workstation, printer, contactless card read/writer (if any) and other peripherals (if any).

The specifications in this section are provided as reference. The workstations to be provided by the Contractor shall materially comply with these specifications and shall be subject to the approval by the Engineer.

Description	Specifications
CPU	Intel Core i5- 6500 Processor (Quad Core , 6 MB Cache, upto 3.60 Ghz w/Turbo Boost) or better
Chipset	Intel Original Q170 PCH-H vPro or better
Memory	08 GB (1 X 8 GB) DDR4 Synchronous Dynamic Random Access Memory
Hard Disk Drive	1TB 7.2K SATA 6Gb/s 2.5inch
Display	18.5inch/ EPEAT Silver/energy star/ 1366x768 resolution/LED Backlit/power consumption 15W/
Video Card	Intel vPro Technology/ Discrete Graphics Supported
Keyboard	104 Keys
Mouse	Optical with USB interface
Sound Card	DTS Studio Sound
Ports	Serial Connector/RJ-45 Network Connector/(2) USB 3.0 Ports with Wake from S4/S5 feature/Line-In Audio Connector/PS/2 Mouse Connector/Line-Out Connector for powered audio devices/(4) USB 3.0 Ports/VGA Monitor Connector/(2) DisplayPort Monitor Connectors/PS/2 Keyboard Connector/Hard Drive Activity Light/5.25-inch Half-Height Drive Bay (behind bezel)/Microphone/Headphone Connector/USB 2.0 Fast Charging (powered) Port (black/Headphone Connector

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Cabinet	Tower architecture
Optical Drive	9.5mm Slim Desktop Super-Multi DVDRW Drive
Graphic Card	Should have 02GB dedicated Graphic Card
Networking facility	Intel® I219LM Gigabit Network Connection LOM (standard)
Operating System & Office S/W	Windows 10 Pro 64Bit preloaded with the media and documentation and Certificate of authenticity. Latest MS Office Pro License
Power Management	High Efficiency Energy Power Supply/Energy Star Certified/ EPEAT Gold
Warranty	Workstation should have 05 years 24 hours a day, seven days a week for assistance on resolving issues. Hardware onsite response within four hours if needed
Software require	Workstation should have 05 years Total security Anti-virus
Server Access CALS	Workstation should be provided with Windows 2012 standard server device CALS

10.7 Fingerprint Scanner

Contractor has to consider all the Server and Workstations locations TPS of MTHL while designing and calculating the quantities of the fingerprint scanner system.

Descriptions	Remarks
Optical Sensor	OPP06
Size (mm)	54 x 74 x 82.6 (With Stand) 27.4 x 40.5 x 73.7(Without Stand)
Image Size	248 x 292 pixels
Resolution	500 DPI
Interface	USB 1.1/2.0 High/Full Speed
Image acquisition time	Full speed : Avg. 500 msec. High speed : Avg. 300 msec.
Operating Temperature	-20~60 ℃
Operating Humidity	< RH 90%
Power Source	USB BUS Power
OS	Windows2000 or higher, Windows Server 2003/2008, Linux Kernel 2.6.x

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10.8 Network Printer (Black & White)

The Black LaserJet printer shall be a high-speed laser printer. A floor stand that accommodates printer paper; shall be provided together with the printer.

Contractor has to consider all the TPS locations of MTHL while calculating the quantities of Network printers of the system.

Technical Specifications:

Descriptions	Specifications
Printing speed	Normal: Up to 38 ppm
First page out	Black: As fast as 5.7 sec
Print resolution	Up to 1200 x 1200 dpi
Monthly duty cycle (Monthly, A4)	Up to 80,000 pages
Print language	HP PCL 5, HP PCL 6, HP postscript level 3 emulation, direct PDF (v 1.7) printing, URF, PCLM, PWG
Paper trays	2 (standard)
Media size	A4
Duplex (both sides) printing	Manual(driver support provided)
Connectivity	1 Hi-Speed USB 2.0; 1 Host USB; 1 Gigabit Ethernet 10/100/1000T network

10.9 Scanner A4 Size

Contractor has to consider all the TPS locations of MTHL while calculating the quantities of Scanners of the system.

Technical Specifications:

Descriptions		Remarks
Scanner type		Flatbed
Optical resolution		2,400 x 4,800 dpi
Scanner element		CIS
Light source		3 Colour LED
Scanning bit depth	Gray scale	48 bit input, 48 bit or 24 bit output
	Colour	16 bit input, 8 bit output
Preview speed 1		Approx. 14 sec.
Scanning speed 2	Colour	Approx. 16 sec. (A4, 300 dpi)
Interface		USB 2.0 High speed

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Descriptions	Remarks
Maximum document size	A4/ LTR, 216 x 297 mm
Scanning buttons (EZ buttons)	4 buttons (PDF, Auto Scan, Copy, Send)
A3 / B4 output size	Support
Gutter shadow correction	Support
Scan to PDF	Multi pages & password protection function
Power Supply	Power & connection via USB cable
Dimension (W x D x H)	250 x 370 x 40mm
Weight	Approx. 1.6 kg
Operation system	Windows 8.1, 8, 7 , Vista SP1 / SP2 , XP SP3 Mac OS X 10.6.8 – 10.9.x3

10.10 Smart Card Reader/ Writer

The SC Reader is used to process read and write to the Contact less Smart card. The distance which the SC reader can access the smart card is approximately 5-10 cm.

Contractor has to consider all the TPS locations of MTHL while calculating the quantities of SCRs of the system.

10.10.1 Technical Specifications

Item	Specifications
Installation and Fixing Details	Mounted on the toll booth panel
Cables	USB cable (Power Through USB) Antenna cable: RG174 AU, 50 ohms
Cable routes	USB cable is connected to the TLC via booth ducting The Reader's antenna is built into the Reader housing.
Material and finishes	PVC sheet with Epoxy painted
Colour	Grey/Black
Power Supply Requirement	5V DC
Access for maintenance, modularity of construction	Modular design. Minor maintenance required
Operating Temperature	-100C to 700C with heat dissipation of < 3.5W
Relative Humidity	5 % to 90 %
Design Criteria	-Data Transmission Between MFGPR2: 106Kbaud

Item	Specifications
	-Card Operating Distance: 5-10 cm -Reading, calculating and writing operations: 200ms -Interface Protocol: According to KENT interface -Security Feature: According to KENT security Standards -MTBF: 30,000 hrs -MTTR: 0.25 hrs

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11. Specifications for TMS System Equipment

11.1 TMS servers

The TMS which is a Logical name shall physically consist of High Availability configuration having 2 servers in HA mode and the backup server. All these three physical servers shall follow same specifications as mentioned below and any configuration equivalent or better than the mentioned shall be supplied. In no case, any inferior configuration shall be offered by the contractor.

Contractor has to consider all the TMS locations of MTHL while Designing the TMS system.

One location of TMS shall be located at the Mainline toll plaza building at Gavan and the other location shall be at Sewri Interchange.

Contractor has to describe, how he proposes to use the distant physical locations of two TMS building with the HA standby configuration.

The specifications mentioned herein are minimum. The contractor shall design the Equipment as per the latest configuration available at the time of implementation.

The TMS which is a Logical name shall physically consist of High Availability configuration having 2 servers in HA mode and the backup server. All these three physical servers shall follow same specifications as mentioned below and any configuration equivalent or better than the mentioned shall be supplied. In no case, any inferior configuration shall be offered by the contractor.

11.1.1 Technical specifications:

The server shall be a microprocessor-based system with components and circuit boards supplied by manufacturers of international repute. Custom built or non-standard equipment shall not be acceptable to the Employer.

The technical specifications mentioned hereunder are minimum requirements. The Contractor shall not deviate materially from the specifications specified and shall obtain the approval for the TPS server from the Engineer.

Description	Specifications
Chassis	2 U Rack mountable
CPU	Four numbers of latest generation Intel Xeon 14-Core processor 2.2 GHz, 19.25 MB Cache, 105W
Memory	256 GB RAM using 32GB Module scalable to at least up to 1.5TB, using DDR4 2666MHz DIMM (RDIMM) memory modules.
HDD Bays	4* 1.6 TB SSD with each SSD having minimum endurance of 3 DPWD
Optical drive Bay	One optical drive DVD-RW
Controller	Server should have RAID controller with 4GB battery backed write cache (on-board or in a PCI Express slot)
Networking	Server should support networking cards with below features:

	1Gb 2-port network adaptor supporting advanced features
	10Gb 2-port with dual SFP+
HBA	Dual 16GB single port PCIe Fibre Channel Host Bus Adapter with Optical Module
PCI Slots	Minimum 6 PCIe Gen 3.0 x4 Slots
Power Supply	Redundant 1500W Platinum hot plug power supply
Fans	Redundant hot-plug system fans
Display Controller	Should support VGA
Management and Maintenance	The server should be provided along with the out-of-band remote management and maintenance capability. Remote management should be possible by using API and Web based GUI
Warranty	5 year on site OEM Warranty with 24X7 support and Next Business Day (NBD) resolution
Operating System	Require this server with Two x MS Windows 2012 Standard 64Bit Operating System

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11.2 Backup Tape Drive

This specification lays down the general, functional and technical requirements of Backup Tape Drive to be used as a sub-system in toll management system.

Contractor has to consider the TMS servers of MTHL while designing the backup tape drives of the system.

The backup shall be done on the tape drive on daily one TD basis. Total 10 tapes shall be supplied and shall be reused for backup on every 11th day.

Technical Specifications

Descriptions	Remarks
Recording technology	LTO-7 Ultrium 15000
Capacity	15 TB Compressed 2.5:1
Host interface	6 Gb/s SAS
Transfer rate	300 MB/s native
Encryption capability	AES 256-bit
Form factor	5.25 inch half-height
Product dimensions (H x W x D)	7.7 x 22.3 x 29.5 cm
Weight	4.65 kg

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11.3 TOR Switch

Contractor has to consider HA server of TMS of MTHL while positioning the TOR switches of the system.

The following table lists the TOR Switch system specifications.

Descriptions	Remarks
Form factor	1U rack mount
Interface Options	24 × 1 GbE (24 RJ-45), 4 × 10 GbE SFP+
Dimensions	17.3 inches wide, 15 inches deep, 1 RU high
Weight	5.3 kg (11.68 lb)
Temperature Ambient operating	0° C to 40° C
Altitude Operating	1,800 m (6,000 ft)
Acoustic Noise	Less than 65 dB
Heat Dissipation	155 BTU/hour
Mean Time Between Failures (MTBF)	128,407 hours with ambient operating temperature of 40° C
Airflow	Rear-to-front cooling

11.4 SAN Storage

Contractor has to consider all the HA server of TMS of MTHL while designing the SAN storage of the system.

S/N	Specification
1	Unified Storage Solution should be IP Based/iSCSI/FC/FCOE/NFS/CIFS as per the application requirement
2	Controllers shall be active-active so that a single logical unit can be shared across all offered Severs. The storage should have no single point of failure on components like controllers, disks, cache memory, I/O Ports, Power supply, Fan, etc.
3	Storage solution should comprise of Active-Active Load Balancing Storage Controllers with 64GB Cache from day one. If cache is provided in additional hardware for the storage solution, then cache must be over and above 64 GB. The storage solution should be scalable up to 256GB Cache.
4	The storage array must have complete cache protection mechanism either by de-staging data to disk or providing complete cache data protection with battery backup for minimum 48 hours


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5	Storage Capacity: Two storage pools, one with 30 TB (in RAID 5 Configuration) applications using SAS-SSD Disks and another pool of minimum 150TB for backup using NL-SAS/SATA Disk. Bidder is free to offer more capacity as per his solution requirement
6	Disks should be of 600 GB/ 900 GB/ 1 TB or more 12 Gbps SSD drives
7	Storage should support all industry standard RAID type like RAID 0, 1, 10, 5,6 & 50
8	The proposed Storage should support 6/12 Gbps Drives. it should support SSD, SAS & NL-SAS all type of Drives.
9	The overall storage solution should scalable up to 2 times of [illegible] disk space Storage without addition of controllers.
10	The offered Storage solution shall be supplied with at least 8 nos. of 10G IP Ports/ 16 Gbps FC ports (Depending upon the connectivity planned) and 4 Nos. of 1GE iSCSI ports.
11	Modular design to support controllers and disk drives expansion
12	Should be Rack Mountable
13	The controllers / Storage nodes should be upgradable without any [illegible] downtime
14	Licenses for the storage management software should include disc capacity/count of the complete solution and any additional disks to be plugged in the future, up to max capacity of the existing controller/units.
15	Should be able to manage from Web and Command Line console for entire storage system.
16	Dual SAN Switch with desired no of ports activated as per the server count

11.5 Server Rack with Front Glass Door

The maximum dimension of the rack shall be 600W X 42U X 1000D (mm) The Server Rack shall be provided with KVM console.

Contractor has to consider the TMS locations of MTHL while designing the Racks.

11.5.1 Technical Specifications

The server lack shall have the specifications below.

Descriptions	Specifications
Make	Rittal or equivalent
Basic Structure	Frame of sturdy 1.5mm frame section construction, consisting of multi folded rolled hollow frame section punched in 25 mm DIN pitch pattern. All profile edges are radiuses. The corners are stiffened with welded zinc die cast

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	corner connectors, gland plates in 3 parts, which are removable and interchangeable.
Doors	1.5mm sheet steel perforated with foamed seal polyurethane gasket, square section tabular frame, with punching in DIN pitch pattern, rod type 3 point lock system and double bit inserts to DIN 43668 (with single door: hinge fitting r/h or l/h freely selectable on site) Hinges with captive hinge pins, door opening angel 130 to VDI, can be retrofitted for 180 . Enclosure fitted with 2 sets of 19" angles, pair of depth rails (73 x 23 mm rails) fitted with swivel spring load lock handles.
Rear Door	1.5mm sheet steel perforated Door.
Roof Panel	With foamed -on seal, removable. Vented roof plate with option of having cable entry provision from top
Load Carrying Capacity	500 KG Static load, Seismic Rated zone - 4 certified
Surface Finish	Sheets cleaned, Degreased, Phosphate, Electro Dip coated primed and electro statically power coated with textured Polyester paint
Required Accessories	Floor standing rack, front and rear perforated doors, screw fixed side panels, top and bottom covers with cable entry Swivel handles on front and rear doors
Standard Mounting	Caster wheels (2 with Brake & 2 without Brake)
Ventilation	The rack shall have proper exhaust / ventilation using at least 4 fans housing units on top of the rack
Mounting Kit	Should have Six pkt of 20 nos. each Hardware mounting kit
Earthing Kit	Should have Rack Ground Kit
Cable manager	Four nos. of 01U Horizontal covered PVC Cable manager
Power Distribution	Two nos. of PDU 12 Point (5/15 amp) with MCB
Rack Trays	Two nos. of Fixed Hardware Shelf
KVM Console	Integrated KVM console with 17" LCD monitor – in a rack mountable housing

11.6 Time server

A time server shall be provided to the toll management centre system to synchronize all servers and workstations operating in the toll management system with the standard time obtained from GPS (global positioning system) satellite.

Time server shall communicate with the servers and workstations through Network Time Protocol (NTP) to adjust the real-time clock of servers and workstations. All servers and workstations shall be provided with simple network time protocol (SNTP) or network time protocol (NTP) software running under a variant of the UNIX or Windows operation

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systems.

A GPS antenna shall be provided together with the time server to receive the GPS satellite signal. The antenna shall be installed at the proper location of good reception at the toll management centre building.

The time server shall be provided with a built-in crystal oscillator to maintain the accurate time when time information is not available from GPS satellites for the minimum duration of 24 hours.

No.	Descriptions	Remarks
1	Built-in crystal accuracy	Average weekly deviation +/- 0.7 seconds at 25°C
2	Correction accuracy	+/- 1 msec or less
3	Time error	Less than 1 msec
4	Leap second	Supported
5	Information from GPS satellite	Year, month, day, hour, minute, second and leap second information
6	Indicator	Time synchronization status Error
7	Network protocol	IPv4 and IPv6
8	Input sensitivity	15 dBi to 30 dBi
9	Network protocol supported	UDP/IP, TCP/IP, ICMP, 10BASE-T/100BASE-TX
10	Time information protocol	NTP v3, NTP v4, Time Protocol, Daytime Protocol
11	Parameter setting	Through front panel and Web browser

Main unit

No.	Descriptions	Remarks
1	Rated voltage	90-250 V AC
2	Rated frequency	50/60 Hz
3	Rated current	12A or less
4	Power consumption	10 W or less
5	Operating temperature	0°C to 40°C
6	Operating humidity	20 to 80 % non-condensing
7	Installation	Rack mount
8	EMI	VCCI-A compliant

GPS antenna

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No.	Descriptions	Remarks
1	Rated voltage	30-140 V AC
2	Operating temperature	-30°C to 85°C (antenna) -10°C to 65°C (coaxial cable)
3	Operating humidity	95 % or less non-condensing
4	Water proof	IPX6

11.7 TMS workstations

This specification lays down the general, functional and technical requirements of TMS workstations to be used as a sub-system in the toll management system at the Toll Plaza.

Contractor has to consider all the TMS Locations of MTHL while calculating the quantities of the workstations of the system.

The workstations at the TMS shall be used for

1) TMS administration workstation
2) TMS reporting workstation
3) Financial management workstation
4) Snapshot image workstation
5) CCTV monitoring workstation

The TMS workstation shall be identical with the Toll Plaza System workstation.

Description	Specifications
CPU	Intel Core i5- 6500 Processor (Quad Core , 6 MB Cache, upto 3.60 Ghz w/Turbo Boost) or better
Chipset	Intel Original Q170 PCH-H vPro or better
Memory	08 GB (1 X 8 GB) DDR4 Synchronous Dynamic Random Access Memory
Hard Disk Drive	1TB 7.2K SATA 6Gb/s 2.5inch
Display	18.5inch/ EPEAT Silver/energy star/ 1366x768 resolution/LED Backlit/power consumption 15W/
Video Card	Intel vPro Technology/ Discrete Graphics Supported
Keyboard	104 Keys
Mouse	Optical with USB interface
Sound Card	DTS Studio Sound
	Serial Connector/RJ-45 Network Connector/(2) USB 3.0 Ports with Wake from S4/S5 feature/Line-In Audio Connector/PS/2 Mouse

Ports	Connector/Line-Out Connector for powered audio devices/(4) USB 3.0 Ports/VGA Monitor Connector/(2) DisplayPort Monitor Connectors/PS/2 Keyboard Connector/Hard Drive Activity Light/5.25-inch Half-Height Drive Bay (behind bezel)/Microphone/Headphone Connector/USB 2.0 Fast Charging (powered) Port (black/Headphone Connector
Cabinet	Tower architecture
Optical Drive	9.5mm Slim Desktop Super-multi DVDRW Drive
Graphic Card	Should have 02GB dedicated Graphic Card
Networking facility	Intel® I219LM Gigabit Network Connection LOM (standard)
Operating system and Office software	Windows 10 Pro 64 bit preloaded with the media and documentation and certificate of authenticity. Latest MS Office Pro License
Power Management	High Efficiency Energy Power Supply/Energy Star Certified/ EPEAT Gold
Warranty	Workstation should have 05 years 24 hours a day, seven days a week for assistance on resolving issues. Hardware onsite response within four hours if needed
Software require	Workstation should have 05 years Total security Anti-virus
Server Access CALS	Workstation should be provided with Windows 2012 standard server device CALS

11.8 Fingerprint Scanner

Contractor has to consider all the Server and Workstations locations TMS of MTHL while designing and calculating the quantities of the fingerprint scanner system.

Descriptions	Remarks
Optical Sensor	OPP06
Size (mm)	54 x 74 x 82.6 (With Stand) 27.4 x 40.5 x 73.7(Without Stand)
Image Size	248 x 292 pixels
Resolution	500 DPI
Interface	USB 1.1/2.0 High/Full Speed
Image acquisition time	Full speed : Avg. 500 msec. High speed : Avg. 300 msec.
Operating Temperature	-20~60 ℃
Operating Humidity	< RH 90%

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Descriptions	Remarks
Power Source	USB BUS Power
OS	Windows2000 or higher, Windows Server 2003/2008, Linux Kernel 2.6.x

11.9 Network Printer (Black & White)

The Operations printers shall be a high-speed A4 size black laser printer. The TMS operations printers shall be connected to the LAN of TMS.

Contractor has to propose the quantities planned for the various TMS locations.

Technical Specifications:

Descriptions	Specifications
Printing speed	Normal: Up to 38 ppm
First page out	Black: As fast as 5.7 sec
Print resolution	Up to 1200 x 1200 dpi
Monthly duty cycle (Monthly, A4)	Up to 80,000 pages
Print language	HP PCL 5, HP PCL 6, HP postscript level 3 emulation, direct PDF (v 1.7) printing, URF, PCLM, PWG
Paper trays	2 (standard)
Media size	A4
Duplex (both sides) printing	Manual(driver support provided)
Connectivity	1 Hi-Speed USB 2.0; 1 Host USB; 1 Gigabit Ethernet 10/100/1000T network

11.10 Scanner A4 Size

Contractor has to propose the quantities of scanners planned for the various TMS locations.

Descriptions		Remarks
Scanner type		Flatbed
Optical resolution		2,400 x 4,800 dpi
Scanner element		CIS
Light source		3 Colour LED
Scanning bit depth	Gray scale	48 bit input, 48 bit or 24 bit output
	Colour	16 bit input, 8 bit output

Preview speed1		Approx. 14 sec
Scanning speed2	Colour	Approx. 16 sec (A4 / 300 dpi)
Interface		USB 2.0 High speed
Maximum document size		A4/ LTR, 216 x 297 mm
Scanning buttons (EZ buttons)		4 buttons (PDF, Auto Scan, Copy, Send)
A3 / B4 output size		Support
Gutter shadow correction		Support
Scan to PDF		Multi pages & password protection function
Power Supply		Power & connection via USB cable
Dimension (W x D x H)		250 x 370 x 40mm
Weight		Approx. 1.6 kg
Operation system		Windows 8.1, 8, 7 , Vista SP1 / SP2 , XP SP3 Mac OS X 10.6.8 – 10.9.x3

11.11 Smart Card Reader/ Writer

The SC Reader is used to process read and write to the contact less smart card. The distance which the SC reader can access the smart card is approximately 5-10 cm.

Contractor has to propose the quantities of SCRs planned for the various TMS locations.

11.11.1 Technical Specifications

Descriptions	Remarks
Installation and Fixing Details	Mounted on the toll booth panel
Cables	USB cable (Power Through USB) Antenna cable: RG174 AU, 50 ohms
Cable routes	USB cable is connected to the TLC via booth ducting The Reader's antenna is built into the Reader housing.
Material and finishes	PVC sheet with Epoxy painted
Colour	Grey/Black
Power Supply Requirement	5V DC
Access for maintenance, modularity of construction	Modular design. Minor maintenance required
Operating Temperature	-100C to 700C with heat dissipation of < 3.5W
Relative Humidity	5 % to 90 %

Descriptions	Remarks
Design Criteria	-Data Transmission Between MFGPR2: 106Kbaud -Card Operating Distance: 5-10 cm -Reading, calculating and writing operations: 200ms -Interface Protocol: According to KENT interface -Security Feature: According to KENT security Standards -MTBF: 30,000 hrs -MTTR: 0.25 hrs

12. Plaza Network Equipment

12.1 General

The Contractor shall supply and install network equipment at each interchange plaza to connect toll Plaza System with toll lane system. The Contractor shall supply and install all equipment, Switches, cables, connectors, terminals, conduit, hand hole and other miscellaneous materials necessary to establish a working local area network for Toll Management system of MTHL.

Below specifications are given just as minimum specifications. Contractor shall use the latest configurations and technologies available at the time of implementation of the Network System for MTHL.

Contractor shall propose all the quantities required for all network components in his technical design.

12.2 24 Port 10/100 Gbps Unmanaged Ethernet Switch

This specification lays down the general, functional and technical requirements of the 24 Port 10/100 Gbps Unmanaged Ethernet Switch to be used as a network interface for the network to be established at each interchange.

Technical Specifications

Descriptions	Remarks
Network Ports	24 x 10/100/1000 Mbps auto-sensing UTP RJ-45 ports
Standard Compliance	• IEEE 802.3 10BASE-T Ethernet • IEEE 802.3u 100BASE-TX Fast Ethernet • IEEE 802.3ab 1000BASE-T Gigabit Ethernet • IEEE 802.3az Energy Efficient Ethernet • IEEE 802.3x Full-duplex flow control
Protocol	CSMA/CD


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Network Cables	• 10BASE-T: UTP Cat. 3, 5 (100 m) • 100BASE-TX: UTP Cat. 5, 5e (100 m) • 1000BASE-T: UTP Cat. 5, 5e, 6 (100 m)
Data Transfer Rates	• Ethernet: 10 Mbps (Half-duplex), 20 Mbps (Full Duplex) • Fast Ethernet: 100 Mbps (Half-duplex), 200 Mbps (Full Duplex) • Gigabit Ethernet: 2000 Mbps (Full-duplex)
Performance Specifications	• Forwarding mode: Store-and-forward • Buffer memory: 448 KB • MAC Address database: 16K • Jumbo Frames: 9KB • Switching fabric: 48Gbps
Power Consumption	14.5 Watts
Status LEDs	• Power • Link & activity indicators for each port
Environmental Specifications	• Operating temperature: 0°C ~ 40°C • Storage temperature: -40°C ~ 70°C • Operating humidity: 10%~90% RH (non-condensing) • Storage humidity: 5 to 90 % RH (non-condensing)
Power Supply	Internal (100~240v, 50-60hz AC)
Physical Specifications	Dimensions: (l x w x h) 266.7 x 121 x 44 mm
Minimum System Requirements	• Network card for each PC or Server • Network cables Min. Cat.5 for 1000 Mbps

12.3 Patch Panel 24 Port

Descriptions	Remarks
Current Rating	1.5amps
Insulation Resistance	>= 500mΩ
Contact Resistance	<=10mΩ
DC Resistance	<=0.1Ω
DC/AC Volt Endurance	DC 1000V/AC 750V 1 Min
Plug Insertion Life	>= 750 Cycles with FCC Compliant RJ-45 Plug
Plug & Jack Contact Force	>= 100 Grams with FCC Compliant RJ-45 Plug

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Plug Retention Force	>= 11 LBF
Durability	200 Termination Cycles
Operating Temperature	-10 Degree ~ 60 Degree
Operating Humidity	10% ~ 90% RH
Storage Temperature	-40 Degree ~ 68 Degree
Panel Frame	SPCC Powder Coating In Black Colour
Housing	High Impact Flame Retardant Plastic, UL 94V-0 Rated
PCB	FR4, 1.6mm Thickness
Jack Wire	50μ" Phosphor Bronze Gold Over Nickel Plating
Jack Configuration	8x3 Module Special Design
IDC Conductor	0.5 mm Phosphor Bronze, Tin Plating
Contact Compatibility	22~26 AWG Stranded and Solid Wires

12.4 9U Switch Rack

This specification lays down the general, functional and technical requirements of the Network racks to be used as a network equipment enclosure in the toll management system at the Toll Plaza.

12.4.1 Technical Specifications

Descriptions	Remarks
Height	9U
Enclosures Dimension	600W x 9U x 500D
Rack	620 x 510 x 535
Material Finishing	Front sheet steel glass door
Side Panels	Top and bottom cover with cable entry provision, integrated side walls
Mounting Angel	1 pair of 19" angles

13. Intercom System at Toll Plaza

13.1 System Outline

Intercom system consisting of intercom master unit, intercom slave unit and exchange unit (if necessary) shall be provided to the toll plaza for the voice communication between the supervision staff at toll control room and toll collector at toll booth. The intercom slave unit shall also be installed at various locations at toll plaza for voice communication.

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Contractor to propose the number of locations and equipment covered under the intercom system in his design.

13.2 System functions

The intercom system shall have the following functions:

1) Voice communication installed in the booths shall provide hands free two-way verbal communication between the supervision staff in the control room and the toll collectors. The toll collector shall be able to attract the attention of the auditor in the control room by pressing a single button on the intercom slave unit in the booth.
2) The equipment shall also have the facility to allow the supervision staff to monitor communication in the booth between the toll collector and the user or between any booth without alerting the toll collector.
3) The voice communication system shall operate independently of the toll lane controller system.
4) Voice communication shall also be implemented in various rooms of the plaza building and at building access points.
5) Two-way communications shall be possible as soon as the supervising staff responds by selecting the appropriate lane button on the master communication unit.
6) One-way communication shall be possible from the control room intercom to all booths simultaneously (broadcast)

13.2.1 Specifications

Intercom system shall be an IP based system and shall have the following specifications:

Technical Specifications: Descriptions	Remarks
Speech method	Handset or hands-free (master), hands-free (slave)
Audio frequency range	300 Hz – 7 kHz
Network I/F	100Base-T,/100Base-Tx
Network protocol	TCP/IP, UDP, ARP, ICMP, HTTP
Transmission system	Unicast, multicast
Installation	Desktop (master), wall mount/desktop (slave)
Power consumption	5 W max. (master/slave)
Power supply (slave)	PoE
Reliability (MTBF)	30,000 hrs

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14. Software

14.1 General

The Contractor shall provide a set of software to operate on the servers and workstation of lane computer system, TPS server system, TMS server system and other workstations to be provided under the Contract. The software shall function as a system to meet the functional requirements specified in the Employer's Requirements.

The set of the software to be provided shall consist of those provided by third party, custom made software by the Contractor or joint venture member or sub-contractor, and those specifically developed for the project. All third party software shall be legally licensed and there shall be no restriction on the use in the toll management system. They shall be registered under the name of Employer and any supports and services provided by the software developer including update and revision shall be available to the Employer.

The software to be specifically developed for the Project shall be fully tested and shall be free from bugs. The Contractor shall state in the Technical Proposal of the Tender, the software quality assurance program that he intends to adopt in developing the software.

14.2 Third party software

The third party software to be provided shall include but not be limited to the following:

1) Server operating system
2) Client operating system
3) Database management software
4) Network management software
5) Antivirus program

All third party programs to be provided shall be widely used and suitable for the application of toll management system in terms of functions, capacity, speed, interface with other software, maintenance and user friendliness. The Contractor shall state in the Technical Proposal of the Tender, the third party software that he proposes. If the Contractor proposes the third party program that is of limited use, he shall explain the reason for using it in the Technical Proposal of the Tender.

If the third party software is provided in CD or DVD, the original CD or DVD shall be submitted as part of documentation. The requirement is not applicable to the software preinstalled in the server or computer.

If the cost of the operating system is included in the server and workstation hardware; the same may not be mentioned in the schedule of prices.

14.3 Toll management system software

The Contractor shall develop new software or modify the existing software to provide the toll management system functions specified herein and as required elsewhere in the Employer's Requirements.

The software to be provided as toll management system software shall include but not be

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limited to the following:

1) Manual and QR code lane system software
2) ETC Lane Software
3) Toll Plaza System software
   a. TPS server interface
   b. Audit and reporting software
   c. Lane status display system software
   d. Snapshot image & Video workstation software
   e. Tour of duty software
   f. Incident management software
   g. Bank-in software
4) Toll management centre (TMS) software
   h. TMS server interface
   i. TMS audit software
   j. TMS reporting software
   k. Snapshot Image TMS central software
5) Utility software
6) Maintenance activity tracking and logging software

The actual configuration of software modules may not be necessarily as listed above; but the software shall perform all functions required as a whole.

All software shall be of modular construction and the interaction between the modules shall be kept as minimum. They shall be designed to operate continuously, and no periodical maintenance of the software shall be required.

All the display on monitor and printed report shall be in English.

The utility software shall include but not be limited to the system backup and restoration, database backup and restoration, and access control and operation log functions. Usage of the server and computer shall be controlled by log in/out procedure and different levels of access control shall be provided to restrict the use of certain software by unauthorized persons. All operations shall be recorded as a log together with staff identification number.

The software that interacts with the auditor shall be provided with fault tolerant functions and access control functions. They shall be designed in such a way that any operation error shall not cause damage to the system, loss of data or system shut down.

All software shall be tested under the different conditions and cases including incorrect operation by auditor and erroneous data to verify the sturdiness of the software.

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15. Specifications for Closed Circuit Television (CCTV)

15.1 General

This part of the Employer's Requirements covers the equipment and services to be supplied under the Contract for CCTV equipment to be installed at the toll plazas. The CCTV equipment shall be categorized as two types, CCTV for Toll Systems and CCTV for Security.

Contractor to propose the design and quantities of the cameras and other equipment to achieve complete surveillance of the Toll Management System of MTHL.

The specifications mentioned herein are only for guidelines of the requirement. The contractor shall use the latest configurations and technologies available for CCTV surveillance at the time of implementation of the CCTV system on MTHL.

The CCTV for toll systems shall be:

1) Toll Booth CCTV cameras
2) Plaza Surveillance CCTV cameras

The CCTV for Security are:-

1) Plaza Building Security CCTV cameras

All the cameras shall be connected to the Network Video Recorder (NVR) with the inbuilt facility to control the cameras at the Supervision Control room at the Interchange Plaza Building.

The individual NVR at the interchange plaza building shall be interfaced to TMS system via the optical fibre cable network to be able to watch and control the cameras for the PTZ activities from the TMS control room. The priority is given to the TPS control room staff.

The functionality of the CCTV cameras provided by the contractor shall be described as follows:

1) Toll booth CCTV cameras – These cameras shall be installed inside of the toll booth to capture the activities of the toll collector all the time and especially when doing the transactions along with the view of the paying vehicle. The position of the booth camera shall be decided accordingly.
2) Plaza surveillance CCTV cameras – These cameras installed on a sufficient height mast shall be intended for general surveillance of the toll canopy and field activity at the plaza and walkways. These cameras shall also be linked to the Traffic Control Surveillance System for remote monitoring. As both the traffic control room staff and toll control room staff can control the pan, tilt and zoom function, the priority shall be given to the Toll control room staff.
3) Plaza Building Security CCTV cameras – These cameras shall be intended for monitoring of security areas such as the plaza compound, general parking area, Toll Control Room, cash room, plaza building lobby, toll collector walkway, server room, UPS room and cash van loading area.

The design of the CCTV system for the plaza shall consider the following:

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1) Provide effective supervision and control
2) Easy to use
3) Self-contained system
4) Increase span of management
5) Reduce unnecessary travel
6) View / evaluate situations quickly
7) Motion detection
8) Savings on time and manpower
9) Easy access to video information and quick playback
10) Minimize the use of security guards
11) Eliminate unnecessary responses to false alarms
12) Provision for future scalability

15.2 Toll Booth CCTV cameras

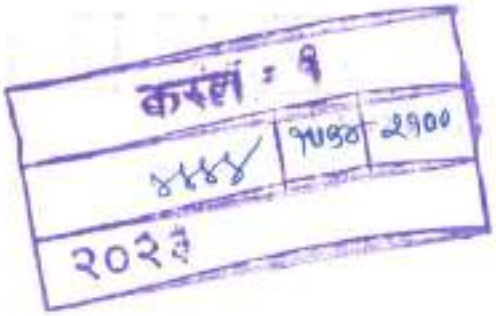
The toll booth CCTV camera shall be a fixed dome type colour cameras installed inside the booth to capture the activities of the toll collector while performing his operations. The camera also shall capture the view of the paying vehicle while capturing the transaction video.

These cameras shall be connected to the NVR system installed at the toll control room at each interchange toll plaza building.

Technical Specifications of the Booth Cameras shall be as follows

The technical specifications mentioned hereunder are minimum guidelines. The Contractor shall not deviate materially from the specifications specified herein.

Descriptions	Remarks
Image Sensor	1/2.7" Progressive Scan CMOS
Min. Illumination	Colour: 0.01 Lux @ (F1.2, AGC ON), 0.028 lux @(F2.0, AGC ON), 0 lux with IR
Shutter Speed	1/3 s to 1/100,000 s
Slow Shutter	Yes
Day & Night	IR Cut Filter
Digital Noise Reduction	3D DNR
WDR	120dB
3-Axis Adjustment	Pan: -30° to +30°, tilt: 0° to 75°, rotate: 0° to 360°
Lens	
Focal length	2.8, 4, 6 mm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Descriptions	Remarks
Aperture	F2.0
FOV	2.8 mm: Horizontal field of view: 114°, Vertical field of view: 62°, Diagonal field of view: 135° 4 mm: Horizontal field of view: 86°, Vertical field of view: 46°, Diagonal field of view: 102° 6 mm: Horizontal field of view: 54°, Vertical field of view: 30°, Diagonal field of view: 62°
Lens Mount	M12
IR	
IR Range	Up to 10 m
Wavelength	850nm
Compression Standard	
Video Compression	Main stream: H.265/H.264 Sub stream: H.265/H.264 /MJPEG Third stream: H.265/H.264
H.264 Type	Main Profile/High Profile
H.264+	Yes
H.265 Type	Main Profile
H.265+	Yes
Video Bit Rate	32 Kbps to 16 Mbps
Audio Compression	G722.1/G711ulaw/G711alaw/G726/MP2L2/PCM
Audio Bit Rate	64Kbps(G.711)/16Kbps(G.722.1)/16Kbps(G.726)/32-192Kbps(MP2L2)
Smart Feature-set	
Behaviour Analysis	Line crossing detection, intrusion detection
Face Detection	Yes
Region of Interest	Support 1 fixed region for main stream and sub-stream separately
Image	
Max. Resolution	1920 × 1080
Main Stream	50Hz:25fps (1920 × 1080, 1280 × 960, 1280 × 720) 60Hz: 30fps (1920 × 1080, 1280 × 960, 1280 × 720)
Sub Stream	50Hz: 25fps (640 × 480, 640 × 360, 320 × 240)

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Descriptions	Remarks
	60Hz: 30fps (640 × 480, 640 × 360, 320 × 240)
Third Stream	50Hz: 25fps (1920 × 1080, 1280 × 720, 640 × 360, 352 × 288) 60Hz: 30fps (1920 × 1080, 1280 × 720, 640 × 360, 352 × 240)
Image Settings	Rotate mode, saturation, brightness, contrast, sharpness adjustable by client software or web browser
Image Enhancement	BLC/3D DNR
Day/Night Switch	Auto/Schedule/Day/Night/Triggered by Alarm In (-S model)
Network	
Network Storage	Support Micro SD/SDHC/SDXC card (128G), local storage and NAS (NFS,SMB/CIFS), ANR
Alarm Trigger	Motion detection, video tampering, network disconnected, IP address conflict, HDD full, HDD error, illegal login
Protocols	TCP/IP, ICMP, HTTP, HTTPS, FTP, DHCP, DNS, DDNS, RTP, RTSP, RTCP, PPPoE, NTP, UPnP™, SMTP, SNMP, IGMP, QoS, IPv6
General Function	One-key reset, anti-flicker, three streams, heartbeat, mirror, password protection, privacy mask, watermark, IP address filter
API	ONVIF (PROFILE S, PROFILE G), ISAPI
Simultaneous Live View	Up to 6 channels
User/Host	Up to 32 users 3 levels: Administrator, Operator and User
Client	iVMS-4200, Hik-Connect, iVMS-5200, iVMS-4500
Web Browser	IE8+, Chrome 31.0-44, Firefox 30.0-51, Safari 8.0+
Interface	
Audio (-S model)	2 Inputs: line in (3.5 mm) or mic in (built-in microphone), 1 Output: line out (3.5 mm), mono sound
Alarm (-S model)	1 Input: Alarm in (3.5mm) 1 Output: Alarm out (3.5mm)
Communication Interface	1 RJ45 10M/100M self-adaptive Ethernet port
On-board storage	Built-in MicroSD/SDHC/SDXC slot, up to 128G

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Descriptions	Remarks
SVC	Support H.264 and H.265 encoding
Audio (-S model)	
Environment Noise Filtering	Yes
Audio Sampling Rate	16 kHz, 32kHz, 44.1kHz, 48kHz
General	
Operating Conditions	-30 °C to +60 °C (-22 °F to +140 °F), Humidity 95% or less (non-condensing)
Power Supply	12 VDC ± 25%, PoE (802.3af, class 3)
Power Consumption and Current	12 VDC, 0.7 A, max. 8.5W, Φ 5.5mm coaxial plug, power PoE (802.3af, 36V to 57V), 0.3 A to 0.1 A, max. 10W
Protection Level	IK08, IP66
Material	Front cover: plastic, Bottom base: metal
Dimensions	Φ110 mm × 56.4 mm (Φ4.3" × 2.2")
Weight	Camera: Approx. 400 g (0.9 lb.)

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15.3 Lane Monitoring Bullet Camera

Technical Specifications of the Lane Monitoring Cameras shall be as stated hereunder. The technical specifications mentioned hereunder are minimum guidelines. The Contractor shall not deviate materially from the specification specified while preparing the Technical Proposal of the Tender.

Descriptions	Remarks
Camera	
Image Sensor	1/2.8" Progressive Scan CMOS
Min.illumination colour	0.01 Lux @(F1.2, AGC ON), 0.028Lux @(F2.0, AGC ON), 0 Lux with IR
Shutter Speed	1/3 s to 1/100,000 s
Slow Shutter	Yes
Auto-Iris	No
Day & Night	IR Cut Filter
Digital Noise Reduction	3D DNR
Wide Dynamic Range	120 dB

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Descriptions	Remarks
Angle of adjustment	Pan: 0° to 360°, tilt: 0° to 100°, rotation: 0° to 360°
Lens	
Focal Length	2.8 to 12 mm
Aperture	F2.0
Focus	-Z: Auto Without –Z: Manual
FOV	Horizontal FOV: 99.6° to 35°, vertical FOV: 53.5° to 20°, diagonal FOV: 118.6° to 40.2°
Lens Mount	Φ14
IR	
IR Range	Up to 30 m
Wavelength	850nm
Compression Standard	
Video Compression	Main stream: H.265/H.264 Sub-stream: H.265/H.264/MJPEG
H.264 Type	Baseline Profile/Main Profile/High Profile
H.264+	Main stream supports
H.265 Type	Main Profile
H.265+	Main stream supports
Video Bit Rate	32 Kbps to 8 Mbps
Audio Compression (-S)	G.711/G.722.1/G.726/MP2L2/PCM
Audio Bit Rate (-S)	64Kbps(G.711)/16Kbps(G.722.1)/16Kbps(G.726)/32-192Kbps(MP2L2)
Smart Feature-set	
Behaviour Analysis	Line crossing detection, intrusion detection
Face Detection	Yes
Region of Interest	1 fixed region for main stream
Image	
Max. Resolution	1920 × 1080
Main Stream	50Hz: 25fps (1920 × 1080, 1280 × 960, 1280 × 720) 60Hz: 30fps (1920 × 1080, 1280 × 960, 1280 × 720)
Sub-Stream	50Hz: 25fps (640 × 480, 640 × 360, 320 × 240) 60Hz: 30fps (640 × 480, 640 × 360, 320 × 240)

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Descriptions	Remarks
Image Enhancement	BLC/3D DNR
Image Settings	Rotate mode, saturation, brightness, contrast, sharpness adjustable by client software or web browser
Target Cropping	No
Day/Night Switch	Day/Night/Auto/Schedule/Triggered by alarm in (-S)
Network	
Network Storage	Support built-in microSD/SDHC/SDXC card (128G), local storage and NAS (NFS,SMB/CIFS), ANR
Alarm Trigger	Motion detection, video tampering, network disconnected, IP address conflict, illegal login, HDD full, HDD error
Protocols	TCP/IP, ICMP, HTTP, HTTPS, FTP, DHCP, DNS, DDNS, RTP, RTSP, RTCP, PPPoE, NTP, UPnP™, SMTP, SNMP, IGMP, 802.1X, QoS, IPv6, Bonjour
General Function	One-key reset, anti-flicker, heartbeat, mirror, password protection, privacy mask, watermark, IP address filter
Firmware Version	V5.5.6
API	ONVIF (PROFILE S, PROFILE G), ISAPI
Simultaneous Live View	Up to 6 channels
User/Host	Up to 32 users 3 levels: Administrator, Operator and User
Client	iVMS-4200, Hik-Connect, iVMS-5200, iVMS-4500
Web Browser	IE8+, Chrome 31.0-44, Firefox 30.0-51, Safari 8.0+
Interface	
Audio (-S)	1 input (line in), 1 output (line out), mono sound
Communication Interface	1 RJ45 10M/100M self-adaptive Ethernet port
Alarm (-S)	2 inputs, 2 outputs
Video Output (-S)	CVBS
On-board Storage	Built-in micro SD/SDHC/SDXC slot, up to 128 GB
SVC	H.264 and H.265 encoding support
Reset Button	Yes
General	
Operating Conditions	-30 °C to +60 °C (22 °F to +140 °F), humidity 95% or less (non-condensing)
Power Supply	12 VDC ± 25%, Φ 5.5 mm coaxial plug power PoE (802.3af, class 3)

Descriptions	Remarks
Power Consumption and Current	-Z: 12 VDC, 0.9 A, max. 11 W PoE: (802.3af, 36V-57V), 0.4 A to 0.2 A, max. 12.9 W Without –Z: 12 VDC, 0.6 A, max. 7W PoE: (802.3af, 36V-57V), 0.3 A to 0.1 A, max. 9 W
Protection Level	IP67
Material	Metal
Dimensions	Φ 105 × 294.5 mm (Φ 4.1" × 11.6")
Weight	Camera: approx. 1050 g (2.3 lb.) With package: approx. 1500 g (3.3 lb.)

15.4 Plaza surveillance PTZ camera

The cameras shall be mounted on a mast of 8 meter or higher to allow for general surveillance of the traffic at toll plaza. These cameras shall have: pan, tilt and zoom functions.

The plaza surveillance CCTV cameras shall be installed at a location from where toll plaza area can be viewed. The exact location of the camera and its height shall be proposed by the Contractor at the time of execution and shall be approved by the Engineer.

The technical specifications mentioned hereunder are minimum guidelines. The Contractor shall not deviate materially from the specifications.

Description	Remark
Image Sensor	1/1.9" progressive scan CMOS
Min. Illumination	Colour: 0.002 Lux @(F1.5, AGC ON) B/W: 0.0002 Lux @(F1.5, AGC ON) 0 Lux with IR
Shutter Time	1/1 s to 1/30,000 s
White Balance	Auto/Manual/ATW (Auto-tracking White Balance)/Indoor/Outdoor/Fluorescent Lamp/Sodium Lamp
AGC	Auto/Manual
Day & Night	IR cut filter
Digital Zoom	16×
Privacy Mask	24 programmable privacy masks
Focus Mode	Auto/Semi-automatic/Manual
3D DNR	Support
BLC	Support
HLC	Support

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Description	Remark
WDR	120dB
Optical Defog	Support
EIS	Support
Lens	
Focal Length	5.7 mm to 205.2 mm, 36× Optical
Zoom Speed	Approx.4.4 s (optical lens, wide-tele)
Field of View	Horizontal field of view: 59.8° to 2.0° (wide-tele) Vertical field of view: 33.6° to 1.1° (wide-tele) Diagonal field of view: 68.6° to 2.3° (wide-tele)
Aperture Range	F1.5 to F4.5
PTZ	
Pan Speed	Configurable, from 0.1°/s to 210°/s, Preset Speed: 280°/s
Movement Range (Tilt)	From -20° to 90°
Tilt Speed	Configurable, from 0.1°/s to 150°/s, Preset Speed: 200°/s
Presets	300
Patrol Scan	8 patrols, up to 32 presets for each patrol
Pattern Scan	4 pattern scans, record time over 10 minutes for each scan
Park Action	Preset/Pattern Scan/Patrol Scan/Auto Scan/Tilt Scan/Random Scan/Frame Scan/Panorama Scan
PTZ Status Display	Support
Preset Freezing	Support
Scheduled Task	Preset/Pattern Scan/Patrol Scan/Auto Scan/Tilt Scan/Random Scan/Frame Scan/Panorama Scan/Dome Reboot/Dome Adjust/Aux Output
Smart Features	
Smart Detection	Intrusion Detection, Line Crossing Detection, Region Entrance Detection, Region Exiting
Smart Tracking	Manual Tracking, Auto Tracking, Event Tracking
Smart Record	
IR	
IR Distance	200 m
Smart IR	Support
Network	

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Description	Remark
Max. Resolution	1920 × 1080
Main Stream	50Hz: 25fps (1920 × 1080, 1280 × 960, 1280 × 720) 50fps (1920 × 1080, 1280 × 960, 1280 × 720) 60Hz: 30fps (1920 × 1080, 1280 × 960, 1280 × 720) 60fps (1920 × 1080, 1280 × 960, 1280 × 720)
Sub-Stream	50Hz: 25fps (704 × 576, 640 × 480, 352 × 288) 60Hz: 30fps (704 × 480, 640 × 480, 352 × 240)
Third Stream	50Hz: 25fps (1920 × 1080, 1280 × 960, 1280 × 720, 704 × 576, 640 × 480, 352 × 288) 60Hz: 30fps (1920 × 1080, 1280 × 960, 1280 × 720, 704 × 480, 640 × 480, 352 × 240)
ROI	Support
SVC	Support
Video Compression	Main Stream: H.265+/H.265/H.264+/H.264 Sub-Stream: H.265/H.264/MJPEG Third Stream: H.265/H.264/MJPEG H.264 with Baseline/Main/High Profile
Audio compression	G.711alaw/G.711ulaw/G.722.1/G.726/MP2L2/PCM
Protocols	IPv4/IPv6, HTTP, HTTPS, 802.1x, Qos, FTP, SMTP, UPnP, SNMP, DNS, DDNS, NTP, RTSP, RTCP, RTP, TCP/IP, DHCP, PPPoE, Bonjour
Simultaneous Live View	Up to 20 channels
User/Host	Up to 32 users 3 levels: Administrator, Operator and User
Security Measures	User authentication (ID and PW), Host authentication (MAC address); HTTPS encryption; IEEE 802.1x port-based network access control; IP address filtering
System Integration	
Alarm Input / Output	7-ch alarm input and 2-ch alarm output
Alarm Linkage	Alarm actions, such as Preset, Patrol Scan, Pattern Scan, Memory Card Video Record, Trigger Recording, Notify Surveillance Center, Upload to FTP/Memory Card/NAS, Send Email, etc.
Audio Input / Output	1-ch audio input and 1-ch audio output

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15.5 PTZ Keyboard

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The camera controller keyboard shall be provided to control the toll plaza camera equipped with pan, tilt and zoom functions. The keyboard shall have the following functions:

Descriptions	Remarks
Control Mode	IP-based
TFT LCD Panel	7" TFT LCD monitor with touch panel
	Resolution: 800 × 480
Joystick	4-axis joystick
Audio Input / Output	Line In : 1-ch, 3.5 mm connector (2.0 Vp-p, 1 kΩ)
	Audio Out : 1-ch, 3.5 mm connector (Linear, 560 Ω)
External Interface	Network Interface : 1 10M/100M/1000M Ethernet interface
	RS-232 Interface : 1, RS-232 interface
	RS-485 Interface : 1, RS-485 interface
	USB Interface : 1, USB2.0 (for data storage and device upgrade)
General	Power Supply : 12V DC
	Power Consumption : ≤ 15W
	Working Temperature: -10°C ~ 55°C (14°F ~ 131°F)
	Working Humidity: 10% ~ 90%
	Dimensions (W × D × H) : 435 × 193 × 110 mm (17.13" × 7.60" × 4.33")
	Weight : 2 Kg (4.41lb)

15.6 CCTV Cabling for Video Transmission

The Contractor shall provide all equipment and cabling necessary for the transmission of video signals from the cameras to the respective control room in the Plaza Control Buildings and the transmission of control signals in the reverse direction. All equipment associated with the video and control transmission system shall be installed at locations to be agreed with the Engineer.

For video signals the Contractor shall use either an optic fibre, coaxial based or Ethernet system. The control transmission shall use digital signals and the medium shall be optic fibre, twisted pair telephone or Ethernet cabling. The PVC over-sheath to the trunk cables and video cables shall be installed at locations to be agreed with the Employer. Ducts provided by others shall not necessarily be for the exclusive use of CCTV cables.

The contractor shall ensure that the transmission system and picture quality are not adversely affected by the CCTV cables running adjacent to other voice, data communication, control and low power mains cables. The contractor shall be responsible

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for providing and installing if necessary, sub-ducts within the toll plaza ducting system.

Protective measures shall be included in the CCTV equipment to minimize possible interference effects that the CCTV system may induce onto cables for other equipment and signals.

15.7 Video wall Screen 55"

Contractor to propose in his design the number of screens that he proposes to implement to achieve the requirement mentioned herein.

Descriptions	Remarks
Screen Size	55"
Panel Technology	60Hz D-LED BLU
Resolution	1920x1080
Aspect Ratio	16:9
Brightness	350nit
Contrast Ratio (Typical)	5000:1
Viewing Angle (H/V)	178° / 178°
Response Time	6ms
Direct Lit	Yes
Input	RGB: Analog D-SUB, DVI-D VIDEO: HDMI1,HDMI2, CVBS AUDIO: Stereo mini Jack, USB: USB 2.0 x 1
Output	AUDIO: Stereo mini Jack
External Control	RS232C(In) thru stereo jack, RJ45
Sensor	IR, Ambient Light
Built-in Speakers	10W + 10W
Without Stand (W x H x D)	48.4" x 27.8" x 2"
Packaging (W x H x D)	53.1" x 31.9" x 5.8"
Bezel Width	9.5mm (Top/Side), 15.0mm (Bottom)
Product Weight	34 lb.
Operating Temperature	0°C~ 40°C
Operating Humidity	10~80%
Recommended Run Time	16/7

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15.8 Network Video Recorder

The Contractor shall provide an integrated central control system that is personal computer (PC) based with a fully digital technology video system. The system shall, at least, have the capability to perform the following functions:

1) Standalone CCTV surveillance system
2) Intelligent digital video recording / quick intelligent video playback
3) Remote monitoring
4) Remote control
5) Alarm notification and alarm verification

The system shall be designed in a way that allows live videos or recordings to be transmitted over the gigabit backbone to the Traffic Control Centre.

The minimum NVR requirement shall be as follows:-

Descriptions	Remarks
IP video input	32-ch
Two-way audio input	1-ch, RCA (2.0 Vp-p, 1kΩ)
Recording resolution	12 MP/8 MP/6 MP/5 MP/4 MP/3 MP/1080p/UXGA/720p/VGA/4CIF/DCIF/2CIF/CIF/QCIF
HDMI output / VGA output	2-ch, resolution: HMDI 1:4K (3840 × 2160)/60Hz, 4K (3840 × 2160)/30Hz, 2K (2560 × 1440)/60Hz, 1920 × 1080p/60Hz, 1600 × 1200/60Hz, 1280 × 1024/60Hz, 1280 × 720/60Hz, 1024 × 768/60Hz VGA1: 2K (2560 × 1440)/60Hz, 1920 × 1080p/60Hz, 1600 × 1200/60Hz, 1280 × 1024/60Hz, 1280 × 720/60Hz, 1024 × 768/60Hz HDMI2/VGA2:1920 × 1080p/60Hz, 1280 × 1024/60Hz, 1280 × 720/60Hz, 1024 × 768/60Hz
Audio output	2-ch, RCA (2.0Vp-p, 1KΩ)
Synchronous playback	16 Ch
Interface Type:	1 eSATA interfaces
eSATA	8 eSATA interfaces for 8 HDDs
Capacity	Up to 6TB capacity for each HDD
Network interface	1 RJ-45 10/100/1000Mbps self-adaptive Ethernet interfaces
Serial interface	RS-232, RS-485, keyboard
USB interface	Front panel: 2 × USB 2.0 Rear panel: 1 × USB 3.0

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Descriptions	Remarks
Alarm in	16
Alarm out	4 channel
Power supply	100~240 VAC, 6.3A, 50~60Hz
Consumption	≤30W
Working temperature	-10 °C ~ +55 °C
Working humidity	10%~90%
Chassis	19-inch rack-mounted 2U chassis
Dimensions (W × D × H)	445 × 470 ×90 mm (17.52" ×18.5"× 3.5")
Weight (Without HDD)	≤ 10 kg (22 lb)

16. Cabling

16.1 General

This specification lays down the general, functional and technical requirements of the cabling activities for the installation of the toll management system on the ORR, BURSAN DIST. (GUJARAT).

The specifications of the cables and the cabling part shall follow the General technical Specifications.

It is required that the Contractor shall estimate, at his own risk, the lengths of the cables required from the drawings of the Interchanges provided in the Employer's Requirement Part D: Drawings.

For the evaluation purpose; the cables shall be divided in following major categories as

1) Power cables required for all the lane equipment
2) Earthing cables
3) Data & Control Cables required for the lane equipment
4) Network Ethernet cables
5) Network Optic fibre cables
6) Communication Cables
7) CCTV Video Cables

The type of cables shall be as follows.

No.	Item	Specifications
1	Indoor Power Cable	At Least 1.5 Sq. mm Flexible 3 Core
2	Outdoor Power Cable	At Least Armoured 1.5 Sq. mm 3 Core
3	Earthing Cables	16 Sq. mm Copper PVC Insulated Cable

No.	Item	Specifications
4	Control Cables	As per equipment rating
5	Network Ethernet Cable	UTP CAT 6
6	Network Optic fibre cables	OF-SM 6C
7	Communication Cable	At Least 2 pair 0.5 Sq. mm
8	CCTV Video Cable	Coaxial or UTP CAT 6

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Indoor power and control cables shall at least meet with following specifications:

1) Bright Annealed, 99.97% Electrolytic Grade
2) Copper conductor (Stranded),
3) Voltage grade 1100 V,
4) Single or multi core cable
5) Flame retardant low smoke (FRLS),
6) PVC insulated, rodent repellent
7) High oxygen and temperature index
8) Un-armoured
9) IS 694, IS 8130 OR BS 6004/ BS 6500IEC 60502

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Outdoor Power & Control cables shall at least meet with following specifications

1) Bright annealed, 99.97% electrolytic grade
2) Copper conductor (solid/stranded),
3) Voltage grade 1100 V,
4) Single or multi core cable,
5) Flame retardant low smoke,
6) PVC / XLPE insulated,
7) High oxygen and temperature index
8) Armoured,
9) IS 8130, IS 5831, IS 3975, IS 1554(Part I)/
10) IS 7098 (Part I) OR BS 6346/ IEC 60502

Network Ethernet Cable shall meet TIA / EIA 568 B.2-1

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Optic fibre Cable shall at least meet with following specifications

1) Single Mode 6 Core
2) Attenuation (Cabled) 0.36dB/Km at 1310nm,
3) Attenuation (Cabled) 0.25dB/Km at 1550nm,
4) Cladding diameter 125.0 µm ± 1.0
5) Coated fibre diameter 245 µm ±10
6) Core/cladding concentricity error ≤ 0.8µm
7) Mode field diameter 9.3 ± 0.5 at 1310nm
8) Coating/cladding concentricity error ≤ 12µm
9) Cladding non-circularity ≤ 1.0 %
10) Fibre curl ≥ 4m
11) Zero-dispersion wavelength 1300 to 1322nm
12) Zero-dispersion slope ≤0.092ps/Sq. Nm .km
13) Cut-off Wavelength ≤1260 nm
14) Polarization mode dispersion Coefficient ≤0.2 @ 1310nm
15) Fibre macro bend 100turns,75mm dia. @ 1550nm ≤0.05dB
16) Fibre macro bend 1turn,32mm dia. @ 1550nm ≤0.5dB
17) Coating strip force 1.3 ≤ F ≤ 8.9
18) Minimum proof strength 0.70(100kpsi) GPa
19) Strain 1%
20) As per international standard ITU G 652
21) Armoured for outdoor usage

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Communication cable shall at least meet with following specifications

1) Bright solid annealed copper conductor
2) High density polyethylene insulated
3) Twisted pair with colour coding,
4) Flame retardant low smoke (FRLS)/ FR
5) PVC insulated, rodent repellent
6) With high Insulation resistance
7) Un-armoured/ armoured(Outdoor)
8) ITD specification G/WIR-06/02.May 94.

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CCTV Video Cable shall at least meet with following specifications

1) Solid 99.97% electrolytic grade
2) Annealed copper conductor
3) Attenuation ~ 15db/100m max
4) At frequencies 1000MHz
5) Impedance 75 Ohm
6) Gas injected physical foam dielectric
7) Jelly flooded poly-aluminium first shield
8) Second shield of aluminium alloy
9) With UV & abrasion resistant PVC jacket
10) Rodent repellent with high insulation resistance
11) Un-armoured/ armoured(outdoor)

The estimate of the optic fibre cable required to connect all the Interchange plaza buildings to the respective toll lanes is given in Attachment. The Contractor is advised to make his own estimate. The Employer will not take any responsibility as to the correctness of the cable length.

The contractor shall do his own assessment for the cable lengths to quote the price for the same. The price quoted shall be fixed price only and no variable price would be considered for the cabling price schedule.

The Contract Price shall not be adjusted on account of increase or decrease of the cable length actually required.

17. Power Conditioning Equipment

17.1 General

This specification lays down the general, functional and technical requirements of the power conditioning equipment to be used as a sub-system in the toll management system at the Toll Plaza and TMS buildings.

Contractor shall mention the quantities of the UPS systems planned based upon the load calculation of each functionality of the Toll Management system in his technical proposal.

17.2 UPS system

The UPS system to be provided under the Contract shall comply with the specifications listed hereunder.

17.2.1 20 KVA UPS Power Supply

Item	Specifications
Phase	3 phase in / 1 phase out

Item		Specifications
Capacity		20000 VA/ 18000 Watt
Normal Voltage		3 X400 VAC (3 ph +N)
Voltage Range		305 – 478 VAC(3 Phase)@ 100% Load
Frequency Range		46 ~ 54 Hz or 56 ~ 64 Hz
Power Factor		≥ 0.99 @ 100% load
THDi		< 6% @ 100% load
Output Voltage		208/220/230/240VAC
AC Voltage Regulation (Batt. Mode)		± 1%
Frequency Range (Synchronized Range)		46 ~ 54 Hz or 56 ~ 64 Hz
Current Crest Ratio		3:1 (max.)
Harmonic Distortion		2 %
Transfer Time	AC Mode to Batt. Mode	Zero
	Inverter to Bypass	Zero
Waveform (Batt. Mode)		Pune Sinewave
AC Mode Efficiency		> 92%
ECO Mode Efficiency		97%
Battery Type		SMF Or Tubular
Numbers		20
Charging Current (max.)		12 A settable to 2/4/6/8/10/12 Amps
Charging Voltage		273 VDC ± 1% (Based on 20 pcs batteries)
Indicators		
LCD Panel		UPS Status, Load level, Battery level, Input/ Output voltage, Discharge timer & Fault conditions
Battery Mode		Sounding every 4 seconds
Low Battery		Sounding every second
Overload		Sounding twice every second
Fault		Continuously sounding
PHYSICAL		
Dimensions D x W x H (mm)		592*250*826
Net Weight (Kgs.)		45

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Item	Specifications
Operation Humidity	0-95 % RH @ 0-50° C (non- condensing)
Noise Level	Less than 60 dB @ 1 meter
Management	
Smart RS-232/USB	Supports Windows 2000/ 2003/ XP/ Vista/ 2008, Windows 7/ 8, Linux, Unix & MAC

17.2.2 10 KVA UPS Power Supply

Description		Remark
Phase		1 phase in / 1 phase out
Capacity		10 KVA/ 8000 Watt
Normal Voltage		230 Vac (1 Phase + N)
Voltage Range		160 Vac – 230 Vac (1-Phase) @ 100% load
Frequency Range		46 ~ 54 Hz or 56 ~ 64 Hz
Power Factor		≥ 0.99 @ 100% load
THDi		<6% @ 100% load
Output Voltage		208/220/230/240VAC
AC Voltage Regulation (Batt. Mode)		± 1%
Frequency Range (Synchronized Range)		46 ~ 54 Hz or 56 ~ 64 Hz
Current Crest Ratio		3:1 (max.)
Harmonic Distortion		≤ 2 %
Transfer Time	AC Mode to Batt. Mode	Zero
	Inverter to Bypass	Zero
Waveform (Batt. Mode)		Pure Sinewave
AC Mode Efficiency		91%
ECO Mode Efficiency		97%
Battery Type		SMF
Numbers		20
Charging Current (max.)		6 Amps settable to 1/2/3/4/5/6 Amps
Charging Voltage		273 VDC ± 1% (Based on 20 pcs batteries)
Indicators		

LCD Panel	UPS Status, Load level, Battery level, Input/ Output voltage, Discharge timer & Fault conditions
Battery Mode	Sounding every 2 seconds
Low Battery	Sounding every second
Overload	Sounding twice every second
Fault	Continuously sounding
Dimensions D x W x H (mm)	442 x 190 x 318
Net Weight (Kgs.)	23
Operation Humidity	0-95 % RH @ 0-50°C (non-condensing)
Noise Level	Less than 55 dB @ 1 meter
Smart RS-232/USB	Supports Windows 2000/ 2003/ XP/ Vista/ 2008/ Windows 7/ 8, Linux, Unix & MAC
Optional SNMP	Power management from SNMP manager & web browser

17.3 Power Distribution Equipment

Below are the minimum specification requirements of the power distribution system.

Contractor shall submit the quantities planned along with the technical proposal.

17.3.1 Fabrication:

Panel/ D.B. is to be Wall Mounted, fabricated/ readymade with 14/16SWG CRCA Sheet, Compartmentalized, Double Door hinged type, Gasket to prevent the ingress of Dust & Vermin and shall Confirm to Degree of Protection IP-54 (Panel)/ IP-43(D.B)/ IP-65(Outdoor) with suitable space & direction for cable entry, DB has to be cleaned with 7 Tank Process , Powder Coated with Primer & Epoxy Paint, As Per IS 2174/1962 and amended therefor.

17.4 Busbar:

Busbar has to be Tinned Electrolytic Grade Copper Busbar ≥ 99.97% purity with more than 100% Conductivity, Supported on SMC/ Epoxy insulators, Covered with heat shrinkable colour coded sleeves, With Current Density 1.5 Amp/mm2 with temperature 85 Celsius.

17.5 Switchgears and meters

All Switchgears (MCCB/ MCB/ Fuses/ Measuring Instruments/ Meters/ Indicating Lamps/ Relays / Switches) rating, capacity, make, kA rating, Dimension shall be as per the type of DB with quick make & break type operating mechanism suitable for rotary operation with suitable extended operating handles with capacity & position marking on Door, Flush Mounted, With Suitable spreaders/Links for cable connection, As per IS 1248, 2208, 4237, 8623, 10118(Part I to IV)

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17.6 Wiring:

All power wiring within Panel/D.B. has to be with suitable size flexible Copper wire of 1.1kV grade, C.T. & control Wiring with 2.5sqmm & 1.5Sqmm respectively with 1.1kV Grade with proper lugging, ferruling, and connection with SS Nut - Bolt with adjustable & fixed washer.

17.7 Indication and marking:

All D.B.'s & Panel shall have suitable Main Name Plate, Feeder Name Plate, Danger Board Plate engraved or anodized aluminium type as per IS 2551. All Panels & D.B.'s shall have earthing node/ point/ strip similar to bulbar as per IS 3043.

17.8 UPS ratings for the Interchanges and toll management centre

The suggesting rating of the UPS at each interchange is listed in the Attachment. The Contractor shall make his own calculation of the rating based on the sound engineering practice. The Contractor shall submit the calculation and the rating to the Engineer for his approval.

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Division 5 A- Outline Specifications – Intelligent Transportation System (ITS)

Part-2 Traffic Management System

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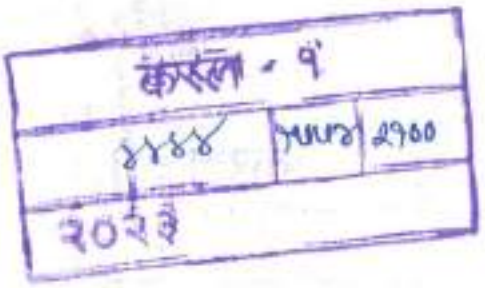
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1. Traffic Management System

1.1 General

This specification covers traffic management system comprising the command control centre system, various roadside equipment, data communication system connecting them, and mobile radio communication system. The centre system shall be a central monitoring and control system for the traffic that traverses the Mumbai Trans Harbour Link (MTHL) in Mumbai, India.

The centre system shall consist of servers, workstations, peripheral equipment, video wall and data communication equipment. The system shall gather traffic and road condition data from roadside equipment, process them into useful road, traffic and weather condition information and disseminate the information to the road users through variable message signs and Internet. In addition, the system shall be equipped with an emergency call system to assist motorists who are in need of help.

The roadside equipment shall include automatic traffic counter cum classifier, closed circuit television camera, meteorological observation equipment, emergency call box and variable message sign. The system shall also monitor the operating condition of the equipment comprising the system. Traffic and road condition shall be stored in the system together with the equipment operation log.

The data communication system shall connect roadside equipment with the command control centre. In addition, it shall provide data communication services for toll management system by connecting toll management centre system with toll plaza system and other applications within MTHL.

It shall be the responsibility of the Contractor to furnish and install all necessary hardware, software, and database, integrate all system components and deliver a complete operational traffic management system. Any equipment, software and work not explicitly mentioned in the Employer's Requirements but necessary for establishing and operating a traffic management system shall be construed to be included in the Contract.

1.2 Command Control Centre system component

The Command Control Centre system shall consist of the following component:

1) Command control centre server.
2) Time server
3) Intelligent transportation system (ITS) workstation;
4) Close circuit television (CCTV) server;
5) Close circuit television (CCTV) switcher;
6) Emergency call box (ECB) workstation;
7) Variable message sign (VMS) workstation;
8) Mobile radio workstation;

9) Network management workstation;
10) External storage device;
11) Video wall;
12) CCTV display monitor;
13) Printers;
14) Internet application server;
15) Internet server;
16) Firewall; and,
17) Data communication equipment.

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1.3 Roadside equipment

Traffic management system shall consist of various roadside equipment for information collection and dissemination. Type and function of the roadside equipment are summarized below.

Facility	Function/Objective
Emergency Call Box (ECB)	Provide communication tool between MTHL users and command control centre to provide assistance in case of accident, breakdown and other incidents.
Closed Circuit Television (CCTV) for traffic	Monitor traffic operation along entire stretch of MTHL. Detect stalled vehicle automatically and alert the operator for his action.
Closed Circuit Television (CCTV) for security	Monitoring of security condition under the bridge
Video Incident Detection System (VIDS)	Detect the incidences like stalled traffic, wrong direction, fallen object, fire, smoke, etc all along the MTHL and generate respective alarms at the Control Center
Automatic Traffic Counters-cum-classifier (ATCC)	Measure traffic volume by vehicle class at each section of MTHL between ICs.
Meteorological Data System (MET)	Detect rainfall, measure precipitation, wind velocity, and wind direction. Inform / warn the MTHL users of adverse driving condition through VMS.
Mobile Radio Communication system (MRCS)	Used for intercommunication between the staff of MTHL. The staff shall include all maintenance and rescue teams of MTHL.

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Variable message sign (VMS)	Provide traffic, road, weather condition and other information to MTHL users with fixed and portable VMS.

Roadside equipment shall be installed at the locations and their quantity shall be as shown below. It shall be noted that the location and quantity are the planning data and their location and quantity may be adjusted at the time of implementation. Contractor shall propose the locations to the Engineer for Approval.

Facility	Location	Quantity
Emergency Call Box (ECB)	At each Truck Layby of the Project. Laybys are planned 3 on each side of traffic direction on MTHL.	6
Closed Circuit Television (CCTV) for traffic	Every 333 m on both sides of entire stretch of MTHL	130
Closed Circuit Television (CCTV) for security	Every 1 km on both sides under the bridge	36
Video Incident Detection System (VIDS)	Every 333 m on both sides of entire stretch of MTHL	130
Automatic Traffic Counters-cum-classifier (ATCC)	One unit for each direction at locations between two interchanges. Eastbound: 1+660 (on VMS), 18+330 (on VMS) Westbound: 16+000 (on VMS), 19+580 (on VMS)	4
Meteorological Data System (MET)	At each Truck Layby of the Project on RHS.	3
Variable message sign (VMS)	For eastbound traffic: KM 1+660 (bridge), KM 18+330 (bridge) For westbound traffic: KM16+000 (bridge), KM19+580 (earth)	4
Portable VMS	Mounted on VMS vehicle	2

1.4 Mobile Radio Communication System

The mobile radio communication system shall consist of base station at the Command Control Centre, vehicle mobile stations and handheld mobile stations. Repeater station shall be provided if necessary.

2. Command Control Centre System

2.1 System capacity

The traffic management system to be supplied under the Contract shall be designed to have the system capacity sufficient to operate and monitor the roadside equipment concurrently with other tasks such as operator's manual operation without noticeable delay.

The loading of the central processors of the server shall be of the order of 50% at the maximum when all scheduled tasks are concurrently executed. The Contractor shall provide a resident program to measure the CPU time loading. The Contractor shall indicate in the Technical Proposal of the Tender the means by which he proposes to demonstrate that this requirement is met.

2.2 System functions

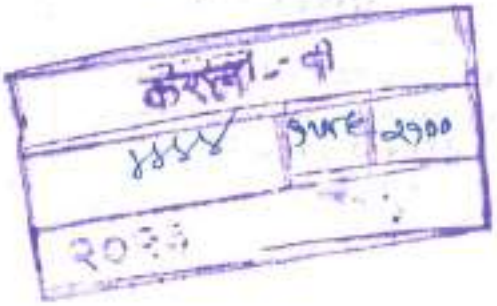
The command control centre system shall have the functions listed below. These functions shall be integrated into a traffic management system.

- Data gathering from roadside equipment.
- Monitoring and control of roadside equipment
- Data communication with roadside equipment
- Database management
- Voice communication with emergency call boxes, mobile phones and fixed line telephones
- Network management and control
- Dissemination of information through variable message sign and Internet
- Human-machine interface
- Automatic traffic monitoring and alarm via VIDS
- System clock
- Operation log
- Fault management
- Report production

The server shall support multi-task, multi-operations functions so that the various functions of the system can be carried out simultaneously with no perceivable delay to the system operators operating the system. This shall be realized by assigning suitable priority level to each software module.

1) Data gathering from roadside equipment.

   The system shall gather the traffic and meteorological data from the automatic



vehicle counter cum classifier and meteorological observation station. It shall also receive the video feed data taken by CCTV cameras. The types of data, data format and collection interval shall be as defined in the requirements for the respective component subsystems and equipment.

2) Monitoring of roadside equipment

All roadside equipment comprising the system shall be constantly monitored for their normal operation. Depending on the type of the equipment monitored, the monitoring mechanism shall be initiated either by the centre system or roadside equipment at fixed interval or as event arises. It shall also be possible for the system operator to initiate the test of roadside equipment and confirm the normal operation.

3) Data communication with roadside equipment

The system shall communicate with the roadside equipment through optic fibre cable network using TCP/IP based data communication system. The communication system shall have redundant dual ring configuration and an interruption of the communication in one ring shall not cause the disconnection of the communication link.

4) Database Management

The server shall store all events within a system in an industry-standard SQL database. The system shall have one centralized database for all the subsystems of the complete traffic management system.

Type and quantity of data to be stored in the database shall be configurable and the system shall have sufficient capacity to store the data for at least ten (10) years of operation.

Each data and event shall be stored with necessary data timestamp to enable the search and retrieval of the data based on the time of occurrence.

At least the following data and events shall be stored:

- Login and logout of operators on to the system.
- All system related events like changes to the system configuration, shutting down and starting of all software services and applications, failure of hardware or software components.
- Data collected from automatic vehicle counter-cum-classifier, and meteorological sensors.
- Incidences collected through VIDS
- Messages and information displayed on the variable message sign.
- Change of equipment operating mode (switching between automatic, manual and local mode of operation) and parameters.
- Emergency call statistics

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- All malfunctions and failures of the automatic vehicle counter-cum-classifier, CCTV cameras, VIDS, meteorological sensors, emergency call box, variable message sign, layer 2 switch, layer 3 switch and media converter.
- Loss of communication link
- All malfunctions and failures of power supply system including low voltage of battery, if any.
- All alarm events triggered by weather conditions, traffic flow parameter and automatic traffic counter-cum-classifier.
- Operator's responses to alarm events.

5) Voice communication

The system shall be provided with a voice communication function with emergency call box, mobile phone and fixed line telephone.

The details of the communication with ECB shall be as defined in the section of emergency call box of this Employer's Requirements.

The mobile workstation shall be provided for the communication with mobile phone and fixed line telephone.

6) Network management and control

The network management function shall be provided to the system. The function shall continuously monitor the conditions of layer 2 switch and layer 3 switch using simple network management protocol. In case a malfunction occurs, network management system shall issue an alarm to the network management workstation.

7) Dissemination of information through variable message sign and Internet

Variable message sign shall be installed at the locations along MHTL as indicated on the drawing. The road, traffic and weather condition information gathered and processed in the command control centre will be provided in text or graphic to the road users through variable message sign and Internet. The information shall be concise and easy to understand. The structure of the message shall be standardized based on the pre-defined nomenclature.

Internet server shall be installed to provide road, traffic and weather condition information and other information related to the operation of MTHL through Internet. Firewall shall be provided to protect the Internet server against the possible attack.

Dedicated Mobile based Applications for Android and iOS shall be developed and made available having various user levels such as System administrator, system user, road user, etc.

8) Human-machine interface

Three kinds of display devices shall be provided as human-machine interface, video wall, CCTV display monitor and workstation display monitor. The CCTV display monitor shall have multiple screen display function in which display area will be divided into smaller screen areas and each of them can display image from

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the different sources. Video wall shall be capable of displaying any image from CCTV system and any workstation.

9) Automated traffic monitoring and alarm

The traffic management system shall have the functionality to monitor data from sub-systems, create alarms to the operator based on the monitored data and recommend actions. Operators shall be able to configure this functionality based on their traffic management experience over time.

If an incident is detected by VIDS system or adverse weather condition is detected by the meteorological observation system, these systems shall send an alarm to the VMS system. VMS system shall then create a warning message indicating the location, type of incident and action to be taken. The message thus created shall not be displayed automatically on the signboard. Instead, a recommendation shall be displayed on the VMS workstation indicating the contents of the message and the location of VMS for which message is recommended. Upon confirmation of the recommendations, the message will be displayed on the specified VMS.

If an abnormal traffic flow parameter is observed at a lane or a section by the automatic traffic counter-cum-classifier, an alarm shall be issued and displayed on the ITS workstation for operator's attention and appropriate action.

10) System clock

The traffic management system shall have a real-time clock Server that shall be used for the timing of monitoring, data transfer, device control, reports, and printouts. The clock server shall have an automatic adjustment function using GPS and the clock shall remain accurate within one second all the time. The real-time clock shall have an internal battery and shall maintain the correct time for at least 48 hours. All sub-systems, equipment and devices comprising the system shall synchronize with the real-time clock.

11) Operation log

All operations by the system operator through the workstation including login and logout shall be recorded as operation log with the operator's ID and time. All malfunctions of the equipment comprising the system shall be recorded with time of occurrence, time of recovery and type of error.

12) Fault management

The traffic management system shall have a fault management system that records and manages all faults and errors (hereafter referred to 'issues') reported by the sub-systems. Each issue shall be associated with all sub-systems including but not limited to ECB, meteorological station, ATCC, VMS, CCTV, network, workstation, system server, time server, Internet server, database, video wall and operating system. The system shall be flexible enough to add more sub-system names. Each entry in the fault management system shall also have a status: new, attended, awaiting parts, temporary fixed and recovered, and corresponding severity level: critical, high, medium and low.

The login to the fault monitoring system shall be integrated with the system login. A new issue shall be automatically assigned "New" status and an alarm shall be automatically issued to the maintenance staff. The system shall record the timestamp of the status change and severity change.

The system shall be able to provide a snapshot of all current unresolved issues at any given time. The system shall also produce a monthly report of all the issues identified during the month, time taken to fix, time taken to close. The system shall also be able to produce fault reports categorised based on the associated sub-system.

13) Report Production

The system shall edit the data and produce the various kinds of report as required herein. The types of report shall include but not be limited to the following:

- Emergency call statistics
- Traffic flow parameters
- Incident Reports
- Weather conditions
- Variable message sign operation
- Equipment malfunction and recovery
- Fault resolution statistics

All report shall be automatically produced according to the schedule and stored in the storage device as the print-out images. For the report periodically produced, a utility program shall be provided to set or cancel the automatic print-out on the printer for each report.

2.3 Workstations

2.3.1 Type and function

The traffic management system shall consist of servers and several workstations as specified herein. Each workstation shall have its own functions and perform the tasks assigned to it under normal conditions. In the event of unavailability of a workstation due to malfunction or maintenance, however, it shall be possible to use any other workstations as substitution to perform the same functions. Access privilege control shall be applied in the same manner when the workstation is being replaced.

The assignment of the functions to each workstation shall be as shown below.

	Workstation	Main functions
1.	ECB workstation	Reception of incoming emergency calls
2.	CCTV switcher	Observation of traffic condition and operation of CCTV camera
3.	VIDS Workstation	To Monitor and respond to all the incidences

4.	ITS workstation	Monitoring and control of the reception and processing of traffic and meteorological data Input and editing of incident data
5.	VMS workstation	Creation and editing of messages to be displayed Control and monitoring of variable message sign
6.	Mobile radio workstation	Communication with mobile and fixed line telephones
7.	Network management workstation	Monitoring and management of the network

14) Emergency call box workstation

The emergency call workstation shall be provided to receive calls from emergency call box installed along the MTHL. Location of the emergency call box issuing an emergency call shall be automatically identified and displayed on the monitor. It shall be possible to transfer the received call to other emergency call receiving telephone. All calls shall be automatically logged and recorded.

15) CCTV workstation

CCTV workstation shall be used to select and control the CCTV camera and manage the recorded video. A camera controller keyboard with a joystick shall be provided to the workstation.

16) VIDS Workstation

VIDS workstation shall be used to monitor all incidences as reported by the VIDS roadside equipment. The incidences shall include, but not limited to wrong direction vehicle, fallen object, accident, fog, fire, etc. It shall be possible to acknowledge the incidences and also the response shall be initiated on the VIDS workstation.

17) ITS workstation

The ITS workstation will be used to monitor and process traffic flow data and weather condition data. In addition, the ITS workstation shall be provided with the event information management function. Information of the event that could affect the traffic on the MTHL will be input through the ITS workstation. The input and editing of event information shall be possible through the selection of the pre-defined event list together with location and duration information to achieve uniformity in the event data management as much as possible.

Event information shall include but not limited to the start and end date and time of planned events, along with the location in kilometre post, direction of travel and number of lanes affected, event category and description of event. The end date and time shall not be mandatory to enter information about unplanned events with uncertain duration.

18) VMS workstation

The variable message sign workstation will be used to create and edit the message to be displayed and control and monitor the variable message signs. The detailed requirements for the VMS workstation is described in the section of variable message sign system.

19) Mobile phone workstation

The mobile workstation shall have the following functions as minimum:

- Phone book to register, edit and delete mobile and fixed line telephone numbers of maintenance organization, maintenance staff, vehicle towing service, ambulance, traffic police and other frequently contacted agencies.
- Display of the calling or called party on the monitor display.
- Call history of both outgoing and incoming calls.

20) Network management workstation

Network management workstation shall be provided to set up and manage a virtual LAN (VLAN). The configuration data shall be stored in the storage device.

The following monitoring function shall be provided:

- Operational status of L2-SW, L3-SW and line
- Failure details (location, date and time, failure part, failure content)

The monitored data shall be stored in the storage device together with operator's inputs as operation log. It shall be possible to search and retrieve the log of specific date and device.

2.3.2 Access control and operation

It shall be possible for any combination of functions to be made available to any level of staff and this combination can be readily changed by keyboard input to the workstation by the persons having the highest access level. Passwords for each level shall be considered as operating parameters of the system and shall be defined in the server system as part of the system parameter. It shall not be necessary to differentiate between display and print of a particular function for the purposes of access control to that function.

The various functions available from the workstations shall be selected from menu type displays through use of cursor controls, programmable function keys, mouse or similar pointing device as per the approval of the Engineer.

Where a function contains too much data for display on a single screen, it shall be possible to use cursor and page control keys to scroll, both vertically and horizontally, the display until the desired data is shown.

2.3.3 Storage device function

All operational data of roadside equipment including failure log information shall be stored in the storage device connected to the command control centre server. Reputed and widely used relational database shall be adopted for the storage of the data. Custom made database management system shall not be accepted. The data shall be

easily searchable with a combination of keys that shall include day, time and item (name of roadside equipment, numbers of roadside equipment or kilo post).

The disk capacity of the storage device shall be calculated considering the need to store the operating system, the application software, other software packages necessary for operation of the system and the data generated by the system to meet the requirements of these Employer's Requirements and to adhere to the manufacturer's recommendations on usable disk capacity for efficient running of programs.

In the calculation of the disk capacity, it shall be assumed that all data generated by the system shall be kept for 10 years in the disk connected with storage device on-line.

The Contractor shall indicate in the Technical Proposal of the Tender the calculations with which the hard disk capacity is chosen.

2.4 Internet server system

Internet server system consisting of an Internet server, a firewall and an application server shall be provided. The basic information to be provided to the road users through Internet shall include but not limited to the following:

- Event and incident on the MTHL such as accident, construction work, lane control, closure, inclement weather and other events that hamper the normal operation of the MTHL.
- Video stream from the selected CCTV camera.

Two types of Internet site shall be prepared, one for access from personal computer and another for access by mobile phone. The site for personal computer shall show the event and incident information in a graphic manner indicating the incident location on the schematic map of the MTHL while the site for mobile phone shall provide the information in text and simplified graphics.

Video image taken by the CCTV camera will be converted to the video streaming signal of the resolution suitable for the distribution through Internet. The user can choose one of the camera symbols indicating the location of camera along the MTHL shown on the display monitor and the video feed taken at the site will be shown.

2.5 Video wall

A video wall shall be provided to the command control centre. The video wall shall be capable of showing two types of images, schematic map of MTHL and video feed from CCTV & VIDS cameras.

The schematic map of the MTHL screen shall show various kinds of static and dynamic information of the MTHL including the location of roadside equipment and its status for the system operator to understand the current condition and to take necessary action. Video feed from the CCTV & VIDS cameras shall also be shown on the video wall.

2.5.1 Video wall layout

A total of 15 units of monitor arranged in three (3) rows and five (5) columns shall be provided as video wall. The size of each display shall be 55 inch or larger. The display

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system shall have two display modes, integrated mode and isolated mode. In integrated mode, video image from a single source shall be shown on multiple monitors, while in isolated mode, each unit shall display video image from different sources independently. Malfunction of a monitor unit shall not prevent normal operation of other monitor units and other part of CCTV camera system.

Video wall shall be mounted on the self-standing structure and video monitors shall be surrounded by a panel paint in mat black of suitable dimensions around them for better view of screen. A digital clock showing date and time provided by the time server shall be placed at the suitable location of panel.

2.5.2 Display items

The video wall shall be capable of displaying the following image and data:

Item	Contents
Route map	Schematic map of MTHL, interchanges and access roads Name of interchange, Kilo-post, Jurisdiction of fire department and police
Equipment location and status	Location of variable message sign and their condition (message / no message and normal / error) Location of CCTV camera Location of VIDS cameras ATCC location details Location of emergency call box and calling emergency call box Location of meteorological station and status
Road, traffic and weather condition	Service level at the location of traffic counter cum classifier Incident (accident, congestion, stalled vehicle, fallen object, construction work) Weather condition (rain, wind velocity, wind direction, precipitation, visibility) Regulation (lane closure, section closure, speed limit)
CCTV video feed	Video feed from the CCTV camera selected Video feed from the VIDS selected
Workstation monitor display	Monitor display of workstation selected
Date and Time	Current system date and time

It shall be possible to selectively show the static and dynamic information on the video wall for easy understanding of the condition.

2.6 Console desk and chair

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The Contractor shall provide the console and the chairs. The number of chairs to be provided shall be two (2) units more than the number of the workstations. The console desk shall be of ergonomic design and neatly accommodate the workstations and cables connected to it to provide efficient and pleasant working environment. It is left to the Contractor's design to use one large size console that accommodates all workstations in the operations room or multiple consoles; each of them accommodates one or more workstations. All cables shall be connected to the workstation through the bottom of the console and shall not be exposed.

The Contractor shall propose the schematic drawing of the console in his proposal.

2.7 Work at command control centre

2.7.1 Layout

The Contractor shall design the layout of the operations room and server room in the command control centre. The operations room is the room where video wall, CCTV monitor display, workstations and consoles will be placed and the operation of the MTHL will be monitored. The server room will be the place where the server, network equipment and other devices will be installed.

The layout shall be designed taking into consideration the function of the server and workstations to be placed in the room, the role of the staff and operators stationed in the room, position of video wall and CCTV monitor screen, cable routes, viewing by visitors and other factors to establish a functional operations room and server room. The layout shall be approved by the Engineer.

The Contractor shall submit the layout plan of the operation room in the tender for reference.

2.7.2 Interior and wiring works.

The command control centre buildings will be constructed by the contractor. The design of the building is as shown in the Drawings. It shall be noted that the drawings included in the Tender Documents show the latest design of the building available at the time of tender documents preparation and the actual construction may differ from the design which shall be preapproved by the Engineer.

The operations room and server room at the command control centre will be handed over to the ITS team without interior works such as ceiling, lighting and flooring. The air-conditioning system will be provided by the contractor. The Contractor shall examine the building design and complete interior works based on his own design and requirements of the equipment to be placed there. Raised floor shall be provided to the whole or part of the rooms for under-floor cabling. All LAN cable and power cable shall be connected to the equipment through the bottom of the equipment. No cable shall be exposed.

The Contractor shall design and construct the panel around the video wall and support for them.

All interior work designs shall be subject to the prior approval by the Engineer.

2.8 Specifications

2.8.1 Traffic management system server

The traffic management system server system shall consist of single server and cluster configuration of servers is not required.

The server and workstation computer hardware shall be standard models manufactured by organizations of international repute. Custom built or non-standard equipment shall not be acceptable.

The computer hardware including printers and display terminals shall be readily available in Mumbai, India. Full maintenance support services and ready availability of consumables, spare parts or replacement units shall also be assured from a third party, based in India; who is not connected with the Contractor and his agent.

The specifications in this section are provided as reference. The server to be provided by the Contractor shall materially comply with these specifications and shall be subject to the approval by the Engineer.

Description	Specifications
Chassis	2 U Rack Mountable
CPU	Four numbers of latest generation Intel Xeon 14-Core processor 2.2 GHz, 19.25 MB Cache, 105W
Memory	256 GB RAM using 32GB Module scalable to at least up to 1.5TB, using DDR4 2666MHz DIMM (RDIMM) memory modules.
HDD Bays	4* 1.6 TB SSD with each SSD having minimum endurance of 3 DPWD
Optical drive Bay	One optical drive DVD-RW
Controller	Server should have RAID controller with 4GB battery backed write cache (on-board or in a PCI Express slot)
Networking	Server should support networking cards with below features:
	1Gb 2-port network adaptor supporting advanced features
	10Gb 2-port with dual SFP+
HBA	Dual 16GB single port PCIe Fibre Channel Host Bus Adapter with Optical Module
PCI Slots	Minimum 6 PCIe Gen 3.0 x4 Slots
Power Supply	Redundant 1500W Platinum hot plug power supply
Fans	Redundant hot-plug system fans
Display Controller	Should support VGA

Description	Specifications
Management and Maintenance	The server should be provided along with the out-of-band remote management and maintenance capability. Remote management should be possible by using API and Web based GUI
Warranty	5 year on site OEM Warranty with 24X7 support and Next Business Day (NBD) resolution
Operating System	Require this server with Two x MS Windows 2012 Standard 64Bit Operating System

2.8.2 Time server

A time server shall be provided to the command control centre system to synchronize all servers and workstations operating in the traffic management system with the standard time obtained from GPS (global positioning system) satellite.

Time server shall communicate with the servers and workstations through Network Time Protocol (NTP) to adjust the real-time clock of servers and workstations. All servers and workstations shall be provided with simple network time protocol (SNTP) or network time protocol (NTP) software running under a variant of the UNIX or Windows operation systems.

A GPS antenna shall be provided together with the time server to receive the GPS satellite signal. The antenna shall be installed at the proper location of good reception at the traffic management Centre building.

The time server shall be provided with a built-in crystal oscillator to maintain the accurate time when time information is not available from GPS satellites for the minimum duration of 24 hours.

No.	Descriptions	Remarks
1.	Built-in crystal accuracy	Average weekly deviation +/- 0.7 seconds at 25°C
2.	Correction accuracy	+/- 1 ms or less
3.	Time error	Less than 1 ms
4.	Leap second	Supported
5.	Information from GPS satellite	Year, month, day, hour, minute, second and leap second information
6.	Indicator	Time synchronization status Error
7.	Network protocol	IPv4 and IPv6
8.	Input sensitivity	15 dBi to 30 dBi

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9.	Network protocol supported	UDP/IP, TCP/IP, ICMP, 10BASE-T/100BASE-TX
10.	Time information protocol	NTP v3, NTP v4, Time Protocol, Daytime Protocol
11.	Parameter setting	Through front panel and Web browser

Main unit

No.	Descriptions	Remarks
1.	Rated voltage	90-250 V AC
2.	Rated frequency	50/60 Hz
3.	Rated current	12A or less
4.	Power consumption	10 W or less
5.	Operating temperature	0°C to 40°C
6.	Operating humidity	20 to 80 % non-condensing
7.	Installation	Rack mount
8.	EMI	VCCI-A compliant

GPS antenna

No.	Descriptions	Remarks
1.	Rated voltage	30-140 V AC
2.	Operating temperature	-30°C to 85°C (antenna) -10°C to 65°C (coaxial cable)
3.	Operating humidity	95 % or less non-condensing
4.	Water proof	IPX6

2.8.3 Internet server

Description	Specifications
Chassis	2 U Rack Mountable
CPU	Four numbers of latest generation Intel Xeon 14-Core processor 2.2 GHz, 19.25 MB Cache, 105W
Memory	256 GB RAM using 32GB Module scalable to at least up to 1.5TB, using DDR4 2666MHz DIMM (RDIMM) memory modules.
HDD Bays	4* 1.6 TB SSD with each SSD having minimum

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Description	Specifications
	endurance of 3 DPWD
Optical drive Bay	One optical drive DVD-RW
Controller	Server should have RAID controller with 4GB battery backed write cache (on-board or in a PCI Express slot)
Networking	Server should support networking cards with below features:
	1Gb 2-port network adaptor supporting advanced features
	10Gb 2-port with dual SFP+
HBA	Dual 16GB single port PCIe Fibre Channel Host Bus Adapter with Optical Module
PCI Slots	Minimum 6 PCIe Gen 3.0 x4 Slots
Power Supply	Redundant 1500W Platinum hot plug power supply
Fans	Redundant hot-plug system fans
Display Controller	Should support VGA
Management and Maintenance	The server should be provided along with the out-of-band remote management and maintenance capability. Remote management should be possible by using API and Web based GUI
Warranty	5 year on site OEM Warranty with 24X7 support and Next Business Day (NBD) resolution
Operating System	Require this server with Two x MS Windows 2012 Standard 64Bit Operating System

2.8.4 Workstation

The Contractor shall provide the workstations as listed hereunder. The workstations shall be the same model and shall have the same configuration.

The specifications in this section are provided as reference. The workstations to be provided by the Contractor shall materially comply with these specifications and shall be subject to the approval by the Engineer.

Description	Specifications
CPU	Intel Core i5- 6500 Processor (Quad Core , 6 MB Cache, upto 3.60 Ghz w/Turbo Boost) or better

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Chipset	Intel Original Q170 PCH-H vPro or better
Memory	08 GB (1 X 8 GB) DDR4 Synchronous Dynamic Random Access Memory
Hard Disk Drive	1TB 7.2K SATA 6Gb/s 2.5inch
Display	18.5inch/ EPEAT Silver/energy star/ 1366x768 resolution/LED Backlit/power consumption 15W/
Video Card	Intel vPro Technology/ Discrete Graphics Supported
Keyboard	104 Keys
Mouse	Optical with USB interface
Sound Card	DTS Studio Sound
Ports	Serial Connector/RJ-45 Network Connector/(2) USB 3.0 Ports with Wake from S4/S5 feature/Line-In Audio Connector/PS/2 Mouse Connector/Line-Out Connector for powered audio devices/(4) USB 3.0 Ports/VGA Monitor Connector/(2) DisplayPort Monitor Connectors/PS/2 Keyboard Connector/Hard Drive Activity Light/5.25-inch Half-Height Drive Bay (behind bezel)/Microphone/Headphone Connector/USB 2.0 Fast Charging (powered) Port (black/Headphone Connector
Cabinet	Tower architecture
Optical Drive	9.5mm Slim Desktop Super-Multi DVDRW Drive
Graphic Card	Should have 02GB dedicated Graphic Card
Networking facility	Intel® I219LM Gigabit Network Connection LOM (standard)
Operating System & Office S/W	Windows 10 Pro 64Bit preloaded with the media and documentation and Certificate of authenticity. Latest MS Office Pro License
Power Management	High Efficiency Energy Power Supply/Energy Star Certified/ EPEAT Gold
Warranty	Workstation should have 05 years 24 hours a day, seven days a week for assistance on resolving issues. Hardware onsite response within four hours if needed
Software require	Workstation should have 05 years Total security Anti-virus
Server Access CALS	Workstation should be provided with Windows 2012 standard server device CALS

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2.8.5 Operations laser printer (colour)

The operations printers shall be a high-speed A3/A4 size colour laser printer. The printers shall be connected to the LAN of the traffic management system.

Technical Specifications:

No.	Descriptions	Remarks
1	Make/Model	HP Colour LaserJet M751n or equivalent
2	Printing speed	Up to 40 ppm (colour, black, A4) Up to 40 ppm (colour, black, A3)
3	First page out	Not more than 7 second (black, colour)
4	Print resolution	Up to 1200 x 1200 dpi (black) Up to 1200 x 1200 dpi (colour)
5	Monthly duty cycle	Up to 150,000 pages (A4)
6	Print language	PCL 6, PCL 5
7	Paper trays	2 (standard)
8	Media size	A3 / A4
9	Duplex (both sides) printing	Manual
10	Connectivity	Hi-speed USB 2.0, 1 Gigabit/Fast Ethernet
11	Network	Built-ibn Ethernet
12	Power consumption	870 watts (max. printing), 850 watts (typical printing), 48 watts (ready), 0.6 watts (sleep)
13	Operating temperature	10 – 30 °C

2.8.6 Operations laser printer (black and white)

The operations printer shall be a high-speed A3/A4 size black and white laser printer. The operations printers shall be connected to the LAN of the traffic management system.

Technical Specifications:

No.	Descriptions	Remarks
1	Make/Model	HP LaserJet M806 or equivalent
2	Printing speed	Up to 55 ppm
3	First page out	As fast as 8.5 second
4	Print resolution	Up to 1200 x 1200 dpi

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No.	Descriptions	Remarks
5	Monthly duty cycle	Up to 300,000 pages
6	Print language	PCL 6, PCL 5
7	Paper trays	3 (standard)
8	Media size	A3 / A4
9	Duplex (both sides) printing	Automatic
10	Connectivity	Hi-Speed USB 2.0 port 1 Gigabit Ethernet
11	Power consumption	1000 watts (printing), 38 watts (ready), 6.5watts (sleep)
12	Operating temperature	10 – 32 °C

2.8.7 Storage Device

The storage device shall be a microprocessor based system with components and circuit boards supplied by manufacturers of international repute. Custom built or non-standard equipment shall not be acceptable to the Employer.

The technical specifications mentioned hereunder are minimum requirements. The Contractor shall not deviate materially from the specifications specified and shall obtain the approval from the Engineer.

S/N	Specification
1	Unified Storage Solution should be IP Based/iSCSI/FC/FCOE/NFS/CIFS as per the application requirement
2	Controllers shall be active-active so that a single logical unit can be shared across all offered Severs. The storage should have no single point of failure on components like controllers, disks, cache memory, I/O Ports, Power supply, Fan, etc.
3	Storage solution should comprise of Active-Active Load Balancing Storage Controllers with 64GB Cache from day one. If cache is provided in additional hardware for the storage solution, then cache must be over and above 64 GB. The storage solution should be scalable up to 256GB Cache.
4	The storage array must have complete cache protection mechanism either by de-staging data to disk or providing complete cache data protection with

S/N	Specification
	battery backup for minimum 48 hours
5	Storage Capacity: Two storage pools, one with 30 TB (in RAID 5 Configuration) applications using SAS-SSD Disks and another pool of minimum 150TB for backup using NL-SAS/SATA Disk. Bidder is free to offer more capacity as per his solution requirement
6	Disks should be of 600 GB/ 900 GB/ 1 TB or more 12 Gbps SSD drives
7	Storage should support all industry standard RAID type like RAID 0, 1, 10, 5,6 & 50
8	The proposed Storage should support 6/12 Gbps Drives. it should support SSD, SAS & NL-SAS all type of Drives.
9	The overall storage solution should scalable up to 2 times of current usable disk space Storage without addition of controllers.
10	The offered Storage solution shall be supplied with at least 4 nos. of 10G IP Ports/ 16 Gbps FC ports (Depending upon the connectivity planned) and 4 Nos of 1GE iSCSI ports.
11	Modular design to support controllers and disk drives expansion
12	Should be Rack Mountable
13	The controllers / Storage nodes should be upgradable without any disruptions / downtime
14	Licenses for the storage management software should include disc capacity/count of the complete solution and any additional disks to be plugged in the future, up to max capacity of the existing controller/units.
15	Should be able to manage from Web and Command Line console for entire storage system.
16	Dual SAN Switch with desired no of ports activated as per the server count

2.8.8 Video wall

The specifications in this section are provided as reference. The video wall to be provided by the Contractor shall materially comply with these specifications and shall be subject to the approval by the Engineer.

No.	Descriptions	Remarks
1	Display panel	S-IPS
2	Display size	55 inch
3	Number of pixels	1920 x 1080 (full HD)

4.	Contrast ratio (typical)	1200:1 or higher
5.	Brightness (typical)	400 cd/m^2 or higher
6	Viewing angle	178° vertical, 178° Horizontal
7	Bezel-to-bezel width	4.0 mm or less
8	Input terminal	Display port, DVI-D, or HMDI
9	Power consumption	140W
10	Operating temperature	5 – 40 ℃
11	Relative humidity	20-80%
12	Reliability and maintainability	MTTR: 1.0 hour

2.9 Software

2.9.1 General

The Contractor shall provide a set of software to operate on the servers, workstations, roadside equipment, and other components and devices to be provided under the Contract. The software shall function as a system to provide end results required in the Contract.

The software will be either the software that the Contractor already has, is modified from the exiting software, or the new software to be developed for the Project. The copyright of the software specifically developed for the project shall remain with the Contractor.

The set of the software to be provided shall consist of those provided by third party and those specifically developed for the project. All third-party software shall be legally licensed and there shall be no restriction on the use in the traffic management system. They shall be registered under the name of Employer and any supports and services provided by the software developer including update and revision shall be available to the Employer.

The software to be specifically developed for the Project shall be fully tested and shall be free from bugs. The Contractor shall state in the Technical Proposal of the Tender the software quality assurance program that he intends to adopt in development and implementation of the software.

The programming of the applications shall be arranged in such a way that maximum flexibility is afforded by the design to allow the Employer to implement modifications or additional equipment which may become available or desirable during the working life of the system. Comprehensive documentation of the software and source codes shall be provided under the Contract to allow such changes to be implemented by the Employer without recourse to the Contractor.

The Employer may wish to implement additional software packages to run concurrently with the software provided under the Contract. These packages may include but will

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not be limited to the following:

21) Programs allowing the traffic management system to operate with other systems such as toll management system interfaced to the data network and involving bi-directional transfer of files.

22) Analytical and statistical program to process the data collected by the system.

23) Software that offers new service to the road users through Internet.

24) Utility and security software that detects any suspicious or erroneous operation of the system.

The Contractor shall propose in the Technical Proposal of the Tender the feasibility and ease with which such applications might be implemented using the traffic management system proposed by him and shall advise the spare memory capacity and processing power which could be available, but not necessarily provided, within the proposed computer to allow such applications to be implemented.

2.9.2 Third party software

The third party software to be provided shall include but not be limited to the following:

25) Server operating system

26) Storage device operating system

27) Client operating system

28) Database management software

29) Firewall and antivirus program

30) Network Management Software

All third-party programs to be provided shall be the software widely used and suitable for the application of traffic management system in terms of functions, capacity, speed, interface with other software, maintenance and user friendliness. The Contractor shall state in the Technical Proposal of the Tender, the third-party software that he proposes. If the Contractor proposes the third-party program that is of limited use, he shall explain the reason for using it in the Technical Proposal of the Tender.

If the third-party software is provided in CD or DVD, the original CD or DVD shall be submitted as part of documentation. The requirement is not applicable to the software preinstalled in the server or workstation.

2.9.3 Traffic management system software

The Contractor shall develop new software or modify the existing software to provide the traffic management system functions specified herein and elsewhere in the contract documents.

The software to be provided as traffic management system software shall include but not be limited to the following:

31) Command control centre software

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32) Utility software

33) Maintenance activity tracking and logging software

The actual configuration of software modules may not be necessarily as listed above; but it shall follow the requirements in the Employer's Requirements.

All software shall be of modular construction and the interaction between the modules shall be kept minimum. They shall be designed to operate continuously, and no periodical maintenance of the software shall be required.

All the display on the display monitor and printed report shall be in English.

The utility software shall include but not be limited to the system backup and restoration, database backup and restoration, and access control and operation log functions. Usage of the server and workstations shall be controlled by log in/out procedure and different levels of access control shall be provided to restrict the use of certain software by unauthorized persons. All operations shall be recorded as a log together with staff identification number.

The software that interacts with the system operator shall be provided with fault tolerant functions and access control functions. They shall be designed in such a way that any operation error shall not cause damage to the system, loss of data or system shut down.

All software shall be tested under the different conditions and cases including incorrect operation by the system operator and erroneous data to verify the sturdiness of the software. The software testing shall also include appropriate load and stress testing.

2.9.4 Outline of software

The Contractor shall describe in his Technical Proposal application software to be provided to the servers and workstation in the command control centre required hereunder.

- Graphical presentation of module and components comprising application of servers and workstation.
- Data processing flow in the form of class diagram, use case diagram, sequence diagram, or data flow diagram.
- Scale or size of the module and components, and programming language used
- Extent of the development required for the Project

3. Emergency Call Box System

3.1 General

This specification covers emergency call box (ECB) system to be installed as one of the sub-systems of the traffic management system for MTHL. ECB system provides a communication tool for the MTHL users in case of emergency. Any call made from an ECB shall be received in a centralized manner by the operator at the ECB workstation in the command control centre. The system shall operate on a 24-hour a day 7-day a week basis.

ECB shall have a good sound quality under the noisy condition on the MTHL. The conversation shall be possible at a noise level of 95 dB.

It shall be the responsibility of the Contractor to furnish and install all necessary hardware, software, and database, integrate all system components and deliver a complete operational emergency call box system.

3.2 System configuration

The ECB system shall consist of the following components;

- ECB at roadside;
- Command control centre Server;
- ECB workstation at command control centre; and,
- Network equipment.

ECB shall be a hand-free type with a microphone, a speaker and a "CALL" button incorporated in the cabinet. A dedicated workstation shall be provided at the command control centre for handling all incoming calls. IP based network equipment shall be provided to connect the ECB at roadside with the ECB workstation at command control centre.

Dedicated ECB operation console may be used in lieu of ECB workstation at the command control centre provided that the console provides the same functions as required herein.

3.3 System functions

ECB workstation shall show the schematic map of MTHL with the location of ECB on the monitor display. The status of each ECB shall be indicated in different colours. The following ECB status shall be indicated in different colours or flashing:

- Standby
- Calling
- Connected
- On-hold
- Transferred
- Out of order

ECB system shall be provided with the functions described below.

34) Call reception function

A call will be initiated by a road user by pressing the CALL button provided to the front surface of the ECB. The call shall be transferred to the ECB workstation at the command control centre through the data communication network. Upon reception of a calling signal, ECB workstation shall issue an alarm on the monitor display of the ECB workstation. The monitor display shall show the schematic map of the MTHL and the calling ECB shall be indicated by a flashing ECB symbol on the map. At the same time, the video wall shall show the incoming call by flickering the ECB symbol at the location of calling ECB on the schematic map of the MTHL.

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The call shall be connected to the speaker and microphone of the ECB workstation, or headset if it is connected to the ECB workstation. Communication link shall be established by operator clicking the calling ECB symbol on the monitor display and the status on the monitor display shall change to connected status. The communication shall be two-way.

Upon termination of a call, the operator will press END button or click the ECB being connected on the monitor display, upon which the connection will be released. No action shall be required for the caller at the roadside to terminate the call.

The ECB system shall be capable of handling multiple calls at a time. This shall be realized by holding the calls not being attended and re-connecting the call being on-hold. The Contractor shall describe in his Technical Proposal the details of the operation to handle multiple calls.

35) Call Transfer

It shall be possible to transfer a call being received to another ECB receiving telephone installed at the maintenance office, traffic police, ambulance station and other designated telephones. It shall be possible to designate a maximum of 20 telephone numbers as ECB receiving telephone.

It shall be possible for the operator at the ECB workstation to monitor the call already transferred to other telephone. The monitor display shall indicate whether the call is connected or terminated.

36) Caller location identification

ECB or the network equipment connected to the ECB shall send an ID signal when a call is initiated. The ECB workstation shall identify the location of the calling ECB and indicate on the monitor display as in the form of kilo-post and direction.

37) Call recording

Conversation of all calls including the call transferred to other telephone shall be automatically recorded in the storage device of the ECB workstation with time stamp. It shall be possible to assign type of call for each record and search the recorded messages with type of call, date and location.

38) Call history

ECB system shall be capable of displaying call history list in chronological order together with location of call on ECB workstation monitor and video wall.

39) Call termination

A connected call shall be terminated and the communication link shall be released upon pressing or clicking "END" button by the operator at the ECB workstation

40) Diagnosis

The ECB system shall have a diagnosis function. The ECB workstation shall inquire the connection with the ECB and the status of ECB by sending the diagnosis signal in every five (5) minute. If ECB fault signal is received or there is

no response from the ECB, the ECB workstation shall issue an alarm and the fault shall be recorded in the log.

The ECB workstation shall also be designed to accept the calls from the land line and Mobile phones; in which all other functionalities except location tracing shall be designed exactly similar to the calls coming from ECB on MTHL.

The Contractor shall state in his Technical Proposal, the types of error and malfunction of the Emergency Call Box System that can be diagnosed from the ECB workstation.

3.4 Monitor display and report

The ECB workstation shall be capable of showing the following screens:

Item	Contents
Route map	Schematic map of MTHL, interchanges and access roads Name of interchange Kilo-post Jurisdiction of fire department and police
Emergency call	Location of emergency call box and calling emergency call box Call status (connected, on hold, transferred) Call history (location, call date and time, duration)
Error log	Error record
Date and Time	Current date and time

The ECB workstation shall produce the reports listed below upon the system operator's request. It shall be possible to output the report as a file in portable document file format.

Item	Contents
Emergency call	Call history (location, type of call, date and time)
Error log	Error record

3.5 Cabinet

The ECB shall be housed in a cabinet together with power supply, network equipment and terminal board. The cabinet shall be rugged but ergonomic in design. Anti-corrosion treatment against constant onslaught of waves and salt spray shall be applied to the cabinet if it is made of steel. ECB shall be either a cabinet put on a pedestal or integrated self-standing type.

41) The cabinet shall not exceed the dimensions of 300 mm (W) x 1000 mm (H) x 300

mm (D).

42) The cabinet shall be electrically and mechanically robust and shall have a degree of protection of IP 55.

43) The push button shall be electrically and mechanically robust having a degree of protection of IP66. It shall have a diameter of 30 mm or larger with the letter "CALL" or other word as approved by the Engineer engraved on it. Push button shall have physical reaction when pressed and touch sensitive type shall not be used.

44) The SOS symbol or telephone symbol shall be displayed prominently on the cabinet. Part of the cabinet shall be provided with reflective sheet for easy identification during dark hours. The symbol design, colour of the cabinet and other design factors shall be subject to the approval of the Engineer.

45) The anti-lightning and surge protection complying with the IEC 61643-1 shall be provided.

46) The cabinet shall be finished with the anticorrosive treatment. The Contractor shall state the details of the anticorrosive treatment and painting in his Technical Proposal.

The Contractor shall submit the outline dimensioned drawing of the cabinet and the component layout drawing of the ECB in his Technical Proposal.

3.6 Installation location

The ECB shall be installed at every layby to be constructed at the location indicated on the Drawings of the Employer's Requirement. The location indicated in the Drawings is tentative and the Contractor shall examine the location for suitability and obtain the approval from the Engineer.

The ECB shall be installed on the outside parapet (wall) of the bridge and outside of guardrail at earth section. At guardrail section, the ECB shall be installed in such a way that the caller faces the incoming traffic.

At bridge section, footing of the ECB with the cable conduit will be constructed by the bridge contractor. At the guardrail section, the Contractor shall modify the existing guardrail and provide an access path to the ECB. If no guardrail is provided to the ECB site, the Contract shall provide the guardrail for about 10 meter to protect the ECB and caller. A platform of the suitable size shall be provided in front of the ECB for the caller to stand on. Handrail shall also be provided at all ECB locations except for the ECB located on the bridge to prevent the caller from falling down the slope. The Contractor shall submit the standard installation drawing of the emergency call box in his Technical Proposal.

3.7 Guide sign

The Contractor shall provide and install guide sign indicating the Command control Centre help line telephone number and chainage of the location at 1 km intervals. The guide sign shall be made of engineering grade reflective sheet attached to aluminium plate having the dimension of approximately 400 mm x 200 mm. The design and colour of the guide shall be subject to the approval of the Engineer's Representative.

3.8 Power supply

3.8.1 Type of power supply

Emergency call box shall operate with DC 12V, DC 24V, or AC 240V power supply. In case DC power is used, the ECB shall be provided with power supply unit that converts AC power to DC power.

3.8.2 Power consumption

Power consumption of all types of ECB shall be 50VA or less.

3.9 Specification of ECB

No.	Item	Specification
1	Operation type	Hands free
2	Noise level	95 dB
3	Speaker	Type: Water resistant Max Power: 15W Impedance: 8 ohm ±15% Bandwidth: 40 Hz to 8 KHz ECB interface output Power: 0 to 6 W
4	Microphone	Type: Dynamic microphone Sensitivity: 1.9 mV +/-3dB /Pa Impedance: 200 ohms Input level at ECB interface: -20 to -50 dBm
5	Cabinet size	W300mm H1,000mm D300mm or less
6	Protection class	IP65
7	Protocol	TCP/IP,UDP/IP,SNMP
8	LAN terminal	10 BASE-T/100BASE-TX (RJ-45)
9	Power Requirements	12 V, 24V ±10% DC, AC 240V
10	Power Consumption	50 VA or less
11	Environmental conditions	0 - +50 °C
12	Reliability and maintainability	MTBF: 30,000 hours MTTR: 0.5 hours

4. Closed Circuit Television System

4.1 General

This specification covers the closed-circuit television (CCTV) system to be introduced to the MTHL. The CCTV camera of different specification shall be installed at the

various locations along the MTHL for different use. In principle, there shall be three types of CCTV camera.

47) CCTV camera for traffic surveillance along MTHL

48) CCTV camera for security surveillance under the bridge along MTHL

49) CCTV camera for security surveillance at toll plaza, toll office area and other locations.

The images taken by camera shall be transmitted to the command control centre in real time using data communication system to be installed along MTHL. In the centre, images are selectively shown on the monitor display of CCTV workstation and the video wall. At the same time, images from all cameras shall be recorded on the storage device. The system shall operate on a 24-hour a day 7-day a week basis. CCTV camera system shall be IP based.

The CCTV system shall be capable of clearly taking video of road, traffic and security conditions under any brightness conditions during the daytime and night time that occurs at CCTV camera locations.

It shall be the responsibility of the Contractor to furnish and install all necessary hardware, software, and database, integrate all system components and deliver a complete operational CCTV system.

4.2 System configuration

The CCTV system shall consist of the following components;

50) CCTV camera with controller installed along the MTHL and toll plaza area;

51) Command control centre CCTV server;

52) CCTV workstation with camera control keyboard at the command control centre;

53) Video wall at command control centre; and,

54) Network equipment.

4.3 System Functions

CCTV system shall be provided with the functions described below.

55) Monitoring function

The road, traffic and security conditions videos taken by CCTV cameras on the MTHL shall be transmitted as video signal to the CCTV workstation at the command control centre through the data communication network. The CCTV workstation shall be capable of selecting video signal from any CCTV camera to be displayed on the display monitor of the workstation and any of the video wall.

Sequential display function shall be provided to the CCTV workstation. The sequential display function shall allow the video image from the multiple cameras to be sequentially displayed at a pre-set interval. It shall be possible to select the cameras for sequential display and to set the display time of the image from each camera.

The CCTV display monitor on the console and CCTV monitor screens shall have multiple screen capability and shall display either one image or multiple images at a time. The image on the video wall shall be controlled by the CCTV workstation. It shall be possible to show the image from a camera to one monitor or multiple monitors.

56) PTZ control function

The CCTV system for traffic surveillance shall have a remote control function of pan, tilt and zoom of the camera selected. Each camera shall have a normal position of pre-set pan and tilt angles and a pre-set focal length to return and stay when the manual control of PTZ is released.

Pan and tilt functions are not required for the CCTV camera for security surveillance under the bridge and toll plaza area.

57) Image recording and retrieval

All images shall be automatically recorded in the storage device of the server with camera ID and time stamp. Frame rate of the video signal can be reduced to one frame per minute to reduce the requirements for the storage capacity required. Images shall be stored for minimum 1 year before taking back up.

58) Diagnosis

The CCTV system shall have a diagnosis function. The CCTV workstation shall inquire the connection with the CCTV and the status of CCTV by sending the diagnosis signal in every five (5) minute. If CCTV fault signal is received or there is no response from the CCTV, the CCTV workstation shall issue an alarm and the fault shall be recorded in the log.

The Contractor shall state in his Technical Proposal, the types of error and malfunction of the CCTV System that can be diagnosed from the CCTV workstation.

4.4 Camera controller keyboard

The Contractor shall provide the required number of camera controller keyboard to be used to select and control cameras and control digital video recorder. The camera controller keyboard shall have the following features:

- Pan, tilt, and zoom control of camera
- 3-D Joystick to control PTZ functions
- Digital video recorder control function
- Matrix switcher control function
- RS-232, RS-422, RS-485, or Ethernet interface

4.5 Monitor display

The CCTV workstation shall be capable of showing the following screens:

Item	Contents

Route map	Schematic map of MTHL, interchanges and access roads Name of interchange Kilo-post Jurisdiction of fire department and police
Equipment location and status	Location of CCTV cameras and location of selected camera
CCTV video image	Video image from the CCTV camera selected with camera ID Video image from the video recorder with camera ID, date and time
Error log	Error record
Date and Time	Current date and time

4.6 Cabinet

The CCTV camera shall be housed in a cabinet which is rugged and withstand adverse weather conditions.

59) The cabinet shall be electrically and mechanically robust and shall have a degree of protection of IP 65.

60) The anti-lightning and surge protection complying with the IEC 61643-1 shall be provided for all camera except under bridge camera.

61) The cabinet shall be finished with the anticorrosive treatment. The Contractor shall state the details of the anticorrosive treatment and painting.

4.7 Installation location

The CCTV camera shall be installed at the following locations:

Type	Location	Remarks
Traffic surveillance	Every 333 meter on both side for entire section	With PTZ functions
Security surveillance (bridge)	Every 1 km on both LHS and RHS of MTHL	Fixed camera
Security surveillance (toll plaza area)	Toll plaza area	Fixed camera

The traffic surveillance camera shall be installed either on the gantry for variable message sign, or on a pole to be supplied under the Contract. In both cases, clearance of 6 meter shall be secured.

The security surveillance camera under the bridge shall be attached to the girder with

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the suitably designed bracket.

The security surveillance camera shall be installed on the pole for the camera or attached to the toll plaza building.

The pole shall be installed on the footing. At bridge section, footing will be constructed by the bridge contractor modifying parapet and anchor bolts and conduit for cable will be prepared. At the earth section, the Contractor shall construct the footing and provide conduit and hand hole for cable.

4.8 Power supply

All types of CCTV camera shall operate with AC single-phase two-wire system 230 V ±10% 50Hz. Power consumption of all types of CCTV camera shall be 100VA or less.

4.9 Specifications

4.9.1 CCTV camera for traffic surveillance

The specifications in this section are provided as reference. The CCTV system to be provided by the Contractor shall materially comply with these specifications and shall be subject to the approval by the Engineer.

62) General

No.	Item	Specification
1.	Power supply	PoE, PoE+ 24 VAC or 230V ±10% AC
2.	Protection class	IP 66
3.	Ambient operating temperature	0 - 55°C
4.	Ambient operating humidity	90 % or less (non-condensing)

63) Camera

No.	Item	Specification
1.	Imaging Device	1/3 inch CMOS
2.	Max resolution	Full HD (1,080p)
3.	Video codec supported	H.264/JPEG
4.	Scanning method	Progressive
6.	Minimum illuminance	0.15 lx (colour), 0.02 lx (B/W)

64) Lens

No.	Item	Specification
1.	Optical zoom	20x

2.	Digital (electronic) zoom	12x
3.	Focal length	5 - 120 mm
4.	Maximum aperture ratio	1:1.6 (wide) – 4.7 (tele)
5.	Focus range	2.0 m – ∞
6.	Aperture range	F1.6 (wide) - Close
7.	Angular field of view	[16.9 mode] Horizontal: 3.3° (tele) - 59° (wide) Vertical: 1.6° (tele) - 37° (wide) [4.3 mode] Horizontal: 3.39° (tele) - 46° (wide) Vertical: 1.6° (tele) - 37° (wide)

65) Panning/tilting

No.	Item	Specification
1.	Panning range	300°
2.	Panning speed	Manual: approx.: 0.066°/S, Preset: up to approx. 300°/S
3.	Tilting range	Operational range: -15° - 196° (level – downward – level) Recommended range 0° - 180°
4.	Tilting speed	Manual: approx.: 0.066°/S, Preset: up to approx. 300°/S

66) Network

No.	Item	Specifications
1.	Network	10 Base-T/100 Base-TX, RJ45 connector
2.	Image compression method	H.264, JPEG
3.	Image resolution	At 2 mega pixel [16:9] H.264: 1920 x 1080 / 640 x 360 / 320 x 180 JPEG: 1920 x 1080 / 640 x 360 / 320 x 180 At 1.3 mega pixel [16:9] H.264: 1280 x 720 / 640 x 360 / 320 x 180 JPEG: 1280 x 720 / 640 x 360 / 320 x 180 At 1.3 mega pixel [4:3] H.264: 1280 x 960 VGA / QVGA

		JPEG: 1280 x 960 VGA / QVGA
5.	Frame rate	0.1 fps – 30 fps

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4.9.2 CCTV camera for security surveillance

The CCTV camera for security surveillance for under-bridge area and toll plaza area shall be the fixed camera without pan and tilt functions. The lens of the camera shall have the specifications listed below.

The camera shall be installed in such a way that the direction of camera axis can be adjusted after installation. The Contractor shall adjust the camera axis angle and coverage area for the camera to cover the area suitable for surveillance.

67) Lens

No.	Item	Specification
1.	Optical zoom	2x
2.	Digital (electronic) zoom	4x
3.	Angular field of view	Bridge: 15 – 30 deg. (H), 8 – 18 deg. (V) Plaza: 35 – 100 deg. (H), 20 – 50 deg. (V)
4.	Maximum aperture ratio	1:1.6 (wide) – 4.7 (tele)

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5. Video Incident Detection System

5.1 General

Video Incident Detection System (VIDS) shall be installed at every 333 Mtr interval in both directions of MTHL. The images taken by VIDS camera shall be transmitted to the Command Control Centre (CCC) through Optic Fiber cable in real time. In the CCC, images are selectively shown on the monitor display of VIDS workstation and VIDS monitor screen. If an incident occurs within the coverage area of camera, operator shall be able to control VIDS camera remotely and check the status visually. At the same time, images from all cameras shall be recorded on the storage device for the specified period.

5.2 System Configuration

The VIDS system shall consist of the following components:

68) VIDS image sensor and VIDS Controller at roadside;

69) VIDS server at Command Control Centre and,

70) Network equipment.

Integrated type; which accommodates both image sensor and processing unit in a cabinet is acceptable. If separate type is adopted, the image sensor and processing unit shall be fully interchangeable except minor adjustment and the combination of the sensor and processing unit shall not be fixed. It shall be possible to connect sensor to any processing unit.

No periodical manual adjustment shall be required for image sensor and processing unit.

The VIDS Server shall be provided to the Command Control Centre for receiving pre-processed data from VIDS terminal equipment on the MTHL. The data collection interval shall be one (1) minute. IP based network equipment shall be provided to connect the VIDS terminal equipment on the MTHL with the VIDS server at CCC.

5.3 Equipment Location

VID sensor shall be installed at every 333 Mtr interval in both directions of MTHL on the pole provided for CCTV camera mounting. The clearance of 8 Mtr shall me provided.

5.4 System Functions

VIDS system shall be provided with the functions described below

5.4.1 Monitoring Function

The road and traffic condition images taken by VIDS cameras on MTHL shall be transmitted as video signal to the VIDS Server at the Command Control Centre through the communication network. The VIDS Server shall be capable of selecting video signal from any VIDS camera to be displayed on the display monitor of the Server and on video wall.

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Sequential display function shall be provided to the VIDS Server. The sequential display function shall allow the video image from the multiple cameras to be sequentially displayed at a pre-set interval. It shall be possible to select the cameras for sequential display and to set the display time of the image from each camera.

The VIDS display monitor on the console and video wall shall have multiple screen capability and shall display either one image or four images at a time. The image on the video wall shall be controlled by the VIDS Server.

5.4.2 Incident Detection (Video)

The VIDS system shall have an incident detection function and automatically detect incident occurred within its viewing area when the camera is set at home position. The system should be able to detect the incidents in all types of light and visibility conditions. Incident refers to those occurrences of:

71) Slow-moving vehicle,

72) Stopped vehicle,

73) Vehicle running in opposite direction,

74) Congestion,

75) Pedestrian movement on MTHL,

76) Fallen objects on the road.

If an incident is detected, VIDS Server shall issue an alarm and incident image shall be automatically displayed on the VIDS operator console monitor display and video wall.

The Contractor shall describe the incident detection mechanism that the Contractor proposes.

5.4.3 Image Recording and Retrieval

All images shall be automatically recorded in the storage device of the VIDS server with camera ID and time stamp. Frame rate of the video signal can be reduced to One frame per second to reduce the requirements for the storage capacity required. Images shall be stored for minimum three (7) days.

5.4.4 Diagnosis

The VIDS system shall have a diagnosis function. The VIDS Server shall inquire the connection with the VIDS camera and the status of VIDS camera by sending the diagnosis signal in every five (5) minute. If VIDS camera fault signal is received or there is no response from the VIDS camera, the VIDS Server shall issue an alarm and the fault shall be recorded in the log.

The Contractor shall state in his Technical Proposal, the types of error and malfunction of the VIDS System that can be diagnosed from the VIDS Server.

5.4.5 VIDS Camera Specifications

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No.	Item	Specification
	Thermal Image	
1	Detector Type	Focal Plane Array (FPA), Uncooled Vanadium Oxide Microbolometer
2	Spectral Range	7.5 to 13.5 µm
3	Resolution	640 x 480
4	Focal	9/13/19/25mm
5	Image Frequency	NTSC : 30 Hz PAL : 25 Hz
6	Image Processing	Automatic Gain Control (AGC), Digital Detail Enhancement (DDE)
	Visual Image	
7	Image Sensor	1/3" CMOS sensor
8	Max Resolution	1920 x 1080
9	Optical Zoom	10x motorized optical zoom
10	Focal Length	5-50mm
	Image Presentation	
11	Video over Ethernet	Two independent channels for each camera (4 total) of streaming H.264 or M-JPEG
12	Streaming Resolutions	Visual : Up to 1920 x 1080 @ 30 Hz Thermal : Up to 640 x 480 @ 30 Hz
	Power	
13	Power Options	230 Vac, 24Vac or dc, PoE camera only, PoE+ for camera & heater 12W heater off, 24W heater on
14	Consumption	12 W Heater Off, 24 W Heater On
	Environmental	
15	Operating Temperature Range	0°C to +65°C
16	Relative Humidity	0% to 100%, No Condensation
17	Ingress Protection	IP66 / IP67
	Network	
18	Interface	10/100 Mbps Ethernet (RJ-45), internal SFP slot optional

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No.	Item	Specification
19	Supported Protocols	IPv4/v6, TCP/IP, UDP, RTP, RTSP, HTTP, HTTPS, ICMP, FTP, SNTP, DHCP, PPPoE, UPnP IGMP, SNMPv1/2/3, QoS, ONVIF, 802.1X

5.4.6 VIDS Controller

VIDS Controller shall be housed in a cabinet together with power supply and network equipment.

77) The cabinet shall be electrically and mechanically isolated and shall have a degree of protection of IP 55 or higher specified in IEC60529.

78) If necessary, the cabinet may be provided with a ventilation fan for controlling internal temperature, but the protection code requirements shall be met.

79) A right hinged door shall be provided on the front to realize easy maintenance work. The turning direction of the handle shall be counter clockwise.

80) The power supply unit shall be provided with a circuit breaker.

81) The anti-lightning and surge protection complying with the IEC 61643-1 shall be provided.

82) The cabinet shall be finished with the anticorrosive treatment. The Contractor shall state the details of the anticorrosive treatment and painting.

5.4.7 Power Supply

Power Supply shall be operated with AC single-phase two-wire system 230 V ±10% 50Hz wired and supplied power nearest substation.

Power consumption of all types of VIDS shall be 100VA or less regardless of the type of power supply.

5.4.8 Installation

VIDS Camera device shall be installed on the top of VIDS pole. The supporting structure with enough length must be provided to keep good visibility.

VIDS camera station shall be installed in VIDS cabinet at the bottom of pole for VIDS camera. VIDS cabinet shall be a shelter made of stainless steel only.

5.4.9 Quality

The system shall operate on a 24 x 7 basis. The VIDS shall be capable of clearly taking image of road and traffic conditions under any brightness conditions during the daytime and night time. It shall be the responsibility of the Contractor to furnish and install all necessary hardware, software, and database, integrate all system components and deliver a complete operational VIDS.

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5.4.10 Acceptance Test

Camera, camera housing, IP camera station and IP camera system central equipment shall be subjected to the test before Acceptance test shall be conducted at factory, during installation work and upon completion depending on the test item. Two types of test, function and performance test and general test shall be conducted.

Details of the test item, test procedure and criteria to judge test result shall be proposed by the Contractor subject to the approval by the Employer.

In principle, function and performance requirement stated above shall be tested. More specifically, the following tests shall be conducted as minimum:

83) Monitoring function

84) Incident detection function

85) Image recording and retrieval function

86) Diagnosis (system self-check) function

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6. Automatic Traffic Counters-cum-Classifier System

6.1 General

This specification covers automatic traffic counters-cum-classifier (ATCC) system to be installed as one of the sub-systems of the traffic management system for MTHL. Image sensor type ATCC shall be adopted as detecting device. The sensor shall be installed at the locations indicated on the Drawing for the direction of the road specified to measure traffic volume at each section of the MTHL. The sensor shall be mounted on the gantry for variable message sign.

The ATCC shall detect, count and classify vehicles within its sensing area set on the main carriageway. The traffic flow parameters measured by the ATCC shall be transmitted to the ITS workstation in the command control centre. The system shall operate on a 24-hour a day 7-day a week basis.

It shall be the responsibility of the Contractor to furnish all necessary hardware and software, install equipment at the specified location, provide necessary wiring, integrate all system components, and deliver a complete operational ATCC system.

6.2 System configuration

The ATCC system shall consist of the following components:

87) ATCC consisting of Video Based image sensor and image processing unit;

88) Command control centre server;

89) ITS workstation at command control centre; and,

90) Network equipment.

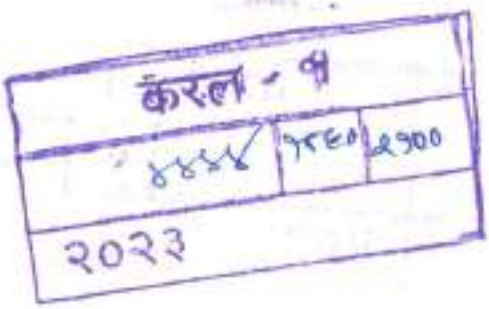
Integrated type automatic traffic counter cum classifier that accommodates both video based image sensor and processing unit in a cabinet is acceptable. If separate type is adopted, the image sensor and processing unit shall be fully interchangeable except minor adjustment and the combination of the sensor and processing unit shall not be fixed. It shall be possible to connect sensor to any processing unit. No periodical manual adjustment shall be required for image sensor and processing unit.

A server and an ITS workstation shall be provided to the command control centre for receiving and monitoring pre-processed data from ATCC roadside equipment on the MTHL. The data collection interval shall be one minute. IP based network equipment shall be provided to connect the ATCC roadside equipment on the MTHL with the traffic management server at the centre.

6.3 Detection capability and accuracy

A unit of ATCC shall cover and measure the volume simultaneously on three (3) lanes. The detection capability shall be the vehicles passing through the sensor area at a speed not more than 160 km/h.

The ATCC system shall have an overall counting accuracy of 98 % or better all the time for any types of vehicles expected to take the MTHL under any weather condition day and night including the case in which multiple vehicles are running closely and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their image is partially overlapping. Completely hidden vehicles owing to overlapping of vehicle image is excluded. No lighting specifically for vehicle detection and measurement during dark hours shall be required. The system shall be capable of detecting vehicle running in opposite direction.

The Contractor shall submit in his Technical Proposal data that support the claimed accuracy of the proposed detector together with vehicle classification adopted and site condition, both of which shall be similar to the vehicle classification and site condition of the Project. The supporting data shall be the data collected at a real world application. The data gathered at test course or under experimental situation shall not be acceptable.

Accuracy of AVCC installed will be measured during the defect liability period. If actual accuracy does not satisfy the requirements, the Contractor shall take necessary actions to improve the accuracy which may include replacement of vehicle detector or sensors installed with the new type of better performance at no cost to the Employer.

6.4 System functions

ATCC system shall be provided with the function described below.

91) Image taking

The ATCC shall continuously take the video based images of the coverage area set on the main carriageway. It shall be possible to adjust the angle and coverage area of the image sensor to maximize the detection accuracy.

92) Image processing

Image taken by the sensor shall be processed to obtain traffic flow parameters. The processing unit shall be capable of:

- Detecting vehicle running in any direction and recognize the shape or edge of the vehicle.
- Counting the number of vehicles that passes the sensing area during the unit measurement time on a lane basis.
- Classifying the vehicle into classes as set forth by MORTH. The definition of classification shall be made according to the vehicle length and axels and the classification parameter shall be adjustable.
- Calculating the time occupancy rate per unit measurement time.
- Calculating a mean speed per unit time which is an arithmetic mean of the speed of vehicles passed in the past unit measurement time.

93) Error checking and substitution

Traffic flow parameter data sent from roadside equipment shall be tested first for possible errors. Malfunction of image sensor and processing unit, and interruption of power supply shall cause vehicle detector output in continuous detection state for error checking purpose. Thresholds shall be pre-defined for traffic flow parameters and detector data shall be compared with them. If detector is judged abnormal or error signal is sent from ATCC roadside equipment, it shall be marked.

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malfunctioned and an alarm shall be issued to the ITS workstation for warning and maintenance operation. Faulty detector shall be recorded in the operation log. The data judged abnormal shall not be used for further processing.

Data from the vehicle detector marked as malfunctioned shall be checked continuously for data abnormality. If data is judged normal, normal processing of the data shall resume automatically.

94) Processing

The ITS workstation shall collect the data from ATCC at the unit measurement interval. The unit measurement time shall be one minute. The unit measurement time shall be a system parameter and shall be adjustable.

The ITS workstation shall accumulate the data collected and produce five minutes data for the same traffic flow parameters.

In addition, the ITS workstation shall calculate sectional traffic flow parameters at the location of ATCC.

If a traffic flow parameter at a lane or a section is lower or higher than the predetermined threshold, the ITS workstation shall issue an alarm to the monitor display as abnormal traffic condition or malfunction of the ATCC sensor. The threshold for alarm shall be user configurable for each location for different time zone of a day. The system shall be initially pre-configured with reasonable values of the threshold based on engineering judgement.

The 5-minute traffic flow parameters shall be accumulated and converted to 15-minutes flow parameters for display purpose and hourly traffic flow parameters as statistics.

95) Diagnosis

The ATCC system shall have a diagnosis function. The ITS workstation shall inquire the connection with the ATCC and the status of ATCC by sending the diagnosis signal in every five (5) minute. If ATCC fault signal is received or there is no response from the ATCC, the ITS workstation shall issue an alarm and the fault shall be recorded in the log.

The Contractor shall state in his Technical Proposal, the types of error and malfunction of the ATCC System that can be diagnosed from the ITS workstation.

96) Check and setting up of ATCC monitor

In order to check or setting up of ATCC at the location of ATCC roadside equipment, the ATCC shall be provided with an output terminal through which video signal from the sensor unit can be monitored.

97) Display and report

It shall be possible to monitor in real-time traffic flow parameter data through monitor display of ITS workstation and printed report. Traffic flow parameter of individual and multiple lanes can be specified for monitoring. Both numerical and graphical presentation of the data shall be provided. Monitoring shall be prompted

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by operator but the data on the display shall be automatically updated at unit time of data.

Real-time monitoring of operating condition of ATCC roadside equipment shall also be possible.

98) Data recording and statistics

All hourly and daily data shall be recorded and stored in the database for analysis and future use. A data retrieval and presentation software shall be provided that can easily retrieve and show the traffic flow parameters and operating condition of the specified ATCC location at the specified time, hour or day. Graphical presentation of historical traffic flow parameters such as hourly variation and daily variation shall also be possible.

99) Operation log

Status of ATCC (normal or malfunctioned) shall be recorded in the database as operation log and for future reliability analysis together with error code and time stamp.

6.5 Monitor display and reports

The ITS workstation shall be capable of showing the following screens:

Item	Contents
Route map	Schematic map of MTHL, interchanges and access roads Name of interchange Kilo-post Jurisdiction of fire department and police
Equipment location and status	Location of vehicle counter cum classifier and its status (normal / error)
Road, traffic and weather condition	Current traffic volume and average speed at ATCC location (figure and in service level) Current incident (accident, congestion, stalled vehicle, fallen object) in list and in map Current regulation in force (lane closure, section closure, speed limit) 15-minute and hourly traffic flow data for display purpose and hourly traffic flow data for report (text and in graphics)
Operation log	List of automatic vehicle counter cum classifier currently not in operation Error record
Date and Time	Current date and time

The ITS workstation shall produce the reports listed below. The reports shall be output according to the schedule or upon the system operator's request. It shall be possible

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to output the report as a file in portable document file format.

Item	Contents
Traffic volume	Daily report containing hourly sectional traffic volume by vehicle class Monthly report containing daily sectional traffic volume by vehicle class and that of the day of the week
Error log	List of automatic vehicle counter cum classifier currently not in operation Error record

6.6 Cabinet

6.6.1 Sensor unit

Sensor unit shall be housed in a cabinet together with power supply equipment.

100) The cabinet shall be electrically and mechanically robust and shall have a degree of protection of IP66 or higher specified in IEC60529 "Test for protection against water for electrical equipment and degrees of protection against ingress of solid foreign objects".

101) The orientation of the sensor unit shall be adjustable in vertical and lateral directions.

102) The cabinet shall be made of anticorrosive material or finished with the anticorrosive treatment. Special attention shall be paid to the salty environment in which the unit operates. The Contractor shall state the details of the anticorrosive treatment and painting against salty splash.

6.6.2 Processing unit

Processing unit shall be housed in a cabinet together with power supply and network equipment.

103) The cabinet shall be electrically and mechanically robust and shall have a degree of protection of IP 55 or higher specified in IEC60529.

104) A right hinged door shall be provided on the front to realize easy maintenance work. The turning direction of the handle shall be counter clockwise.

105) The power supply unit shall be provided with a circuit breaker.

106) The anti-lightning and surge protection complying with the IEC 61643-1 shall be provided.

107) The cabinet shall be finished with the anticorrosive treatment. Special attention shall be paid to the salty environment in which the unit operate. The Contractor shall state the details of the anticorrosive treatment and painting.

6.7 Installation location

ATCC shall be installed on the gantry for VMS at the location listed below.

No.	Direction	Location
1.	Eastbound	1+660, 18+330
2.	Westbound	16+000, 19+580

6.8 Requirements for ATCC

The system shall be connected to the ITS workstation located in the command control centre. The ATCC shall be mounted on gantry for VMS and power to the ATCC shall be provided from the nearest power substation along MTHL

The technical specifications mentioned hereunder are minimum guidelines. The Contractor shall not deviate materially from the specifications.

No.	Item	Specification
1	Power Requirements	230 V ±10% AC, 50Hz
2	Power Consumption	400 VA or less
3	Minimum illuminance	2.1 lx, 0.19 lx (with night mode)
4	Video S/N ratio	50 dB or more
5	Lens iris	Automatic
6	Environmental conditions	0 to +50 °C
7	Reliability and maintainability	MTBF: 30,000 hours MTTR: 0.5 hours

7. Meteorological Observation System

7.1 General

This specification covers meteorological observation (MET) system to be installed as one of the sub-systems of the traffic management system for MTHL. MET system shall collect weather condition data at the meteorological observation stations continuously. The data collected shall be transmitted to the server at the command control centre for data processing and logging. In case of adverse weather, the system shall automatically issue an alarm to the system operator. There shall be a total of three (3) meteorological observation stations along the MTHL. They shall operate on a 24-hour a day 7-day a week base.

It shall be the responsibility of the Contractor to furnish all necessary hardware and software, install equipment at the specified location, provide necessary wiring, integrate all system components, and deliver a complete operational meteorological observation system.

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7.2 System configuration

The Meteorological Observation System shall consist of the following components:

108) Thermometer;

109) Rain gage;

110) Rainfall detector ;

111) Ultrasonic anemometer;

112) MET observation station (data logger);

113) Command control centre server;

114) ITS workstation at command control centre; and,

115) Network equipment.

ITS workstation shall be provided to the command control centre for receiving all MET data. IP based network equipment shall be provided to connect the meteorological observation stations with the ITS workstation at the command control centre.

7.3 Weather condition measurement

The following measurement equipment shall be provided to each meteorological observation system:

116) Thermometer

Thermometer shall continuously measure ambient air temperature at the rage of 0 to 70 degree Celsius in units of 0.1 degree. The measured data shall be sent to the server at command control centre at one minute interval as current air temperature.

117) Rain gauge

Tipping bucket rain gauge shall be provided. The rain gauge shall produce a pulse of contact signal every time precipitation reaches 0.5 mm. The signal shall be converted into voltage or current signal for transmission to the server at command control centre.

118) Rainfall detector

The rainfall detector shall output ON signal when rain is detected and OFF signal when rain stops.

119) Anemometer

The anemometer shall measure the wind velocity at the range of 0 m/sec to 60 m/sec in units of 0.1 m/sec. The anemometer shall also detect wind direction and convert it into one of 16 directions.

7.4 Data processing at meteorological observation station

The meteorological observation station shall perform the following process:

120) Data validity check

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Error checking shall be performed for the received data by comparing them with the pre-defined threshold. Threshold may include upper limit, lower limit, and variation from the previous data. The threshold shall be user definable. The data judged faulty shall not be used as observed data. The defective device that has produced faulty data shall be recorded in the operation log and an alarm shall be issued.

121) Calculation of hourly and cumulative precipitation

Precipitation data shall be processed into hourly precipitation and cumulative precipitation.

7.4.1 Data communication to the command control centre

The following processed data shall be transmitted from MET to ITS workstation at the centre every one minute.

- Maximum and minimum value of wind speed and visibility in the past one minute
- Wind direction at the maximum and minimum wind speed
- Instantaneous value of ambient temperature and rainfall detection on every one minute
- Hourly cumulative value of rainfall in the past one hour
- Cumulative value of rainfall from the start of rainfall

7.4.2 Data processing at command control centre

The ITS workstation shall gather the observed meteorological data and monitoring signal from the station at a regular interval. The data received from the station shall be converted to the physical weather data.

The ITS workstation shall perform the data processing as listed in the table below for display and logging. Display shall be updated every minute.

Data	Display	Logging
Temperature		
Instantaneous (every 1 minute)	X	
Instantaneous (every 5 minutes)		X
Wind velocity		
Maximum during previous 1 minute	X	X
Wind direction		
Direction at maximum wind during previous 1 minute	X	X
Precipitation		
Moving total for previous 1 hour	X	X

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Total continuous precipitation	X	X	

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A warning system shall be introduced in which an alarm is issued to the system operator when the wind data or precipitation data exceeds the pre-defined threshold. After the measured value has exceeded the threshold, another warning shall be issued when the measured value becomes lower than the threshold to notify the system operator that the measured value is within the normal range. Several types and values of threshold shall be provided and the threshold shall be alterable.

All meteorological observation data shall be recorded in the database in the form of 5-minute, daily and monthly data and data retrieval software shall be provided for easy access to the recorded data. It shall be possible to show graphically the retrieved data from the database.

7.4.3 Diagnosis

The MET system shall have a diagnosis function. The ITS workstation shall inquire the connection with the MET and the status of MET by sending the diagnosis signal in every five (5) minute. If MET fault signal is received or there is no response from the MET, the ITS workstation shall issue a warning and the fault shall be recorded in the log.

The Contractor shall state in his Technical Proposal, the types of error and malfunction of the meteorological observation system that can be diagnosed from the ITS workstation.

7.5 Monitor display and reports

The ITS workstation shall be capable of showing the following screens:

Item	Contents
Route map	Schematic map of MTHL, interchanges and access roads Name of interchange Kilo-post Jurisdiction of fire department and police
Equipment location and status	Location of weather observation station and its status (normal / error)
Road, traffic and weather condition	Current weather condition (rain, wind velocity, wind direction, precipitation) Historical variation of weather conditions
Operation log	List of meteorological observation equipment currently not in operation Error record
Date and Time	Current date and time

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The ITS workstation shall produce the reports listed below. The reports shall be output according to the schedule or upon the system operator's request. It shall be possible to output the report as a file in portable document file format.

Item	Contents
Meteorological data	Daily report containing hourly maximum and minimum wind velocity, its direction and time Daily report containing hourly precipitation Monthly report containing daily maximum and minimum wind velocity, wind direction, and time. Monthly report containing daily precipitation
Error log	List of meteorological observation equipment currently not in operation Error record

7.6 Cabinet

The meteorological observation station shall be housed in a rugged cabinet together with power supply and network equipment. The cabinet shall accommodate MET circuit and devices, power supply, network device and terminal board.

122) The cabinet shall be electrically and mechanically robust and shall have a degree of protection of IP55 or higher specified in IEC60529 "Tests for protection against water for electrical equipment and degrees of protection against ingress of solid foreign objects."

123) A right hinged door shall be provided on the front to realize easy maintenance work. The turning direction of the handle shall be counter clockwise.

124) The power supply shall be provided with a circuit breaker.

125) The anti-lightning and surge protection complying with the IEC 61643-1 shall be provided.

126) The cabinet shall be finished with the anticorrosive treatment. Special attention shall be paid to the salty environment in which the unit operate. The Contractor shall state the details of the anticorrosive treatment and painting.

7.7 Installation location

The meteorological observation station shall be established at the following three (3) locations:

- Kilo post 1+660 (on VMS gantry)
- Kilo post 9+000 (self-standing or on CCTV pole)
- Kilo post 16+660 (on VMS gantry)

The Contractor shall construct meteorological observation station at the designated

locations and undertake the necessary works including wiring for data communication and power supply.

7.8 Power supply

Each meteorological observation station shall be supplied power from the nearest power station along MTHL. The Contractor shall install the power cable from the power station to the observation station. The meteorological observation station shall operate with AC single-phase two-wire system 230 V ±10% 50Hz. The Contractor shall present the calculation of power consumption of the MET system.

Total power consumption of MET at each station shall be 1000VA or less.

7.9 Specification of MET

127) Thermometer

No.	Item	Specification
1	Detection method	Platinum resistance type
2	Measurement range	0 to +70 degree Celsius in unit of 0.1 degree
3	Specified current	2 mA
4	Protection tube material	Stainless

128) Vent sleeve for thermometer sensor

No.	Item	Specification
1	Method	Forced ventilation type
2	Construction	Inside-and-outside double cylinder
3	Ventilation speed	5 to 7 m/s
4	Material	Corrosion resistant metal
5	Power supply	Supplied from the observation station

129) Rain gage

No.	Item	Specification
1	Detection method	Tipping bucket type
2	Diameter of water inlet	200 mm
3	Tipping bucket rain gauge	0.5 mm or 1.0mm
4	Contact output signal	No potential mark contact signal
5	Material	Stainless
6	Operating temperature	0 to +50 °C

130) Rainfall detector

No.	Item	Specification
1	Detection method	Print electrode plate type
2	Detected rain drop diameter	More than 0.5 mm diameter
3	Output signal	No potential mark contact
4	Power supply	Supplied from observation station
5	Operating temperature	0 to +50 degree Celsius

131) Ultrasonic anemometer

The Tender shall submit the test results of the anemometer conducted in accordance with ISO 16622:2002 Meteorology – Sonic anemometers/thermometers – acceptance test methods for mean wind measurements together with his technical proposal.

No.	Item	Specification
1	Detection method	Wind direction: 2-axis type Wind velocity: Ultrasonic wave
2	Measurement range	Wind direction: 0 to 360 degree Wind velocity: 0 m/s to 60 m/s
3	Sampling rate	1, 2, 4 Hz
4	Digital output signal	RS232, RS422 or RS 485
5	Material	SUS 316
6	Power supply	Supplied from observation station
7	Operating temperature	0 to +50 °C

132) Meteorological observation station

No.	Item	Specification
1	Cabinet size	Width: 500mm or less Height: 1,000mm or less
2	Weight	500kg or less
3	Material	Stainless steel 2.0 t or cold rolled steel sheet (SPCC) 2.3 t
4	Power consumption	1,000 VA or less (sensor included)

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5	Operating temperature	0 to +50 °C
6	Humidity	20 to 85 % non-condensing
7	Wind speed endurance	50 m/s
8	Reliability and maintainability	MTBF : 30,000 hours MTTR : 1.0 hour

8. Variable Message Sign System

8.1 General

This specification covers variable message sign (VMS) system to be installed as one of the sub-systems of the traffic management system for MTHL. VMS system is intended to provide the MTHL users with the information of road, traffic and weather conditions of MTHL to promote safe and comfortable drive. The VMS will provide information related to the MTHL. The system shall operate on a 24 hour a day 7-day a week basis.

The VMS shall be capable of creating, managing and displaying messages in three languages (English, Marathi and Hindi) separately, alternately, and simultaneously. Simultaneous display in multiple languages shall display one-line simple message in three languages in three lines for drivers who understand only one of these three languages.

It shall be the responsibility of the Contractor to furnish all necessary hardware and software, provide gantry, install equipment at the specified location, provide necessary wiring, setup database and parameters, integrate all system components, and deliver a complete operational variable message sign system.

The standards listed below shall apply for the requirements not specifically stated in the Employer's Requirements. Any requirement in the standards below that are incompatible or inconsistent with the specifications herein, the requirements in the Tender Document shall prevail.

- IRC SP 85-2010 Guidelines for variable message signs 2010
- EN 12966-1 European standard for variable message traffic signs
- NEMA TS4 Hardware standards for dynamic message signs with NTCIP requirements

8.2 System configuration

The variable message sign system shall consist of the following components:

133) Variable message signboard;

134) Variable message sign local controller;

135) Command control centre server;

136) VMS workstation at command control centre; and,

137) Network equipment.

The variable message sign local controller will be accommodated in a separate cabinet or in the variable message signboard housing.

A dedicated VMS workstation shall be provided to the command control centre for message preparation, monitoring and control of the variable message signs. IP based network equipment shall be provided to connect the VMS with the traffic management system at the centre.

8.3 System functions

8.3.1 Message structure

Message to be displayed on the VMS shall be concise and clear as drivers driving a vehicle have to read and understand the message in a short time. Messages shall have uniform structure and simple words shall be used. Messages on the VMS shall be in expressed English, Marathi and Hindi. Messages in different language will be separately managed and automatic translation is not required.

In principle, a message to be displayed on the variable message signboard shall be composed of three parts, "location", "event", and "instruction or regulation".

138) Location

Location indicates the relationship between the VMS location and the event location. They can be expressed as section (between Interchange A to Interchange B), distance (ahead, xx km ahead), or specific location (near Interchange A).

139) Event

Event is a thing that has happened or taken place. It includes traffic conditions (accident, congestion, car on fire), traffic regulation (lane closure, road maintenance work), road condition (wet road surface, fallen object, damaged pavement), and weather condition (rain, strong wind).

140) Instruction or regulation

The instruction is the action to be taken by the MTHL users such as "slow down", "cautious", "exit here", "exit at next interchange", and "use right/left lane". The regulation is the traffic regulation being enforced like "lane closure" or "MTHL closed".

Three components are not necessarily required all the time. Messages consisting of one or two components described above or simple message will also be displayed.

8.3.2 Message creation and editing

Three message composition methods shall be provided; (1) manual input, (2)

combination of pre-defined phrase, and (3) selection of ready-made message. The functions specified herein shall be possible in three languages. In addition, a set of graphic symbols shall be provided to complement the text message.

141) Manual composition

In the manual input, it shall be possible to display on the VMS any text message input by the system operator through the keyboard of the VMS workstation. There shall be no restriction as to the contents of message but the length of message is limited to the display capacity of the variable message signboard. If manual composition mode is selected, the VMS workstation shall show the image of the signboard and the message as it is input by the system operator.

142) Combination of pre-defined phrase

In the case of combination of pre-defined phrase, frequently used words or phrases such as "accident", "congestion", "construction work", "slow down" and so on are used to compose a message. It shall be possible to insert a word into the message composed by combination method. There shall be sets of pre-defined words. They shall contain words indicating location, event and instruction or regulation. Each set shall have a capacity of 100 words in each language. In this mode, the VMS workstation shall show the categories and the words or phrases in each category for the system operator to select. It shall be possible to alter the pre-defined words by the system operator.

143) Ready-made message

Ready-made message selection method shall allow the system operator to choose one of the ready-made messages. If the ready-made message mode is selected, the VMS workstation shall indicate the list of ready-made messages grouped into categories for the system operator to select. Message set shall have the capacity of 100 messages in each language.

144) Graphic symbols

Graphic symbols that show typical incidents such as expressway closure, construction work, and rain graphically shall be provided to complement the text message. The sample graphic symbols are provided in these Employer's Requirements for reference. The design of graphic symbols shall be subject to the Employer's approval.

145) Dot matrix pattern

The VMS system shall be provided with a function to create a display pattern by specifying the on/off status and colour of each pixel comprising the display area of the signboard. It shall be possible to mix the dot matrix pattern and character message on the signboard.

146) Automatic message creation from incident information

If an incident is detected by CCTV system or adverse weather condition is detected by the meteorological observation system, these systems shall send an alarm to the VMS system. VMS system shall then create a warning message

indicating the location, type of incident and action to be taken. The message thus created shall not be displayed automatically on the signboard. Instead, a recommendation shall be displayed on the VMS workstation indicating the contents of the message and the location of VMS for which message is recommended. Upon confirmation of the recommendation, the message will be displayed on the specified message.

As the display area of VMS is divided into three (3) lines, the message composed shall fit into each line without splitting a word at the end of a line. The controller shall have automatic layout and centring functions to arrange words into rows.

The VMS workstation shall be provided with updating and editing function of pre-defined word, phrase, message and symbol. Editing of symbol shall be possible on a pixel basis.

The Contractor shall describe the details of the message creating and editing function using flowchart or other graphical presentation in his Technical Proposal.

8.3.3 Message priority

The VMS system shall be provided with an automatic message selection function based on the priority or severity of the events and coefficient that represents the importance of event to each VMS. The function shall select and recommend the message to be shown separately for each VMS when there are two or more events to be informed to the MTHL users.

The Contractor shall describe the mechanism of automatic message selection function in his Technical Proposal.

8.3.4 Time to live

Each message being displayed on the VMS shall be assigned with a time-to-live (TTL) value, during which message is displayed, to prevent inadvertently displaying false message after event has been removed. Upon expiration of TTL, message shall be automatically extinguished. A warning shall be issued to the operator console before TTL expires for operator to choose extension of TTL or termination of the display as scheduled.

8.3.5 Alternate display function

The VMS system shall have an alternate display function, in which a maximum of three sets of message shall be displayed alternately. The function is intended to display a message in three different languages (English, Marathi and Hindi) of the same contents.

If multiple messages are displayed alternatively, it shall be possible to adjust the display duration of each message in the range of one to four seconds in units of one second. The changeover of the messages shall take place instantaneously without noticeable mixture of two messages.

8.3.6 Interface with system operator

The VMS workstation communicates with the operator through monitor and keyboard

for message composition, message display and operation monitoring. Message composition shall be made interactively with one of the methods described above. Graphic user interface shall be adopted in the interface as much as possible for user friendly operation and fail safe mechanism shall be incorporated to prevent VMS system from showing inadequate message inadvertently.

The system shall be equipped with a text input method in Marathi and Hindi languages commonly used in India through the standard keyboard. The Contractor shall specify and describe the input method of local languages (Marathi and Hindi) in his Technical Proposal.

8.3.7 Data conversion

Text and symbol message to be displayed shall be converted to pixel image data to control display unit before transmitting to the variable message sign.

8.3.8 Communication with local controller

The VMS workstation shall communicate with the local controller through the data communication system. It shall send out message converted to dot pattern for display. It shall also send out command data to control the variable message sign local controller and to confirm normal operation of the signboard. In return, the VMS workstation shall receive status data from the local controller. The Contractor shall describe the details of data exchange including but not limited to the establishment of communication link, type of command, contents of data, data structure and communication timing in his Technical Proposal.

8.3.9 Operation monitoring

Operating status of the variable message sign shall be checked periodically. Status (message on, no message, fault, local control, test and switch off) shall be collected from the local controller. If any abnormality is reported, an alarm shall be issued. The collected operation monitoring data shall be recorded as part of operation log.

It shall be possible for the VMS workstation to send a command to the local controller and collect the dot pattern data being displayed on the signboard upon system operator's initiative.

The Contractor shall state in his Technical Proposal, the types of error and malfunction of the VMS System that can be diagnosed from the VMS workstation.

8.3.10 Operation log

Message displayed together with the starting and ending time shall be recorded as operation log. Status or malfunction of the variable message sign and local controller shall also be recorded. Data retrieval software shall be provided and operation log can be retrieved for display on monitor and as printed report.

8.4 Monitor display

The VMS workstation shall be capable of showing the following screens:

Item	Contents

Route map	Schematic map of MTHL, its interchanges and access road, name of ICs, Kilo-post, jurisdiction of each fire department and police
Equipment location and status	Location of variable message sign and their condition (message / no message and normal / error)
Message	Message being displayed at selected variable message sign with starting time and scheduled end time Pre-defined words and phrases Pre-defined messages Graphic symbols
Operation	List of variable message signs currently not in operation Operation log and error record
Date and Time	Current date and time

The VMS workstation shall produce the reports listed below. The reports shall be output according to the schedule or upon the system operator's request. It shall be possible to output the report as a file in portable document file format.

Item	Contents
Variable message sign operation	Daily report summarizing VMS location, message displayed, start time, end time
Error log	List of variable message signs currently not in operation Error record

8.5 Variable message signboard

8.5.1 Display unit

High intensity LED (light emitting diode) shall be used as light source for VMS. At least three colour elements, blue, red and green, shall be provided and a total of five (5) colours of white, yellow, green, red and blue shall be displayed. Brightness and colour shall be uniform throughout the surface.

Life of LED unit shall be long enough to withstand the severe environmental conditions in which the signboard operates. The Contractor shall submit the results of high temperature high moisture biased test of LED to be used to the satisfaction of the Engineer.

Display panel of VMS shall be of unit construction using LED matrix. The size of the LED matrix unit shall be as per the manufacturer's design. The unit shall be easily replaceable from backside or front without affecting other units. One pixel may be composed of multiple elements or LEDs for colour presentations. The total number of

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pixels on the display panel shall be determined by the character size, pixel pitch, number of character per line, and number of lines. Display unit shall be capable of detecting open circuit condition of each LED.

Malfunction of an LED, a pixel, and a display unit shall not affect the normal operation of other LEDs, pixels and display units.

VMS designs, components, and enclosures primarily designed for commercial, advertising, billboard or other display purposes shall not be accepted.

8.5.2 LED

The LED used for the display unit shall be from the reputable LED manufacture. All LEDs used shall be from the same manufacturer and shall have the same part number. The type of LED shall be as indicated below.

LED colour	Type	
Blue	InGaN	(Indium-Gallium-Nitride)
Red	AlInGaP	(Aluminium-Indium-Gallium-Phosphide)
Green	InGaN	(Indium-Gallium-Nitride)

The Tender shall state the source, type and part number of LED used for VMS in his Technical Proposal. Data sheet of LED issued by LED manufacturer shall be included in the Technical Proposal as supporting document.

8.5.3 Optical performance

The display unit shall be matrix of LED of blue, red and green. The dominant wavelength range of LED shall be as indicated below.

Display colour	Dominant wave length
Blue	460～485nm (±5nm)
Red	625～630nm (±5nm)
Green	510～550nm (±5nm)

It shall be possible to display in five colours (white, yellow, green, red and blue) using three colour LEDs. LED packages shall be fabricated from UV light resistant epoxy.

LED shall be selected from the same bin sorted by the LED manufacturer for intensity and colour respectively

The luminance, luminance ratio and beam width shall comply with the type specified by EN 12966-1 2007 Vertical road traffic signs – Part 1: Variable message signs as specified below with the modifications of the requirements and measurement conditions stated below.

- luminance class: L3

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- luminance ratio: R3
- beam width: B3

The Contractor shall submit the certified optical performance data of the VMS proposed as measured by the test method described in EN 12966-1 showing that the VMS complies with the Employer's Requirements in his Technical Proposal.

8.5.4 Character size

The character size of the VMS on the MTHL shall be minimum 400 mm in height excluding blank rows between lines. The VMS shall be capable of displaying a total of 22 English characters of the standard width including space between words in one line. The standard width of character and number of pixels will be the value defined by the manufacturer. The width shall be adjusted proportionally for each character to display message in proportional font. The display panel shall be capable of displaying all characters used in three languages.

A character shall be expressed by a matrix of pixels and on/off status of each pixel shall be independently controlled. The number of pixels comprising a character shall be minimum 20 pixels vertically to express characters of local languages in smooth and legible font. The horizontal number of pixels shall vary depending on the character. Spacing between lines shall be at least 10% of the character height.

8.5.5 Dimming

Dimming function shall be provided to VMS to reduce the brightness depending on the ambient light levels and prevent glaring during the dark hours. There shall be at least four (4) levels of brightness. Dimming control may be activated by photo electric cell attached to the signboard, local timer or command from the Control Centre. A mechanism shall be provided to prevent chattering.

8.5.6 Temperature monitoring and control

The VMS shall be equipped with a temperature sensor or sensors to measure the temperature inside the cabinet and ventilation fans to control temperature inside the cabinet. The temperature shall be continuously measured and the data shall be sent to the command control centre as one of the monitoring data.

The air route of ventilation system shall be designed in such a way that heat generated by LED and other electronic circuits, and heat of Sun light absorbed by cabinet shall be efficiently and equally dissipated.

The ventilation system shall be designed to keep the temperature inside cabinet lower than 60 degree Celsius at any time of the year when VMS is operating normally. Special attention shall be paid to the climate conditions of the Project site, where ambient temperature goes as high as 45 degree Celsius or higher.

A safety mechanism shall be provided that shuts down the VMS if the temperature inside cabinet reaches pre-define threshold temperature that shall be manually adjustable with the default setting of 60 degree Celsius. If shut down at 60 degree

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Celsius occurs under normal operation during the defect liability period of the VMS, it is considered a design defect and the Contractor shall take countermeasures to prevent forced shut down due to high temperature including replacement of VMS with the new design at no cost to the Employer.

Air conditioning system shall not be used to control the temperature inside the cabinet.

8.5.7 Display off mode

The VMS shall be provided with display off mode, in which it shall operate normally both in local mode and remote mode but the display units shall be turned off for testing purpose.

8.6 Housing

8.6.1 Cabinet

The variable message signboard shall be accommodated in the cabinet of suitable design made of cold rolled steel sheet or aluminium. Both signboard and controller may be accommodated in one cabinet, or alternatively they will be accommodated in separate cabinets.

The cabinet shall be electrically and mechanically robust having protection level of IP55 or higher.

If steel is used as material for cabinet, anticorrosive treatment described hereunder shall be applied. The steel surface shall undergo sand blasting first. Then thermal spraying of zinc as per ISO 2063 shall be applied to the surface followed by coating with melanin plastic paint to both interior and exterior. Finally, two (2) layers of polyurethane resin enamel shall be applied. The thickness of paint shall be minimum 100 micro-meter for exterior and 60 micro-meter for interior. The Contractor shall state the details of the anticorrosive treatment and painting if steel cabinet is proposed.

Sunshade may be attached to the top or side panel of the cabinet except front as countermeasure against Sun light. The sunshade, if adopted, shall be rugged enough to withstand the maximum wind stipulated and shall not cause any obstruction to the view of VMS.

8.6.2 Front screen

VMS may or may not have front screens covering the entire display surface. If front screen is used, it shall consist of perforated aluminium sheeting on the exterior and anti-glare polycarbonate sheeting on the interior. The size of the hole on the aluminium panel shall be large enough so as not to block the light emitted by LED. The polycarbonate panel shall have light transparency of minimum 85 %.

Front screen may consist of one piece or several pieces of panel. If multiple panels are used to form front screen, they shall be sealed together to prevent water from entering inside the cabinet. The front screen shall not be fixed to the VMS frame permanently and shall be detachable for maintenance purpose.

A mechanism shall be provided to absorb the difference in coefficient of thermal expansion of polycarbonate and other materials and to prevent deformation of

carbonate panel and ingress of water into interior.

8.6.3 Service outlet

The VMS housing shall have minimum two (2) service outlets for maintenance use at convenient location inside the cabinet.

8.7 Variable message sign local controller

VMS local controller shall have the following functions:

- Communication control
- Display control
- Monitoring
- Local operation

The VMS local controller shall communicate with the VMS workstation through the data communication system. It shall receive display data from the VMS workstation and send back the operating status data to the VMS workstation.

Display data received from the central controller shall be stored in the buffer until all the data have been correctly received without error. Upon confirmation of correctness of data, display shall be changed to the new message. Changeover shall be fast and no irregular display shall be shown during the transition. Under any circumstances, the changeover of message shall be completed within 3 seconds after the system operator in the command control centre has issued a message changeover command.

Several test pattern shall be provided to local controller, with which defect of LED can be tested by indicating one of them sequentially.

Operating condition of the VMS shall be monitored regularly by VMS itself and the local controller. If any abnormality is detected, error signal shall be issued to the VMS workstation together with the type of error, and location of defective LED unit, if applicable.

It shall be possible to operate the local controller and the signboard manually at the site. The manual control panel shall be provided to the local controller. Alternatively, manual control shall be made with a notebook computer connected to the local controller through serial port or network port.

8.8 Installation

8.8.1 Location

The VMS shall be installed on the gantry over the main carriageway of MTHL at six (6) locations and as shown below. Five (5) VMS locations are the bridge section and the VMS shall be placed on the footing to be constructed by the bridge contractor, while the Contractor shall construct a footing and provide conduits and hand hole for cables at the earth section.

Direction	For eastbound traffic	For westbound traffic:

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Location	KM 1+660 (bridge)	KM16+000 (bridge)
	KM 18+330 (bridge)	KM19+580 (earth)

8.8.2 Gantry

The VMS shall be mounted on a gantry crossing entire width of the road in each direction of main line section. Design and construction of the gantry shall be included in the Contract. If no guardrail is existing at VMS site, the Contractor shall provide guardrail of at least 10 meter long to protect VMS support and prevent damage to the post caused by vehicle crash at earth section of VMS locations.

Typical designs of the gantry and cantilever support are included in the Drawing of the Employer's Requirements for reference only. The Contractor shall design the gantry and their foundations taking such factors as weight and dimensions of VMS proposed, bearing capacity of ground, wind load, fixing method of signboard with the gantry, cable route, location and size of cable hole and grounding method.

The cost of the support to be entered in the financial proposal shall reflect the design of support and foundation prepared by the Contractor.

The width of the gantry shall be adjusted to the road width at the installation location and minimum clearance of 5.5 meters shall be secured above carriageway.

The Contractor shall also prepare design calculation of support to indicate that support is strong enough to bear the load created by the VMS. The design and calculation of support and foundation shall be submitted as part of Technical Proposal.

The Contractor shall obtain the approval of design and design calculation from the Engineer before the start of the fabrication work of gantry.

A mechanism to adjust the tilting angle of VMS shall be provided to the VMS housing or fixture used to attach the VMS to the support. It shall be possible to adjust the tilting between 0 degree (vertical) and 10 degree (tilted forward).

The Contractor shall undertake foundation work for the gantry where required, communication cable and power cable works, protection against lightning, grounding and other works incidental to the installation of VMS.

The structural steel used for gantry and cantilever support shall be hot dipped galvanized with the zinc amount of 550 g/m2. The amount of zinc shall be measured before erection of the support and materials not conforming to the requirement shall be rejected. No additional work that affects galvanization such as drilling a hole or application of file shall be allowed at site.

8.8.3 Cable work

The VMS shall be connected with the optic fibre cable to be installed along the MTHL and power supply cable extended from the nearest power station. The Contractor shall undertake the cable works to connect the VMS along MTHL with the VMS system.

The cable installation work design included in the Drawing is reference only. The

Contractor shall examine the optic fibre cable route along the MTHL and the power cable from the power station to the VMS site and prepare his own cable work design based on the actual site condition. Hand hole, pull box and junction box shall be used at the location where cable route bends and where cable route shifts from embankment to bridge. The size of power cable shown in the Drawing was selected based on the assumed power consumption of the VMS. The Contractor shall select the power cable of suitable size that is sufficient for the VMS proposed.

All cables shall be placed on the cable tray to be laid inside box girder at bridge section or laid underground at earth section and no aerial cable installation shall be used. Underground cable shall be put through conduit of suitable type and size. End of the conduit or protective tube shall be firmly fixed on the equipment, junction box, hand hole or VMS support using fixture and shall not left unattached. No cable shall be left suspended in the air and visible from outside.

8.9 Specifications of variable message signboard

The technical specifications mentioned hereunder are minimum guidelines. The contractor shall not deviate materially from the specifications.

The Contractor shall submit the power consumption data of the VMS proposed for two cases; when 50% of pixels are ON in white colour with the highest brightness and when 25% of the pixels are ON with the highest brightness, in his Technical Proposal. The former case shall be the maximum power consumption of VMS signboard with all fans and other components in operating status.

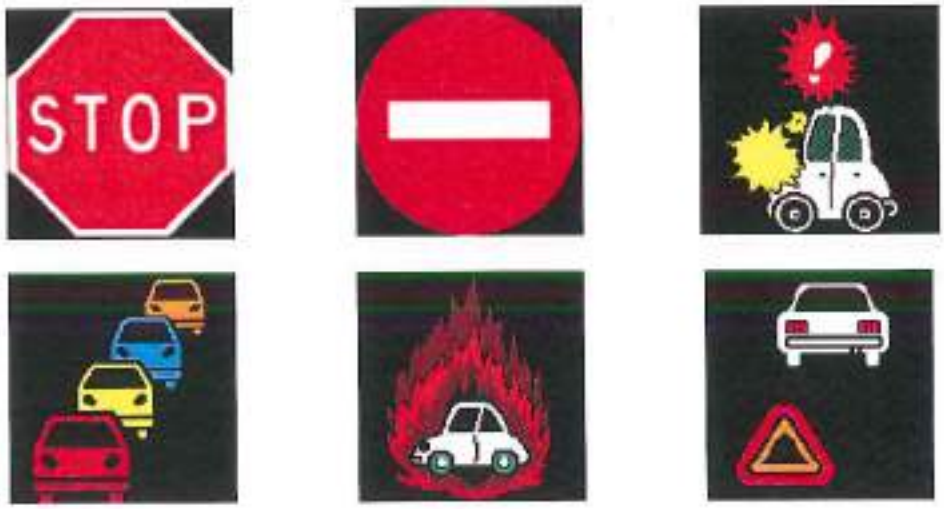
No.	Item	Specification
1.	Board size	6,000 mm (W) or more x 2,000 mm (H) or more
2.	Weight	As per manufacturer's design
3.	Material	Cold rolled steel sheet (SPCC) 2.3 t, or aluminium 2.0 t
4.	Character height	Minimum 400 mm in height
5.	Pixel/character	Vertical: minimum 20 pixels Horizontal: Proportional to character
6.	Display capacity	22 English characters of standard width without graphic symbol per line. Three (3) lines
7.	Display device	Light emitting device LED Luminescent colour (blue , red , green)
8.	Power supply	230 V ± 10% 50 Hz
9.	Power consumption	2000 VA (reference)

10.	Operating ambient temperature	0 to 50 °C
11.	Humidity	20 to 85 % (non-condensing)
12.	Wind resistance	50 m/s
13.	Reliability and maintainability	MTBF: 10,000 hours MTTR: 1.0 hour

If the maximum power consumption of the VMS proposed exceeds the figure above, the Contractor shall modify the power supply system and re-calculate the size of power cable that supplies power to the VMS indicated in the Drawing. The re-calculation shall be reflected in the cost proposed. No cost adjustment shall be allowed to the cost of power supply system to the VMS that is agreed at the time of contract.

8.10 Graphic symbols

The variable message sign system shall be capable of displaying the graphic symbols. The sample symbols are listed below for reference only. The Contractor shall design and propose graphic symbols to be used on the variable message sign for approval by the Engineer. The graphic symbols shall be compliant with the IRC: 67-2012 standard where applicable. The system shall be capable of having a maximum of twenty (20) graphic symbols. Graphic symbols shall be defined as dot matrix and editing of the symbol shall be possible. It shall be possible to combine text and graphic symbol in a message.



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9. Vehicle Actuated Speed Warning System (VASS)

This specification covers Vehicle Actuated Speed Warning System (VASS) to be installed as one of the sub-systems of the traffic management system for MTHL. The VASS system is intended to provide warning to the MTHL users with the information of Speed Of the User and the warning if necessary.

It shall be the responsibility of the Contractor to furnish all necessary hardware and software, provide poles, install equipment at the specified location, provide necessary wiring, setup database and parameters, integrate all system components, and deliver a complete operational Vehicle Actuated Speed Warning System.

The specifications mentioned herein are only for the Indicative purpose. The contractor shall design the system as per the latest technologies at the time of implementation and shall obtain the approval of Engineer for the design before implementation.

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No.	Item	Specifications
1	Aluminum protective cover	0.1875" (d)
2	Intensity	Yellow or white High-Intensity prismatic reflective sheeting on the sign face with black colored text
3	Operating Temperatures	-40°F/-40°C to 185°F/85°C
4	Power Input	AC 100~240 VAC
		12 VDC
		Built in ambient light sensing and automatic brightness control
		Wireless battery charge monitor
5	Power Options	AC power input: 100~240 VAC
		DC power input: 12 VDC
		Solar power: 85W solar panel
6	Radar	Internal Radar: Doppler (FCC approved)
		Radar RF out: 5 mW maximum
		Beam polarization: Linear


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No.	Item	Specifications
		Pickup distance: Up to 1,200 ~~feet (366m)~~
		Beam angle: 11 x 11
		Radar f-center: 24.125 GHz center +/-25MHz
5	Display	LEDs 1,322: - Digits: 768 Amber, 23°, 5 mm, luminous intensity (5680 – 8200 mcd/LED) - Matrix: 512 Amber, 23°, 5 mm, luminous intensity (5680 – 8200 mcd/LED) - Speed Violator Strobes: 42 White, 15°, 5 mm, luminous intensity (28,150 mcd/LED)
		Optical lenses: 1,322 polycarbonate lenses
		Ambient light sensor and automatic brightness adjustment
8	Enclosure	12/14 gauge aluminum, light gray powder coated body to minimize heat absorption
		Weatherproof, NEMA 4X-12, IP65 level compliant
		Non-sealed and ventilated
9	Mounting Options	Banding brackets (standard)
10	Communication	Bluetooth 4.0 (standard)
		Wi-Fi (optional)

10. Data Communication System

10.1 General

The Contractor shall construct a data communication system using optic fibre cable along MHTL. The system shall provide data communication service along the MTHL


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for toll management system, traffic management system, security surveillance system and other applications.

The data communication system shall be an IP based system and all data, video image, and voice signal shall be transmitted through the standard TCP/IP protocol. The system shall operate on a 24-hour a day 7-day a week basis.

The Contractor shall provide and install the data communication equipment, cabinets that accommodate the equipment, cable and connector, terminal board, conduit, hand hole, manhole, cable tray, fixing metals, control and monitoring software, and other device and accessories to establish a functional data communication system meeting the Employer's Requirements stated herein.

10.2 System configuration

Optic fibre cable shall be laid along both sides of the MHTL to connect toll management centre and command control centre at main line toll plaza, toll plaza office at Shivaji Nagar Interchange, command control sub-centre new Sewri Interchange and various roadside equipment.

The data communication system consists of layer 3 switch (L3-SW), layer 2 Switch (L2-SW), media converter or small form factor pluggable (SFP) and optic fibre cable. The quantity of the layer 3 switch, layer 2 switch and media converter indicated in the pricing document shall be understood as an indicative quantity and the Contractor shall provide and install these devices in the quantity necessary to connect all the equipment the Contractor provides.

Four (4) Ethernet rings shall be established using the optic fibre cable to be installed along both sides of the MTHL. Optic fibre cable on each side shall form a ring connecting alternately along the MTHL and cables on both sides shall be connected at the end of cable route. Normally, one side of the optic fibre cable rings shall be used as operating ring. In the event of interruption of the operating ring, the system shall automatically switch over to the standby ring.

10.3 System functions

10.3.1 Multiplexing

The data communication system shall adopt coarse wave division multiplexing (CWDM) at the interface with layer 2 SW, media converter or SFP.

10.3.2 Ethernet switch function

The network shall be provided with operation, administration, maintenance and provisioning (OAM & P) features as defined by IEEE 802.1ag and shall be provided with connectivity fault management (CFM) functions including connectivity check, loopback and link trace.

A virtual LAN (VLAN) shall be established by the network management system workstation and the system parameters shall be set up by the workstation. The processing capacity of L2-SW shall be not less than 12 G bps.

10.3.3 Network function

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Managing function

147) IEEE 802.1ag,IEEE 802.3ah, ITU-T Y.1731,

148) Switching Database Manager templates for Layer 2 and Layer 3 deployment

Network Security

149) IEEE 802.1x,

150) Dynamic ARP Inspection.

151) Port security secures the access to an access or trunk port based on MAC address.

152) Multilevel security on the console.

Availability and Scalability

153) IEEE 802.1w Rapid Spanning Tree Protocol (RSTP).

10.4 Cabinet

10.4.1 Case

The L2 switch, media converter or SFP and optic fibre cable terminating unit shall be housed in a dedicated cabinet with a power supply or alternatively in the cabinet for roadside equipment. The cabinet shall be rugged in both cases.

154) The protection of the cabinet against water and dust shall have a degree of protection of IP66 or higher specified in IEC60529 "Tests for Protection against Water for Electrical Equipment and Degrees of Protection against Ingress of Solid Foreign Objects."

155) The anti-lightning and surge protection complying with IEC61643-1 shall be provided.

10.5 Installation location

L2 switch and media converter or SFP shall be installed at the location of the CCTV camera for traffic surveillance. Dedicated cabinet for L2 switch, media converter or SFP and optic fibre cable terminating unit shall be provided and installed in the equipment room at toll plaza building and server room at command control centre, Shivaji Nagar interchange and command control sub-centre at Sewri IC.

10.6 Power supply

Data communication system shall operate with AC230V±10% 50Hz except the devices that are accommodated in the emergency telephone call box, for which DC 12 V may be used.

10.7 Specifications

The devices comprising data communication system shall have the specifications as specified below. Layer 2 switch shall be of fan-less type and the operating temperature shall be up to 70 degrees Celsius. Media converter or SFP shall also have the operating temperature up to 70 degrees Celsius.

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156) Layer 3 Switch

Layer 3 switch shall meet the specifications below.

No.	Item	Specifications
1.	Switching bandwidth	298 Gbps
2.	Interface	10/100/1000 Base-T 24 ports SFP slot 4 ports
3.	Standard	10 Base-T (IEEE 802.3) 100 Base-Tx (IEEE 802.3u) 1000 Base-T (IEEE 802.3ab)
4.	Routing protocol	OSPF, RIP
5.	IP multicast	IGMPv2, IGMPv3
6.	QoS	Supported
7	VLAN	4094
8	Switching	MSTP, RSTP
9	Others	Loop protection
10	Management	SNMP v1/v2c/v3
11	Power supply	AC 230V / 50 Hz
12	Operating temperature	0° C to 50 °C

157) Layer 2 Switch

Refer the specifications for layer 2 switch in the part of toll management system.

158) Media converter/SFP

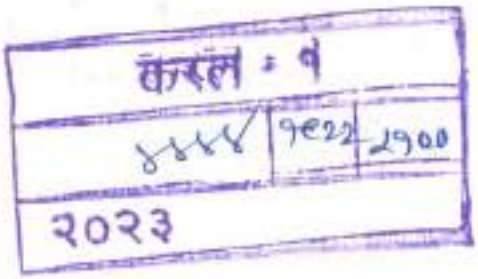
Refer the specifications for media converter/SFP in the part of toll management system.

159) Optic fibre cable splicing unit

No.	Item	Specifications
1.	I/O core wire number	60 core
2.	Connector type	IEC60874-14 Type SC
3.	Composition	Housing, SC adapter panel, splice tray
4.	Box type	Rack-mounted, wall type
5.	Dimensions (H×W×D)	90 mm x 490 mm x 530mm or less

160) Network Cabinet

No.	Item	Specifications
1.	Standard	DIN 41494
2.	Front door	Tinted glass
3.	Rear door	Steel fully perforated
4.	Top cover	Vented, with cable carry provision
5.	Mounting angles	Full 19" at front and rear. Rear mounting angles to be supplied in pairs
6.	Side panels	With slam latches
7.	Load Rating	1000 KG
8.	Height	36 U
9.	Finish	Vender specific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11. Mobile Radio Communication System

11.1 General

Mobile Radio Communication System (MRCS) will be used to provide private wireless communication for the personnel engaged in the MTHL operation and maintenance. The system shall cover the entire MTHL with high quality of voice communication. It is expected to be used to provide private voice communication for maintenance purpose.

The system shall conform to the existing laws and regulations regarding radio wave transmission in India.

The Contractor shall be responsible to select candidate locations, transmit power, and antenna height of the MRCS station/repeaters, based on the radio propagation simulation result, and radio propagation test at site, if necessary. The contractor is also responsible for coordinating with stakeholders and applying licence on behalf of the Employer to an appropriate authority in local/central Government in India.

11.2 System Configuration

MRCS is combination of Wireless Communication System Controller, Wireless Communication Repeater, and Mobile Station.

In MRCS system, the radio control will be managed in Command Control Centre. Repeater station may be established to ensure the coverage area of entire MHTL. Repeater station if established will be connected to the base station through wireless link or through digital transmission system to be constructed under this project. Mobile unit shall be installed in the vehicles used for MTHL operation and maintenance. Portable unit shall be provided for the use by the staff engaged in operation and maintenance work.

11.3 Command Control Centre Workstation

The Command Control Centre workstation will consist of, but not limited to, radio equipment (transmitter and receiver), antenna, coaxial arrester, communication control equipment and radio communication console. Two sets of transmitter and receiver shall be installed as hot standby system.

The radio communication console equipped with microphone shall have such functions as to select and communicate with any mobile unit or mobile unit group to be preset, select transmitter and receiver to be used, control the base station equipment, track vehicle location, and log operation record through the communication control equipment.

8-element Yagi type antenna or equivalent shall be used to transmit the radio signal effectively. The coaxial arrester shall be installed to protect the equipment from lightning surge.

The power supply to each equipment will be made from DC power supply or Uninterruptible Power Supply (UPS) with battery having enough capacity to supply power until the emergency generator starts.

11.4 Base Station / Repeater

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The base station shall consist of, but not limited to, repeater equipment including two sets of transmitter and receiver, control equipment, antenna (8-element Yagi type or equivalent) and coaxial arrester. The base station shall have following functions.

- To connect and communicate with CCC workstation and mobile units
- To receive control signal from CCC workstation or mobile units and initiate repeater equipment
- To change over transmitter or receiver based on the control signal from CCC workstation
- To detect transmitter and receiver failure, and have automatic radio changeover function
- To send operating status in compliance with control signal from CCC workstation

The power supply to each equipment will be made from DC power supply or UPS with battery having enough capacity to supply power until the emergency generator starts.

11.5 Mobile Station

Both vehicle mounted type unit and portable type mobile unit with cradle type battery charger shall be provided. The mobile unit shall be of compact size and light in weight in consideration of the usability.

11.6 Requirement Specifications

The MRCS system shall have following functions

161) Radio Dispatch

162) Events & voice logging

163) GPS-Tracking

164) Text & Data Transfer

165) Simulcast

11.6.1 Radio Dispatch

- Two-way individual, group and all calls from SmartPTT Dispatch Console
- Conference calls to individuals or groups
- Recording of all voice calls even individual between subscribers
- Hot keys for quick private and group calls
- Calling Subscriber Identification
- Emergency calls
- Voice calls and text message exchange between dispatchers (Intercom)
- Radio check
- Call alert
- Flexible sound control
- Configurable profiles to manage access of dispatchers to control stations, groups

services.

- Channel Selector for switching channels at the control stations
- Muting of talk groups

11.6.2 Event and Voice Logging

SmartPTT voice logging system stores sound files in MP3 format. Files can be played back from the dispatcher console event viewer or by ordinary sound player from the folder where the MP3 files are stored. Subscribers of all types, Control Stations and Groups can be arranged in the flexible Category tree. Each subscriber can belong to multiple categories simultaneously. In addition, the set of custom subscriber properties can be defined for every subscriber. This feature allows users to have business specific subscriber attributes, for example vehicle type, vehicle ID, etc.

11.6.3 GPS Tracking

- Know exact GPS location of subscribers
- Control subscribers in the dangerous zone
- Track where subscriber was at what time
- Subscriber positioning in real time
- Subscriber location history
- Track animation
- Track details and reporting
- Speeding and stops control
- Automatic and manual location request
- Different map formats supported (vector, raster, online)
- Integration with Google Earth (export locations to KML)

11.6.4 Text & Data Transfer

166) Text Message Service

SmartPTT Dispatcher Console allows sending text message either to individual subscriber or group. Subscribers with the radio having display and keyboard can send text message back to the Dispatcher Console.

167) Status Control

SmartPTT supports flexible list of statuses for subscribers. Every status can have its own colour. Statuses can be assigned to subscribers, either from the dispatcher console or by pressing accessory button on subscriber radio. Status filter in the dispatcher console allows easy selection of the subscribers having specific status.

11.6.5 Simulcast

Broadcasting the voice message to all Mobile Stations simultaneously.

11.7 Technical Specifications

11.7.1 Mobile/Base Station

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No.	Item	Specifications
	General	
	Frequency Range	136 MHz to 174 MHz, (Full Band)
	No. of Channel	255 or more
	Channel Spacing	12.5 KHz
	Frequency Stability	+/- 1.5 PPM or better
	Protocol & Technology	Digital TDMA Technology or better
	Type of Emission	Analogue: FM Digital:4 FSK or equivalent technique complying to open standard / non-proprietary Digital Protocol as defined by an international standards body like ETSI / FCC etc.
	Type of Operation	Simplex, Press to Talk
	Weight	Less than 2000 grams
	Power Source	12 Volt DC +/- 15%
	Protection	Reverse Polarity Protection Protection against high VSWR
	Transmitter	
	RF Power Output	25 W Programmable / selectable (Mobile) 5 W / 1 W (Portable)
	FM Hum Noise	-40 dB or better
	Modulation Limiting	±2.5 KHz @ 12.5 KHz
	Adjacent Channel Power	- 60 dB or better
	Audio Distortion	Less than 3%
	Receiver	
	Sensitivity	Analogue – 0.30 µV for 12 dB SINAD or better Digital - 0.30 µV @ 5 % BER or better
	Selectivity (Adjacent Channel)	60 dB or better
	Inter Modulation	70 dB or better
	Audio Output	3 Watt or more
	Audio Response	+1, -3 dB
	Rated Audio Distortion	Less than 3%

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No.	Item	Specifications
	Environmental	
	Operating Temperature Range	-30 ° C to + 60 ° C
	Storage Temperature	-40 ° C to + 70 ° C
	Humidity maximum	95% @ 40 ° C non- condensing
	Environmental standards i.e., Low and high temperature, Low pressure, temperature shock, solar radiation, rain, salt, fog, vibration, dust and shock	MIL Standard 810 C, D, E and F
	Dust and water intrusion	IP 54 or better
	Accessories	
	Microphone	DTMF microphone should be supplied with radio
	Battery Cable and mounting fixture	should be supplied with Radio
	Antenna	0 dB / 3 dB Gain Whip Antenna with 5 meters co-axial cable with suitable connector magnetic base / mounting bracket for vehicle use will be provided as per user's requirements. 3 dB / 6 dB Omni Directional Antenna with 50 meters 1/2" COAX RF cable for base station will be provided as per user's requirements
	Power Supply Unit	13.8VDC 10A with power cable
	LPU with Patch cord	LPU with Patch cord. Polyphaser make
	Literature	User manual shall be provided to each Radio
	Configuration	
	Caller ID Display	To be provided
	Busy channel Lockout	To be provided
	Scan with priority	To be provided
	Transmitter Time Out Timer (TOT) Operation	The Time should program to best suit the application
	LCD Display	To be provided

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No.	Item	Specifications
	Mode of calls	Selective Call, Group Call, inter and intra group call facilities
	Remote radio Kill / Stun / Revive Facility,	To be provided
	Mode of operation	Radio should operate in analogue mode and digital mode. (Compatible with all existing all types of VHF analogue radio sets)
	Emergency button	Allow a user to obtain help in critical situation.
	SMS texting	Shall be capable of sending pre-defined messages and short messages from keypad.
	Programming	Front panel programming with password protection or PC programming.
	Support GPS	Built-in GPS system with accuracy of less than 10 meters.
	Networking	Shall be IP based for automatic roaming etc.
	GIS	Radio shall have application protocol interface along with software applications to provide locations and messaging on PC/ Console.
	Over the air programming	Radios shall be capable of programming over the air.
	Intelligent Audio	Radio audio output shall adjust automatically as per the environment noise
	Hands free accessory with Bluetooth	Hands free accessory shall be Bluetooth complaint

11.7.2 MRCS Repeater

No.	Item	Specifications
	General	
	Frequency Range	136 MHz to 174 MHz, Full Band
	Synthesis Step	50Hz
	Channel Spacing	25/20/12.5/6.25 KHz or better
	Frequency Stability	0.5 PPM or better
	Protocol & technology	Digital TDMA technology or better
	Synchronization Source	Internal, GPS/GLONASS, Ethernet, 2wire,

No.	Item	Specifications
	for Simulcast	Digital RX, External
	Weight	Less than 3.5 kg.
	Power Supply	-15V
	RF Power Output	25W or more (Programmable / selectable) 100% duty cycle
	Audio Lines	2*4 wire/ E&M
	LAN Port	Ethernet 10BT/100TX (auto MDI/MDI X) on as RJ45 socket
	IP Multisite traffic	70kb/s in analog to/from Master 24kb/s in DMR to/from Master (both DMR Timeslots)
	Maximum tolerable IP delay	960ms
	Operating Temperature Range	-30°C to + 60°C
	Simulcast	Repeater should have simulcast system
	Diversity Receiver	Should be part of Repeater
	Networking and Interfaces	
	Networking	Should be capable to support IP site connects
	Interfaces	Ethernet Port RJ-45 to provide. Wide area IP Connectivity for Voice and data Remote monitoring and status check
	Channel Spacing	25/20/12.5/6.25 KHz or better
	Frequency Stability	0.5 PPM or better
	Protocol & technology	Digital TDMA technology or better
	Synchronization Source for Simulcast	Internal, GPS/GLONASS, Ethernet, 2wire, Digital RX, External
	Weight	Less than 3.5 kg.
	Accessories	
	Battery Cable and mounting fixture	should be supplied with Repeater
	Antenna	3dB/6dB Omni Directional Antenna with 50


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No.	Item	Specifications
		meters 1/2" COAX RF cable for base station shall be provided as per user's requirements
	Local Operator	Along with POL
	Industrial grade Ethernet switch with cat 5 cable	4 port Ethernet switch with 500mtr cat 5 e cable.
	LPU with Patch cord	LPU with Patch cord. Polyphaser make.
	Outdoor rated cabinet	IP65 Outdoor cabinet with 1.5mtr stand and foundation
	Solar panel with battery backup	525Watt solar panel with 450mAH battery backup. MPPT Charge controller with emergency change over. Solar panel mounting structure

11.8 Installation

Antenna for WCS is installed on the top of Guyed Tower, with proper tilt and azimuth angle.

11.9 Acceptance Test

After system completion, drive test along MTHL shall be executed at least once for both direction. More than 99% of the measurement points shall be covered along MTHL.

12. Optic fibre Cable System

12.1 General

This specification covers optic fibre cable (OFC) to be installed as a backbone communication for MTHL. The cable shall connect command control centre at main line toll plaza, toll plaza building at Shivaji Nagar Interchange, command control sub-centre at Sweri Interchange and all the traffic management system roadside equipment, In addition, optic fibre cable will be used by the toll management system to connect plaza server system at Shivaji Nagar Interchange with toll management centre system at mainline toll plaza.

Optic fibre cable shall be laid along all sections of the MHTL on both sides as shown on the Drawings. The cable shall be placed on the cable tray inside the box culvert for bridge section and inside the underground conduit along the embankment section. The dual ring configuration of the cable shall ensure the high reliability of the cable system and interruption of a ring shall not affect the normal operation of the highway traffic management system, toll management system, and other data and voice communication system used for the management of the MTHL.

12.2 Specifications

The optic fibre cable to be supplied and installed under the Contract shall be single-mode optic fibre cable having characteristics meeting ITU-T G.652B or better and the specifications below.

No.	Item	Specifications
1.	Cable type	OF-SM 12C OF-SM 4C or 6C
2.	Number of cores	OF-SM 12C: 12 cores OF-SM 4C or 6C: 4 cores or 6 cores
3.	Mode	Single mode
4.	Cladding diameter	125.0 µm ± 1.0
5.	Coated fibre diameter	245 µm ±10
6.	Core/cladding concentricity error	≤ 0.8µm
7.	Coating/cladding concentricity error	≤ 12µm
8.	Cladding non-circularity	≤ 1.0 %
9.	Mode Field Diameter	9.3µm ± 0.5 at 1310nm
10.	Attenuation (cable)	0.36dB/Km at 1310nm 0.25dB/Km at 1550nm,
11.	Zero-Dispersion Wavelength	1300 to 1322 nm

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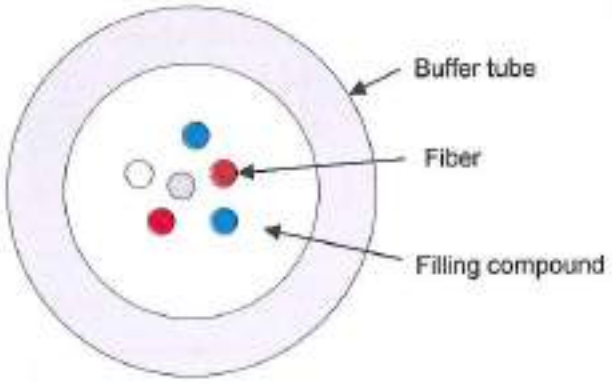
No.	Item	Specifications
12.	Zero-Dispersion Slope	≤0.092 ps/Sq. Nm .km
13.	Cut-off Wavelength	≤1260 nm
14.	Polarization Mode Dispersion Coefficient	≤0.2 at 1310nm
15.	Fibre macro bend loss	≤0.05dB at 1550 nm with 75 mm dia., 100 turns ≤0.5dB at 1550 nm with 32 mm dia., 1 turn
16.	Coating Strip Force	1.3 ≤ F ≤ 8.9
17.	Minimum Proof Strength	0.70 (100kpsi) Gpa
18.	Strain	1 %

The optic fibre cable shall be water-blocking type and shall be armoured for underground installation. It shall have virtually same construction as shown in the reference drawing below. The Contractor shall include the cross section construction drawing of the optic fibre cable proposed in his Technical Proposal.



Loose Tube Construction (6 cores / tube)

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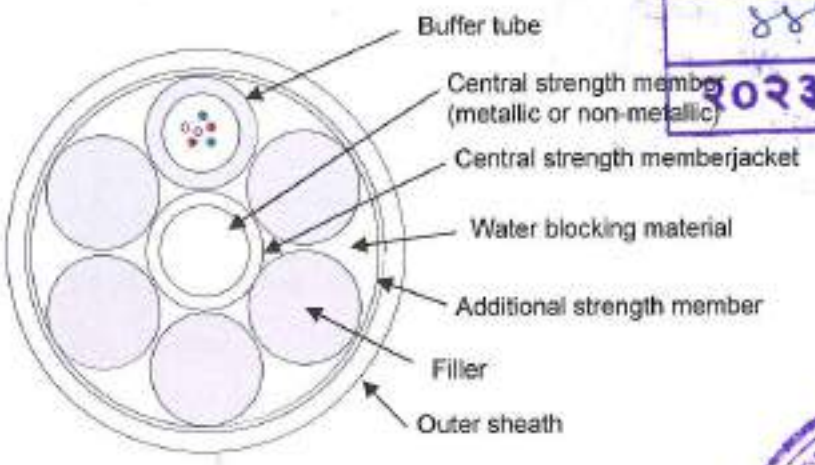

Cable Construction (6 cores)

Construction of Optic fibre Cable (6 cores) – reference only

12.3 Cable length

The cable length shown on the Drawings of Employer's Requirement is the estimated cable length based on the design of the MTHL. The Contractor shall make his own estimate of the optic fibre cable based on his own design. The Employer will not take any responsibility as to the correctness of the cable length.

12.4 Cable installation work

12.4.1 Packing and delivery

Packing and delivery of optic fibre cables shall conform to the following:

168) Each length of cable shall be coiled on a substantial wooden or steel drum. Standard cable peace length shall be 1000 meters.

169) After completion of the optical tests, both ends of the cable shall be sealed by a suitable method to prevent the entrance of moisture.

170) If required, the running end of the cable shall be fitted with a suitable pulling eye, which shall grip the steel tension member.

171) The cable end at which the colour scheme sequence follows a clockwise direction shall be marked red. The other end shall be marked green. Suitable self-adhesive tape may be used for this purpose.

172) Both ends of the cable shall be firmly secured and available for tests without uncoiling the cable.

173) The starting end of the cable shall be secured on the inside of the drum flange.

174) Due care shall be taken during the transportation of the cable drum so as not to cause damage the cable.

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12.4.2 Cable pulling

Cable installation work shall be undertaken in the following manner.

175) Before pulling cable into conduit, the cable shall be checked for possible damage. The damaged cable shall not be used.

176) Conduit shall be cleaned before cable pulling.

177) At no time shall more than the allowable tension specified by the cable manufacturer be placed on any optic fibre cable while it is being pulled through conduit. It is preferred that all optic fibre cable be pulled with hand power only. If power winches or mechanical devices are used to pull cable, a tension meter must be used to insure that maximum tension is not exceeded. Torsion shall be avoided by the use of a swivel at the cable end.

178) The extension of optic fibre cable shall be carried out at a constant speed and suitable back tension shall be applied to the drum to prevent hunching.

179) While under tension, a minimum bend radius of 20 times the outside cable diameter shall be maintained through the use of pulleys and sheaves where required. After pulling, no bend may have a radius, at rest, of less than 10 times the outside cable diameter.

180) Dedicated cutting tool shall be used if the cable is to be cut.

181) At the splicing point, slack of minimum 3 meter shall be kept on each side of splicing kit. The slack shall be neatly arranged and the requirement for the minimum radius shall be met.

182) A white vinyl adhesive tape shall be attached around the cable at about 50 mm from the conduit end as a marker for detection of cable movement.

183) Measures shall be taken to prevent the creeping of the optic fibre cable placed in the conduit having 3% or steeper longitudinal gradient.

184) Plastic plate describing the cable ID and number of cores shall be attached to the optic fibre cable near the end terminating at the terminal.

12.4.3 Fibre optic cable splicing kit

The Contractor shall provide water-proof splicing kits suitable for underground connection of optic fibre cables in the junction box. The splicing kit shall be of heat shrinkable type and capable of jointing a maximum of 12 cores. Cable joints shall be firmly attached to the fixing on the junction box wall and cables shall be placed neatly in the junction box. Unless otherwise approved by the Engineer, splicing of optic fibre cables shall be made only at the points shown on the cable network drawings.

12.4.4 Cable splicing

The Contractor shall provide an arc fusion splicer and other tools necessary for jointing optic fibre cables, which shall include, but not be limited to, fibre jacket stripper, cleaver, and heater for shrinkable tube protector. Splicing attenuation shall be measured for all cores at all splicing points. The Contractor shall keep the record of splicing loss and

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submit the record to the Engineer. The average splice loss shall not exceed 0.3 dB for single mode fibre.

12.4.5 Fibre distribution frame and terminal box

The Contractor shall provide an optic fibre cable distribution frame and a terminal box in the command control centre, command control sub-centre and each of toll plaza building for the termination of outside optic fibre cables and connection with the optical codes.

12.5 Testing

12.5.1 Test before installation

It is suggested that each individual fibre in a cable be tested with an optical time domain reflectometer (OTDR) for length and transmission anomalies while on the reel before installation.

12.5.2 Test after installation and termination

After termination, each and all fibres core shall be tested with an OTDR for length, transmission anomalies, and end-to-end attenuation. Results shall be recorded and supplied to the Engineer in the form of hard-copy printouts or photographs of screen traces.

Should the cable fail to meet the performance requirements specified herein, the cable shall be replaced and test be repeated at the Contractor's cost.

13. Power and Other Cables

13.1 General

This specification lays down the general, functional and technical requirements for the power cable, earthing cable and Ethernet cables to be used for the traffic management system, toll management system and other applications. The requirements for the optic fibre cable are set forth in a separate section.

13.2 Specifications

13.2.1 Type of cables

The types of cables shall be as shown below. The table shall be understood as the guideline and it shall be the Contractor's responsibility to select the type and size of cable suitable for its use.

No.	Item	Specifications
1	Indoor Power Cable	Minimum 1.5 square mm flexible 3 Core
2	Outdoor Power Cable	Minimum 1.5 square mm - 22 square mm, 3 cores

No.	Item	Specifications
3	Earthing Cables	16 square mm copper PVC insulated cable
4	Network Ethernet Cable	UTP CAT 5 or 6 cable for indoor use STP CAT 5 or 6 cable for outdoor use

13.2.1.1 Indoor power cable

Indoor power cable shall meet the following specifications:

- Bright annealed, 99.97% electrolytic grade
- Copper conductor (stranded),
- Voltage grade 1100 V,
- Single or multi core cable
- Flame retardant low smoke (FRLS),
- PVC insulated, rodent repellent
- With high oxygen and temperature index
- Un-armoured
- IS 694, IS 8130 or BS 6004/ BS 6500IEC 60502

13.2.1.2 Outdoor power

Outdoor power cable shall meet the following specifications:

- Bright annealed, 99.97% electrolytic grade
- Copper conductor (solid/stranded),
- Voltage grade 1100 V,
- Single or multi core cable,
- Flame retardant low smoke (FRLS),
- PVC / XLPE insulated,
- With high oxygen and temperature index
- Armoured,
- IS 8130, IS 5831, IS 3975, IS 1554 (Part I) / IS 7098 (Part I) or BS 6346/ IEC 60502

13.2.1.3 Network Ethernet cable

The network Ethernet cable shall comply with the following standards:

- IEEE802.3u, IEEE802.3ab, TIA/EIA-854

13.2.2 Length of cables

The cable length shown in the Pricing Document is the estimate only. The Employer will not take any responsibility as to the correctness of the cable length except when

the location of the equipment is substantially changed.

The contractor shall do his own assessment for the cable lengths to quote the price for the same. The price quoted shall be fixed price only and no variable price would be considered for the cabling price schedule.

13.3 Cable installation work

13.3.1 Cable pulling

185) Sufficient care shall be taken and measures shall be applied during the loading, transportation and unloading of cable drum so as to avoid shock and damage to the cable.

186) Appropriate surplus of cable shall be required at inside of junction box.

187) Cable shall be connected only inside the junction box.

188) Plastic plate describing the name of the cable (power cable or earthing cable) and the origin of cable (interchange name) shall be attached to the cable.

189) During the installation of cable, the following constraints shall be observed:

- The maximum tension allowed.
- The minimum curvature radius allowed: When installing cable at the junction box, curvature radius shall be more than 6 times of the diameter of the cable being laid at all times. After cable laying work, minimum radius of more than 20 times of the diameter shall be ensured.
- Extension speed of laying:
- Towing cable shall be made smoothly without any excessive tension intermittently at the time of laying, and calibration of appropriate apparatus for setting up allowable tension shall be required.

190) The extension of cable shall be carried out at a constant speed and it shall apply the suitable back tension for a drum to avoid hunching.

191) Cable in the point in a junction box shall have at least 3 m margin complied with curvature radius at every junction box and the point of junction box for roadside equipment shall have the 3 m margin at both sides of branch.

192) Winding up of insulating tape for the connecting point of electric wire shall be required and connected electric wire shall be robust.

193) Connection between electric wire and roadside equipment shall be connected robustly using terminal lug or a screw.

13.3.2 Cable jointing kit

Cable jointing kit for power cable shall be capable of dismantling and reassembling and shall meet the following specifications:

No.	Item	Specifications

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1.	Case material	FRP sleeve with resin	४४४४	१८५३	२१००
2.	Method for cable connection	straight joint or branch joint	२०२३		
3.	Protection	IP67			
4.	Dielectric strength	DC 3500V, 5 minute			

14. Power Conditioning Equipment System

14.1 General

This specification lays down the general, functional and technical requirements of the power conditioning equipment to be used as a sub-system in the traffic management system and toll management system at mainline toll plaza, Shivaji Nagar Interchange and Sewri command control sub-center..

Power supply rated at 440V, 3 phases will be made available at the Essential Supply Board of the interchange toll plaza building. This supply will be backed up by standby generators to be provided by others; should there be an absence of electrical power.

A power distribution board (PDB) as detailed in the drawing shall be supplied and installed under this Contract. The Contractor shall provide power distribution board at other locations where necessary, and the cost of such power distribution board shall be considered included in the Contract Price.

The Contractor shall supply and install UPS systems in the manner shown in the Drawing of Employer's Requirement. All equipment comprising toll management system at toll plaza and all command control centre equipment shall be provided power through this UPS to make sure that the stable power is continuously available during the interruption of commercial power.

Command control centre equipment and all roadside equipment shall operate at 240 volts, single phase supply with 50Hz. However, the equipment of DC 12V supply shall be used for a part of emergency call box, CCTV camera, and automatic traffic counter cum classifier.

The load of command control centre equipment and roadside equipment shall be arranged in the power distribution board in such a manner as to give the best practicable balance over the three phases of supply.

Complete earthing network constructed using earthing rods and chambers of not more than one (1) ohm shall be provided for highway traffic management system equipment.

14.2 System configuration

The UPS system shall consist of the following components:

194) UPS at command control centre, command control sub-centre and interchange

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195) Power distribution board at command control centre, command control sub-centre and interchange

14.3 Type of UPS

Rating of UPS Type shall be 10KVA, 15KVA or 30KVA as specified.

The suggested rating of the UPS at each interchange is listed below. The Contractor shall make his own calculation of the rating based on the power requirement of the equipment he supplies and the sound engineering practice. The Contractor shall submit the calculation and the rating to the Engineer for his approval.

14.4 Cabinet

14.4.1 Fabrication

Panel or distribution board shall be wall mounted. It shall be fabricated of readymade with 14/16SWG CRCA Sheet, compartmentalized, double door hinged type. Gasket shall be provided to prevent the ingress of dust and vermin confirming to degree of protection IP-54 (panel) and IP-43 (distribution board), IP-65 (outdoor) with suitable space & direction for cable entry. Distribution board shall be cleaned with 7 Tank process, powder coated with primer and epoxy paint as per IS 2171/1963 as amended.

14.4.2 Busbar

Busbar has to be tinned electrolytic grade copper busbar having not less than 99.97% purity with more than 100% conductivity. It shall be supported on SMC or epoxy insulators, covered with heat shrinkable colour coded sleeves with current density of 1.5 Amp/mm2 with temperature 85 degree Celsius.

14.4.3 Switchgears and meters

All switchgears (MCCB / MCB / fuses/ measuring instruments / meters/ indicating lamps / relays / switches) rating, capacity, make, kA rating, dimension shall be as per the type of DB with quick make & break type operating mechanism suitable for rotary operation with suitable extended operating handles with capacity and position marking on door, flush mounted, with suitable spreaders / links for cable connection as per IS 1248, 2208, 4237, 8623, 10118 (Parts I to IV).

14.4.4 Wiring

All power wiring within panel and distribution board shall be with suitable size flexible copper wire of 1.1kV grade, C.T. & control wiring with 2.5 square mm and 1.5 square mm, respectively with 1.1kV grade with proper lugging, ferruling, and connection with SS Nut - Bolt with adjustable and fixed washer.

14.4.5 Indication and marking

All distribution board and panel shall have suitable main name plate, feeder name plate, danger board plate engraved or anodized aluminium type as per IS 2551. All panels

and distribution boards shall have earthing node, point or strip similar to bulbar as per IS 3043.

14.5 Installation location

Rating of UPS at command control centre, command control sub-centre and the toll plaza building shall be as indicated below.

No.	Interchange	KVA Rating
1.	Mainline toll plaza building	30
2.	Shivaji Nagar interchange	30
3.	Sewri interchange	10

14.6 Power supply

All equipment except the roadside equipment powered by solar power supply shall operate with AC three-phase three-wire system 440 V ± 10% 50 Hz.

14.7 Requirements for UPS

The UPS system to be provided under the Contract shall comply with the specifications listed hereunder.

No.	Item	Specifications
1.	Rating in KVA	30
	Input	
2.	Rectifier design	IGBT charger - Advanced rectifier
3.	Nominal voltage	415 VAC (-20% to +15%) 3 Phase and neutral
4.	Nominal Frequency	50 Hz (+/- 6%) (60 Hz optional)
	Output	
5.	Inverter design	IGBT Based PWM with Digital Control
6.	Voltage	230 VAC (220/240, Selectable) 1 Phase & N
7.	Regulation	+/- 1 %
8.	Frequency	50 Hz (+/- 0.1 Hz) in Free running mode, (+/- 2.5 Hz) in Synchronous Mode, (60 Hz Optional)
9.	Waveform	True Sine Wave
10.	Total Harmonic Distortion	<2% on linear load and <5% on non Linear load (Reference IEC 62040-3)

No.	Item	Specifications
11.	Crest Factor	3:1
12.	Overload Capacity	125% for 10 Minutes, 150% for 60 Sec (Inverse Time Characteristic)
13.	Dynamic Response	Complies to IEC 62040-3, Class 1
14.	Duty	Continuous
	Environment	
15.	Ambient temperature	0°C to 40 °C
16.	Relative humidity	Up to 90% (Non Condensing)
17.	Altitude	Less than 1000 meter above sea level
	Physical	
18.	Cabinet Protection	IP - 20
19.	Cooling	Forced Air
20.	Colour	Vendor's standard colour
21.	Cable Entry	Bottom /Rear
22.	Testing standard	IEC 62040-3

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DIVISION 5B. OUTLINE SPECIFICATIONS – ARCHITECTURAL, CIVIL, PLUMBING & FIREFIGHTING WORKS

TABLE OF CONTENT

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1. GENERAL SPECIFICATIONS

1.1. EMPLOYER'S REQUIREMENTS - OUTLINE SPECIFICATIONS

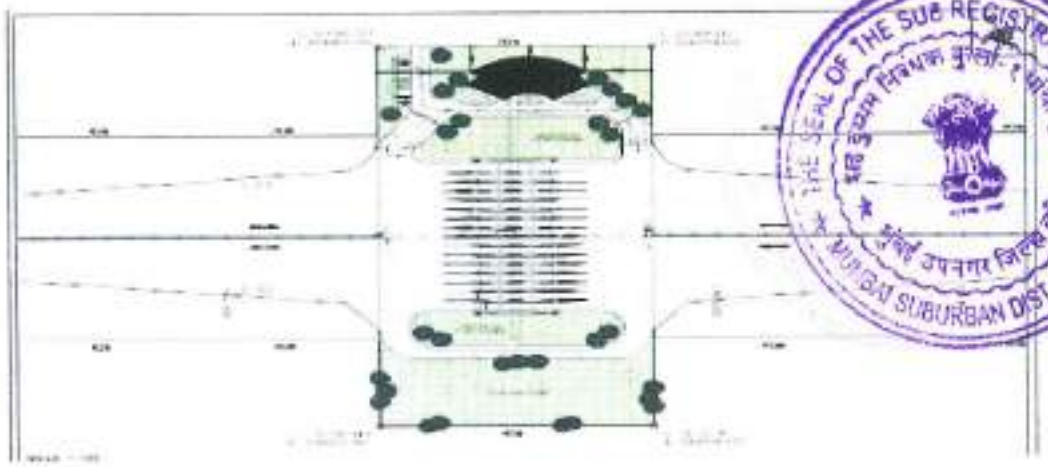
The Employer's Requirements - Outline Specifications present the design and construction specifications for the Works. The Works shall be designed and constructed in strict compliance withthe specifications presented herein.

The Outline Specifications are as follows:

Specifications for Design and Construction of the Buildings and toll plaza Structures.

1.2. DESIGN AND CONSTRUCTION OF MTHL

The Outline Specifications for the design and construction of the MTHL involved in the Works are given below.



1.2.1. DESIGN STANDARDS

Except where specifically permitted otherwise by the Engineer in writing, the Contractor's design and Construction of the Buildings and toll plaza structures shall be in strict accordance with thefollowing design standards and/or specifications applicable.

Table 1.2.1. - IRC Standards and Specifications

Code No.	Title
IRC: 2	Route Marker Signs for National Highways
IRC: 12	Guidelines for Access, Location and Layout of Roadside Fuel Stationsand Service Stations (Third Revision)
IRC: 27	Specifications for Bituminous Macadam
IRC: 30	Standard Letters and Numbers of Different Heights for Use on Highway Signs
IRC: 35	Code of Practice for Road Markings
IRC: 67	Code of Practice for Road Signs
IRC: 98	Guidelines on Accommodation of Utility Services on Roads in UrbanAreas

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IRC:103	Guidelines for Pedestrian Facilities
IRC: SP: 87	Manual of Specifications and Standards for Six Lanning of Highways
IS :875(Part 2)	Codes of Practice for Design Loads (Other than Earthquake) For Buildings and Structures
IRC: SP-99	Manual of Specifications and Standards for Expressways
IRC: SP-85	Guidelines for Variable Message Signs
IRC: SP-110	Application of Intelligent Transport System for Urban Roads
IRC: SP:119	Manual of Planting and Landscaping of Urban Roads
NBC: Vol 1 & Vol 2	National Building code of India for Architectural design, Structuraldesign and Services.
Navi Mumbai DCR	Development Control Rules for Navi Mumbai
Mumbai DCR	Development Control Rules for Mumbai
IS 1200 -	Method of measurement of building and civil engineering works.(Part 1) - Part 1 Earthwork (Part 27) - Part 27 Earthwork done by mechanical appliances.
IS 3764	Excavation work-code of safety.
IS 2720 -	Methods of test for soils: (Part 1) - Part 1 Preparation of dry soil samples for various tests(Part 2) - Part 2 Determination of water content (Part 4) - Part 4 Grain size analysis (Part 5) - Part 5 Determination of liquid and plastic limit (Part 7) - Part 7 Determination of water content-dry density relationusing light compaction (Part 8) - Part 8 Determination of water content-dry density relationusing heavy compaction art (9) - Part 9 Determination of dry density - moisture content relationby constant weight of soil method (Part 14) - Part 14 Determination of density index (relative density) ofcohesionless soils (Part 28) - Part 28 Determination of dry density of soils in place, by thesand replacement method (Part 29) - Part 29 Determination of Dry Density of Soils In-place bythe Core cutter Method (Part 33) - Part 33 Determination of the density in place by the ring andwater replacement method (Part 34) - Part 34 Determination of density of soil in place by rubberballoon method (Part 38) - Part 38 Compaction control test (Hilf Method)

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Note;

1. IRC Codes and Guidelines may be subject to review. Hence the latest revision shall beadopted for the design.
2. The priority order of Design Standards and Codes for Building and toll plaza Structures is,
   1) IRC, IS
   2) BS or AASHTO
   3) Internationally recognized standards
3. If there are no standards for specific design items for the Design and Construction of theBuildings and toll plaza Structures in the codes listed above, equivalent international standards shall be applied after obtaining approval from the Engineer.

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2. TECHNICAL SPECIFICATIONS

Section A - DESIGN BASIC FOR CONDITIONS FOR MAIN CIVIL WORKS

The following design basis shall be followed in general for designing the building and its supportingstructures.

2.1 STRUCTURAL SPECIFICATION

2.1.1 LOADS

The structures shall be designed keeping the following loads as basis.

i) Dead Loads

The dead loads to be considered in design of structures are based on following density of materialsas per IS-875(Part-I)-1987

ii) Live Loads

The live loads considered for the design are as per IRC: 875(Part-II)-1987

iii) Wind Loads

Wind load on the structure is IS: 875 (Part-III)

iv) Seismic Loads

Seismic loads to be calculated as per map of India given in IS-1893-2000(Part-I).

2.1.2 COMBINATION OF LOAD CASES

Combinations of the above loads are carried out as IS: 456-2000.

2.2 DESIGN

Design of all Reinforced Concrete members are as per IS: 456-2000 & IS-3370:2009.

2.3 GRADE OF CONCRETE AND REINFORCEMENT

The following grade of concrete and steel shall be used:

a. For all Structures – M30 concrete

b. For all Structures – Fe 500 - HYSD reinforcement

2.4 CLEAR COVER TO REINFORCEMENT

The minimum clear cover to reinforcement shall be as follows:

a. The minimum cover to the main reinforcing bars for different members shall be as follows unlessstated otherwise:

Slab (Floor, Roof, Canopy and Staircase)
30mmBeams (Sides, Bottom & Top) 40mm
Columns 50mm
Pedestals (in contact with earth) 50
mmBasement wall, retaining walls

i. Face in contact with earth 40 mm

ii. Interior face 30 mm

iii. Foundations 75 mm

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2.5 DESIGN CONDITIONS FOR UNDERGROUND OR PARTLY UNDERGROUND

All underground or partly underground structures shall be designed for the following conditions:

i. Structure empty (i.e., empty of liquid, any material, etc.): full earth pressure and surcharge pressure wherever applicable, to be considered;

ii. Partition wall to be designed as per specifications mentioned in the drawings;

iii. Structures shall be designed for uplift in empty conditions

iv. Walls shall be designed under operating conditions to resist earthquake forces from earth pressure mobilization and dynamic water loads;

v. Underground or partially underground structures shall also be checked against stresses developed due to any combination of full and empty compartments with appropriate ground/uplift pressures from below to base slab. A minimum factor of 1.2 shall be ensured against uplift or floatation.

2.6 SAFE BEARING CAPACITY

The data for safe bearing capacity of the soil shall be obtained from the soil investigation report.

2.7. DESIGN AND DRAWING SOFTWARE

The computer software for the design of the MTHL shall be approved by the Engineer prior tocommencement of the design works.
All the Contractor's drawing for submission to the Engineer shall be prepared using the Autodesk of the version acceptable to the Engineer, unless otherwise permitted in writing by the Engineer.

2.8 REQUIREMENTS FOR CONCRETE SUPERSTRUCTURE, SUBSTRUCTURE AND FOUNDATION

2.8.1. General Requirements

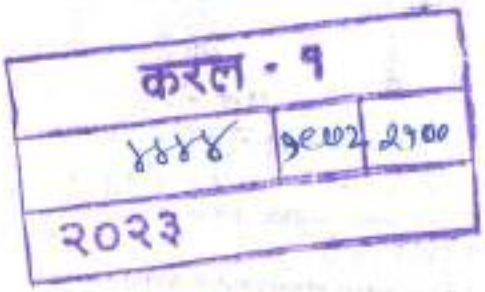
2.8.1.1 Substructures and Foundations

The following requirements shall apply to the design and construction of the foundations of Buildings and Toll Plaza:

(i) At the time of bidding, for the purpose of preparing the preliminary/bidding design, the Contractor must set an estimate based on the geological/subsoil investigation report issued by the Employer in the Technical Design stage after award of the Contract,

(ii) The Contractor shall determine the final ground levels at the proposed locations of the Toll plaza and buildings. based on that if required additional subsoil investigation may be carried out by the Contractor at his own cost.

(iii) The Contractor is expected to carry out soil investigations conforming the provisions ofIRC for design of the foundations during the Technical Design stage.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(iv) The Contractor shall carry out subsoil investigations involving boreholes at least at every proposed Structure or abutment location to assess the nature and characteristic of founding strata to finalize the base design. Additional boreholes shall also be taken, atno additional cost to the Employer, as may be ordered by the Engineer, as needed to confirm the strata as per requirement emerging during the design or Execution of the Works.

(v) In case there is a variation found in the information presented in the subsoil investigation report provided by the Employer and the depth of foundations assumed in the preliminary/bidding design is required be changed due to the difference in sub-soil strata, costs for the difference in the depth of foundation shall be adjusted equitably under GCClause 13.

(vi) The onus of proving the variation in the information presented by the Employer in the geological/subsoil investigation report shall be on the Contractor.

(vii) The Contractor shall take necessary measures to prevent siltation.

(viii) The concrete piles shall be verified for its integrity by Sonic echo test. Sonic tubes shall beinstalled in all of piles, and the test shall be carried out randomly according to the Engineer's decision.

(ix) Foundation types shall be designed by the contractor for all area. Types of foundation canbe proposed to the Engineer by the Contractor for his approval, but no diagonal pile will beaccepted.

2.8.1.2 Concrete Superstructure

The following requirements shall apply to the design and construction of concrete superstructureof Buildings and Toll Plaza:

(i) The minimum span length of the superstructure can be proposed to the Engineer by theContractor for his approval,

(ii) Superstructure for the concrete Areas can be proposed to the Engineer by the Contractor for his approval.

2.8.1.3 Durability

Concrete should be durable to provide satisfactory performance in the anticipated exposure conditions during service. The materials and mix proportions specified and used, and the workmanship employed should be such as to maintain its integrity and to protect embedded metal from corrosion.

Total chloride content in concrete, expressed as chloride-ion, shall not exceed the following values by mass of cement used:

Type	Amount (percent)
Prestressed concrete	0.10
Reinforced concrete	-
(i) in severe condition of exposure	0.20
(ii) in moderate condition of exposure	0.30

The following test shall be made in order to secure the durability of concrete:

(1) Chloride Migration Coefficient Test
Chloride Migration Coefficient Test shall be tested as per NT Build 492.

Concrete quality classification based on the migration coefficient

Non-steady state migration coefficient ($\times 10^{-12}$ m^2/s)	Concrete quality
< 2	Very good
2 – 8	Good
8 – 16	Normal
> 16	Poor

For Substructure, Chloride migration coefficient shall be less than 2 x 10-12m2/s. For Superstructure, Chloride migration coefficient shall be 2 to 8 x 10-12m2/s

2.6.1.4 Cement

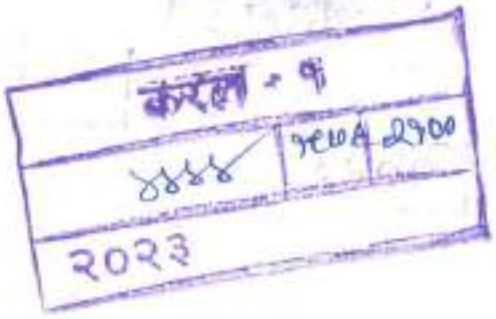
Cement for various structural elements shall be the following types.

- Pile (Severe Exposure): PSC as per IS 455, PPC as per IS 1489 Part 1 with minimumcompressive strength of 53 MPa at 28 days as per IS 14343
- Pile Cap, Raft Foundation: PSC as per IS 455, PPC as per IS 1489 Part 1 with minimumcompressive strength of 53 MPa at 28 days as per IS 14343
- Superstructure: OPC, PSC as per IS 455, PPC as per IS 1489 Part 1 with minimumcompressive strength of 53 MPa at 28 days as per IS 14343

Cement to be used in the works shall be any of the following types with the prior approval of theEngineer:

a) Rapid Hardening Portland Cement, conforming to IS:8041.
b) Ordinary Portland Cement, 43 Grade, conforming to IS:8112.
c) Ordinary Portland Cement, 53 Grade, conforming to IS: 12269.

Cement conforming to IS: 8112 and IS: 12269 may be used provided the minimum cement content mentioned elsewhere from durability considerations is not reduced. From strength considerations, these cements shall be used with a certain caution as high early strengths of cement in the 1 to 28- day range can be achieved by finer grinding and higher constituent ratioof C3S/C2S, where C, S is Tricalcium Silicate and C2S is Dicalcium Silicate. In such cements, the further growth of strength beyond say 4 weeks may be much lower than that traditionally expected. Therefore, further strength tests shall be carried out for 56 and 90 days to fine-tunethe mix design from strength considerations.
Cement conforming to IS: 8041 shall be used only for precast concrete products after specific approval of the Engineer.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2.9 REQUIREMENTS FOR STEEL SUPERSTRUCTURE

2.9.1. General Requirements

The following requirements shall apply to the design and construction of the Buildings and Tollplaza Structures:

i. Specific Requirements

ii. General

Contractor's responsibilities include, but not be limited to, the following.

The Contractor shall provide all materials and equipment required to complete the Works in every respect, whether such materials and equipment are required as part of the permanent structures or temporary for fabrication or erection or maintenance including specifically structural steel plates, shapes, flats, bars, welding rods, rivets, bolts and nuts, paint, welding sets in the shop and at site, all workshop facilities, derricks, cranes, pulley blocks, wire ropes, slings, hemp or manila ropes, winches, small tools and tackles, jacks, erection cleats and temporary braces or supports and all other materials required to deliver the Works complete inevery respect.

The Contractor shall supply all labour required for fabrication and erection for any cleaning, making good, rectifying, hauling, and painting and for any other ancillary work required to complete fabrication and erection.

The Contractor shall observe all safety requirements for erection of structural steelwork as covered in IS: 7205 as a minimum and other relevant Indian / international standard.

2.10. PAVEMENT

2.10.1. Site Investigation

The Contractor shall undertake, at his own cost, the necessary geotechnical/subsoil investigations/surveys as needed for the proper Technical Design of the MTHL including CBRtests for pavement design at earthwork sections.

2.10.2. Design Conditions for Pavement Design

Traffic demand forecast data (by vehicle type) for a period of 20 years after commencement ofthe MTHL operation are shown in the Table below for the Technical Design. Other design conditions and criteria shall be set by the Contractor for approval by the Engineer prior to commencement of the respective design. The pavements shall be designed for the minimum service life of 20 years.

Future Traffic Volume on MTHL (PCU/day(both directions))

(Unit : vehicle/day/direction)

Vehicle Type	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Car	12,050	14,170	16,280	18,400	20,510	22,630	24,740	26,860	28,970	31,090	33,200
Taxi	1,350	1,920	2,490	3,060	3,630	4,200	4,770	5,340	5,910	6,480	7,050
Bus	450	470	480	500	520	530	550	570	580	600	620
LCV	730	800	860	930	990	1,050	1,110	1,180	1,240	1,310	1,370

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HCV	500	560	620	680	730	790	850	910	970	1,030	1,080
MAV	510	560	610	660	710	760	810	860	910	960	1,010
Total	15,590	18,480	21,340	24,230	27,090	29,960	32,830	35,720	38,580	41,470	44,330

Vehicle Type		2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Car		34,590	35,970	37,360	38,740	40,130	41,510	42,900	44,280	45,670	47,050
Taxi		7,360	7,660	7,970	8,270	8,580	8,880	9,190	9,490	9,800	10,100
Bus		620	620	620	620	620	620	620	620	620	620
LCV		1,420	1,470	1,520	1,570	1,620	1,670	1,720	1,770	1,820	1,870
HCV		1,110	1,140	1,160	1,190	1,220	1,240	1,270	1,300	1,320	1,350
MAV		1,060	1,120	1,170	1,220	1,270	1,320	1,380	1,430	1,480	1,530
Total		46,160	47,980	49,800	51,610	53,440	55,240	57,080	58,890	60,710	62,520

* Traffic vollume by direction was caliculated as onehalf of traffic volume for both direction

2.10.3. Types of Pavement to be constructed

The following pavement types shall be applied to the bridge section depending on the bridge type. The minimum thickness is specified only for the bridge sections. The pavement structure and the thickness at the toll plaza section and the embankment section shall be determined based on the traffic data and geotechnical data of the sub-grade. Cement concrete pavement shall be constructed in the toll gate section (tentatively from No. 19+365 to No. 19+465)

Table 2.4 – Pavement Type and Minimum Thickness

Section		Pavement Type		Min. Thickness	Min. Total Thickness	Package
Bridge	Steel Deck	Base Course	Stone Mastic Asphalt Pavement	40 mm	80 mm	1&2
		Surface Course	Stone Mastic Asphalt Pavement	40 mm		

	Concrete Deck	Base Course	Stone Mastic Asphalt Pavement	40 mm	80 mm	
		Surface Course	Dense Graded Asphalt Pavement	40 mm		
Asphalt & Grade			Dense Graded Asphalt Pavement	To be designed by the Contractor. Supplied by appropriate Sub-grade		3
Toll Gate			Cement Concrete Pavement			4

2.10.4. Design Procedure

The pavement shall be designed by a certified Professional Engineer who has sufficient experiences of design of asphalt concrete pavements and cement concrete pavements of highways/roads, and the designer shall be approved by the Engineer in accordance with GC Sub-Clause 5.1. The Contractor shall design the pavements taking into account the structuralfeatures of bridge type, type of the deck to be paved, strength of the ground/road bed, climaticand environmental conditions, traffic volume and loading conditions. The pavement designs, asan integral part of the Contractor's Documents, shall be approved by the Engineer in accordance with GC Sub-Clause5.2.

Stone Mastic Asphalt (SMA) Pavement shall be designed to the established international design standards and practices such as SPECIFICATION FOR DENSE GRADED AND STONE MASTIC ASPHALTS, NZTA M10:2014, NZ TRANSPORT AGENCY. The Contractor shall obtaina prior approval of the Engineer on the standards to be used. The binder of SMA shall be the polymer-modified binder. The Contractor shall select, for approval by the Engineer, the most suitable materials for the bonding coat and the waterproofing membrane to secure the sufficient adhesion and waterproofing between the deck and the SMApavement, taking the climatic, loading and surface conditions of the deck into account. A bonding coat of bituminous emulsion type shall be applied to the cleaned surface of the deck prior to applying the waterproofing membrane. Waterproofing membranes shall be as mentioned at para 3.6.

Cement concrete pavements shall be designed to IRC and/or AASHTO or other internationally recognized design standards acceptable to the Engineer. The cement concrete pavements shall comprise Pavement Quality Concrete (PQC) of flexural strength of M-45 Grade. The pavementshall be laid over Dry Lean Concrete (DLC) of M-15 Grade, over the drainage layer of GranularSub Base (GSB). To ensure internal drainage of the pavements on the embankment, the GSBshall extend, right across the carriageway on the embankment, to the side drains, if marine clayis encountered, the pavement of embankment will have to be designed accordingly.

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2.10.5. Mix Design and Job-Mix Formula

The Contractor shall prepare mix designs of all types of pavements to be used and submit them to the Engineer for approval prior to its usage. The Contractor shall provide the information listed in the following table for approval of the job-mix formula by the Engineer prior to commencement of the mixing production.

Table 2.5 - Information for Engineer's Approval of Job-Mix Formula

No.	Information
1	Properties of aggregates, filler, binder
2	Grading, binder content and design air voids
3	Test results of trial mixes to decide design mix
4	Test results of mix properties
5	Test results on a batch of proposed mix to be used

1) Grading
2) Max. specific gravity of mix
3) Bulk density of compacted mix
4) Bulk density of combined mineral aggregates
5) Air voids
6) Total binder content
7) Binder density
8) Voids in mineral aggregate
9) Binder film thickness

2.10.6. Materials

The polymer-modified binder to be used for SMA pavements shall be in accordance with the following Table. The Contractor shall submit the test results of the polymer modified binder to the Engineer for approval.

Table 2.6 - Property of Polymer-Modified Binder

Item	Unit	Type II	Type III
Softening point	°C	56.0<	70.0<
Ductility (25°C)	cm	30<	50<
Toughness (25°C)	Nm	8.0<	16<
Tenacity (25°C)	Nm	4.0<	-
Penetration (25°C)	1/10mm	40<	40<
Loss on thin film oven test	%	0.6>	0.6>
Residual penetration after thin film oven test	%	65<	65<
Flash point	°C	260<	260<

2.10.7. Construction

The pavement construction works shall be in accordance with the relevant IRC standards. Theworks of SMA pavement shall comply with the established international standards acceptable to the Engineer. The Contractor shall submit the proposed method statements of the pavement

works to the Engineer for approval prior to commencement of the subject works. The following acceptance criteria shall apply:

1) Level
   The finished level at the top of each layer shall not differ from the specified level by more than 10 mm.

2) Thickness
   The finished thickness of asphalt pavement placed on the deck of bridge shall be not be less than the specified thickness by more than 10%, and the total thickness of any core taken shall not beless than the specified thickness by more than 5mm.

2.11. SIGNAGE AND PAVEMENT MARKING

The Contractor shall design, supply/furnish and construct the permanent signage for traffic safety and information and the pavement marking in accordance with the applicable IRC standards. The Contractor shall submit the proposed designs of the signage and pavement marking to the Engineerfor approval.

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SECTION B - EARTHWORK IN GRADING, EXCAVATION AND BACK FILLING

1) SCOPE

This specification covers the general requirements of earthwork in excavation in different materials, site grading, filling in areas, filling back around foundations and in plinths, conveyanceand disposal of surplus soils or stacking them properly as directed by the Engineer and all operations covered within the intent and purpose of this specification.

2) APPLICABLE CODES

The Indian Standard Codes mentioned in the codes and standards shall be applicable.In all cases, the latest revision of the codes shall be referred to.

3) DRAWINGS

The Contractor shall furnish drawings wherever, such drawings are required to show areas to beexcavated/ filled grade level, sequence of priorities etc. The Contractor shall obtain Engineer's approval before proceeding with works and follow strictly such approved drawings.

4) GENERAL

a) The Contractor shall furnish all tools, plants, instruments, qualified supervisory personnel, labour, materials any temporary works, consumables, any and everything necessary, whether such items are specifically stated herein for completion of the job in accordance with the specification requirements.

b) The Contractor shall carry out the survey of the site before excavation and set properly all lines and establish levels for various works such as earthwork in excavation for grading, foundations, plinth filling, roads, drains, cable trenches, pipelines etc. Such survey shall be carried out by taking accurate cross sections of the area perpendicular to established reference/ grid lines at 8 m. intervals or nearer as determined by the Engineer based on ground profile. These shall be checked by the Engineer and thereafter properly recorded.

c) The excavation shall be done to correct lines and levels. This shall also include, where required, proper shoring to maintain excavations and the furnishing, erecting and maintaining of substantial barricades around excavated areas and warning lamps at night for ensuring safety.

d) Rock/ soil excavated shall be stacked properly as directed by the Engineer. As a rule, all softer material shall be laid along the centre of heaps, the harder and more weather resisting materials forming the casing on the sides and the top. Rock shall be stacked separately.

5) CLEARING

The area to be excavated/ filled shall be cleared of fences, trees, plants, logs, stumps, bush, vegetation, rubbish, slush, etc. and other objectionable matter. If any roots or stumps of treesare met during excavation, they shall also be removed. The material so removed shall be burnt or disposed of as directed by the Engineer. Where earth fill is intended, the area shall be stripped of all loose/ soft patches, topsoil containing objectionable matter/ materials before fillcommences.

6) CLASSIFICATION

a) All materials to be excavated shall be classified by the Engineer into one of the followingclasses. No distinction shall be made whether the material is dry, moist or wet. The decision of the Engineer regarding the classification of the material shall be final and binding on the Contractor and not be a subject matter of any appeal or arbitration.

b) Any earthwork will be classified under any of the following categories:

i) **Ordinary and Hard Soils**

These shall include all kinds of soils containing kantar, sand, silt, murrum and/or shingle, gravel, clay, loam, peat, ash, shale, etc., which can generally be excavated by spade, pick axes and shovel, and which is not classified under "Soft and Decomposed Rock" and "Hard Rock" defined below. This shall also include embedded rock boulders not longer than 1 metre in any one direction and not more than 200 mm in any one of the other two directions.

ii) **Soft and Decomposed Rock**

This shall include rock, boulders, slag, chalk, slate, hard mica schist, laterite andall other materials which in the opinion of Engineer is rock but does not need blasting and could be removed with picks, hammer, crow bars, wedges, and pneumatic breaking equipment. The mere fact that the Contractor resorts to blasting for reasons of his own, shall not qualify for classification under 'Hard Rock'. This shall also include excavation in macadam and tarred roads and pavements.This shall also include rock boulders not longer than 1 metre in any direction andnot more than 500 mm in any one of the other two directions. Masonry to be dismantled will also be measured under this item.

iii) **Hard Rock**

This shall include all rock occurring in large continuous masses which cannot beremoved except by blasting for loosening it. Harder varieties of rock with or withoutveins and secondary minerals which, in the opinion of the Engineer require blasting shall be considered as hard rock. Boulders of rock occurring in such sizes and notclassified under 7.2.1 and 7.2.2 above shall also be classified as hard rock. Concrete work both reinforced and unreinforced to be dismantled will be measured under this item, unless a separate provision is made in the Schedule of Quantities.

7) EXCAVATION

a) All excavation work shall be carried out by mechanical equipment unless, in the opinion ofthe Engineer, the work involved and time schedule permit manual work.

b) Excavation for permanent work shall be taken out to such widths, lengths, depths and profiles as are shown on the drawings or such other lines and grades as may be specifiedby the Engineer. Rough excavation shall be carried out to a depth 150 mm above the final level. The balance shall be excavated with special care. Soft pockets shall be removed even below the final level and extra excavation filled up as directed by the Engineer. The

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final excavation if so, instructed by the Engineer should be carried out just prior to layingthe mud-mat.

c) The Contractor may, for facility of work or similar other reasons excavate, and backfill later, if so, approved by the Engineer, at his own cost outside the lines shown on the drawingsor directed by the Engineer. Should any excavation be taken below the specifiedelevations, the Contractor shall fill it up, with concrete of the same class as in the foundation resting thereon, up to the required elevation. No extra shall be claimed by theContractor on this account.

d) All excavation shall be done to the minimum dimensions as required for safety and working facility. Prior approval of the Engineer shall be obtained by the Contractor in each individual case, for the method he proposes to adopt for the excavation, including dimensions, side slopes, dewatering, disposal, etc. This approval, however, shall not in any way relieve theContractor of his responsibility for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner. Side slopes shall be as steepas will stand safely for the actual soil conditions encountered. Every precaution shall be taken to prevent slips. Should slips occur, the slipped material shall be removed, and the slope dressed to a modified stable slope. Removal of the slipped earth will not be paid forif the slips are due to the negligence of the Contractor.

e) Excavation shall be carried out with such tools, tackles and equipment as described herein before. Blasting or other methods may be resorted to in the case of hard rock; however not without the specific permission of the Engineer.

f) The Engineer may also direct that in some extreme case, the rock may be excavated byheating and sudden quenching for splitting the rock. Firewood shall be used for burning and payment shall be made for such work as called for in the schedule of quantities.

8) STRIPPING LOOSE ROCK

a) All loose boulders, semi-detached rocks (along with earthy stuff which might move therewith) not directly in the excavation but so close to the area to be excavated as to be liable, in the opinion of the Engineer, to fall or otherwise endanger the workmen, equipment, or thework, etc., shall be stripped off and removed away from the area of the excavation. The method used shall be such as not to shatter or render unstable or unsafe the portion which was originally sound and safe.

b) Any material not requiring removal as contemplated in the work, but which, in the opinionof the Engineer, is likely to become loose or unstable later, shall also be promptly and satisfactorily removed as directed by the Engineer. The cost of such stripping will be paid for at the unit rates accepted for the class of materials in question.

9) FILL, BACK FILLING AND SITE GRADING

a) GENERAL

All fill material will be subject to the Engineer's approval. If any material is rejected by the Engineer, the Contractor shall remove the same forthwith from the site at no extra cost to theEmployer. Surplus fill material shall be deposited/ disposed of as

directed by the Engineer after the fill work is completed.
No earth fill shall commence until surface water discharges and streams have been properlyintercepted or otherwise dealt with as directed bythe Engineer.

b) **MATERIAL**

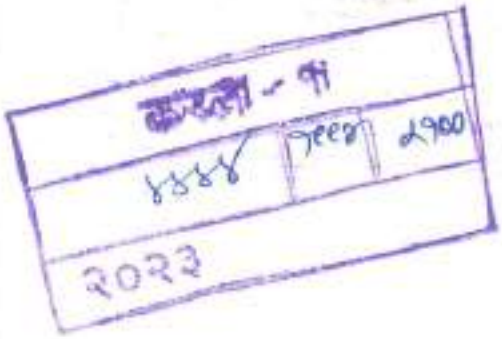
To the extent available, selected surplus soils from excavated materials shall be used asbackfill. Fill material shall be free from clods, salts, sulphates, organic or other foreign material. All clods of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not larger than 150 mm size, mixed with properly graded fine material consisting of murrum or earth to fill up the voids and the mixture used for filling.

c) If any selected fill material is required to be borrowed, the Contractor shall plan for bringing such material from outside borrow pits. The material and source shall be subject to priorapproval of the Engineer. The approved borrow pit area shall be cleared of all bushed, roots of trees, plants, rubbish etc. Topsoil containing salts/ sulphate and other foreign material shall be removed. The materials so removed shall be burnt or disposed of as directed by the Engineer.
The Contractor shall make necessary access roads to borrow areas and maintain the same, if such access road does not exist, at his own cost.

d) Filling in pits and trenches around foundations of structures, walls etc.
As soon as the work in foundations has been accepted and measured, the spaces around the foundations, structures, pits, trenches etc. shall be cleared of all debris, and filled withearth in layers not exceeding 15 cm., each layer being watered, rammed and properly consolidated, before the succeeding one is laid. Each layer shall be consolidated to the satisfaction of the Engineer. Earth shall be rammed with approved mechanical compaction machines. Usually no manual compaction shall be allowed unless the Engineer is satisfied that in some cases manual compaction by tampers cannot be avoided. The final backfill surface shall be trimmed and levelled to proper profile as directed by the Engineer or indicated on the drawings.

e) **PLINTH FILLING**

Plinth filling shall be carried out with approved material as described herein before in layers not exceeding 15 cm, watered and compacted with mechanical compaction machines. The Engineer may however permit manual compaction by hand tampers in case he is satisfied that mechanical compaction is not possible. When filling reaches the finished level, the surface shall be flooded with water, unless otherwise directed, for at least 24 hours allowed to dry and then the surface again compacted as specified above to avoid settlements at alater stage. The finished level of the filling shall be trimmed to the level/ slope specified. Where specified in the schedule of works, compaction of the plinth fill shall be carried outby means of 12 tonne rollers smooth wheeled, sheep-foot or wobbly wheeled rollers. In case of compaction of granular material such as sands and gravel, vibratory rollers shall be used. A smaller weight roller may be used only if permitted by the Engineer. As rollingproceeds, water sprinkling shall be done to assist consolidation. Water shall not be sprinkled in case of sandy fill.
The thickness of each unconsolidated fill layer can in this case be up to a maximum of 300 mm. The Engineer will determine the thickness of the layers in which fill has to be consolidated depending on the fill material and equipment used. Rolling shall commence from the outer edge and progress towards the centre and continue until compaction is tothe satisfaction of the Engineer, but in no case less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than 10 passes of the roller will be accepted for each layer.
The compacted surface shall be properly shaped, trimmed and consolidated to an even and uniform gradient. All soft spots shall be excavated and filled and consolidated. At some locations/ areas it may not be possible to use rollers because of space restrictions etc. The Contractor shall then be permitted to use pneumatic tampers; rammers etc. and he shallensure proper compaction.

f) **SAND FILLING IN PLINTH AND OTHER PLACES**

At places backfilling shall be carried out with local sand if directed by the Engineer. The sand used shall be clean, medium grained and free from impurities. The filled-in-sand shall be kept flooded with water for 24 hours to ensure maximum consolidation. Any temporarywork required to contain sand under flooded condition shall be to the Contractor's account. The surface of the consolidated sand shall be dressed to required level or slope. Construction of floors or other structures on sand fill shall not be started until the Engineerhas inspected and approved the fill.

g) **FILLING IN TRENCHES**

Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipesand drains have been tested and passed. The backfilling material shall be properly consolidated by watering and ramming, taking due care that no damage is caused to thepipes.

Where the trenches are excavated in soil, the filling from the bottom of the trench to the level of the centreline of the pipe shall be done by hand compaction with selected approved earth in layers not exceeding 8 cm; backfilling above the level of the centreline of the pipeshall be done with selected earth by hand compaction or other approved means in layersnot exceeding 15 cm.

In case of excavation of trenches in rock, the filling up to a level 30 cm. above the top ofthe pipe shall be done with fine materials, such as earth, murrum, etc. The filling up of the level of the centreline of the pipe shall be done by hand compaction in layers not exceeding 8 cm. whereas the filling above the centreline of the pipe shall be done by hand compaction or approved means in layers not exceeding 15 cm. The filling from a level 30 cm. abovethe top of the pipe to the top of the trench shall be done by hand or other approved mechanical methods with broken rock filling of size not exceeding 15 cm mixed with finematerial as available to fill up the voids.

Filling of the trenches shall be carried simultaneously on both sides of the pipe to avoid unequal pressure on the pipe.

10) GENERAL SITE GRADING

a) Site grading shall be carried out as indicated in the drawings and as directed by the Engineer. Excavation shall be carried out as specified in the specification. Filling and compaction shall be carried out as specified under Clause 10.0 and elsewhere unless otherwise indicated below.

b) If no compaction is called for, the fill may be deposited to the full height in one operation and levelled. If the fill must be compacted, it shall be placed in layers not exceeding 225 mm and levelled uniformly and compacted as indicated in Clause 10.0 before the next layer is deposited.

c) To ensure that the fill has been compacted as specified, field and laboratory tests shall be carried out by the Contractor at his cost.

d) Field compaction test shall be carried out at different stages of filling and after the


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fill to the entire height has been completed. This shall hold good for embankments as well.

e) The Contractor shall protect the earth fill from being washed away by rain damaged in any other way. Should any slip occur, the Contractor shall remove the affected material and make good the slip athis cost.

f) The fill shall be carried out to such dimensions and levels as indicated on the drawings after the stipulated compaction. The fill will be considered as incomplete if the desired compaction has not been obtained.

g) If so specified, the rock as obtained from excavation may be used for filling and levelling to indicategrades without further breaking. In such an event, filling shall be done in layers not exceeding 50 cms approximately. After rock filling to the approximate level, indicated above has been carried out, thevoid in the rocks shall be filled with finer materials such as earth, broken stone, etc. and the area flooded so that the finer materials fill up the voids. Care shall be taken to ensure that the finer fill material does not get washed out. Over the layer so filled, a 100 mm thick mixed layer of broken material and earth shall be laid, and consolidation carried out by a 12-tonne roller. No less than twelve passes of the roller shall be accepted before subsequent similar operations are taken up.

11) FILL DENSITY

The compaction only where so called for, in the schedule of quantities/ items shall comply with the specified (Standard Proctor/ Modified Proctor) density at moisture content differing not more than 4 percent from the optimum moisture content. The Contractor shall demonstrate adequately at his cost, byfield and laboratory tests that the specified density has been obtained.

12) LEAD

Lead for deposition/ disposal of excavated material, shall be as specified in the respective item of work. For the purpose of measurement of lead, the area to be excavated or filled or area on which excavatedmaterial is to be deposited.

13) SITE FILLING

(a) SCOPE

Apart from any other work/ purpose for which this specification may be made applicable by the Engineer, this shall generally govern work involving filling site over the entire area, most of the area to raise the general grade level to the desired elevation. This work shall be carried out as per applicable clauses of section "Earthwork in Grading, Excavation and Backfilling" particularly Clauses 10 and 11.

14) FILL MATERIAL

a) GENERAL

All fill material whether such material is brought from outside borrow areas or from excavation fromwithin the site, will be subject to the Engineer's approval. Notwithstanding any approval given to thefill material of borrow areas from which fill material is proposed to be brought, the Engineer/ The Employer reserves the right to reject such material which in his opinion either does not meet the specification requirements or is unsuitable for the purpose for which it is intended.

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b) BORROW AREAS

It shall be Contractor's responsibility to locate suitable borrow areas for borrowing fill material. Sucharea will be inspected by the Engineer and approved before the Contractor plans to borrow the fill material. The topsoil which may contain vegetation, rubbish, slush, etc. shall not be used. If demanded by the Engineer, the Contractor shall arrange to have trial pits of specified dimensions and numbersdug at locations specified, for the Engineer to examine the nature and type of material likely to be obtained from the borrow area.

c) LEAD, LIFT AND TRANSPORTATION

Unless separately provided for, all lead, lift and transportation required for bringing in the fill materialfrom borrow areas or from excavation from within the site shall be included.

d) QUALITY

The borrowed soil shall be generally granular, and non-cohesive. It shall consist of sand, silty sand, murrum, ordinary soil, gravel and shingle. Dredged material shall also be free from sulphates, salts, organic, foreign and other harmful or objectionable materials. Any material rejected by the Engineershall be removed from the site immediately.

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15) ACCESS ROAD

Roads, whether of temporary or other nature, required to be constructed for access and for movement of men, materials, equipment, transport vehicles, vehicles carrying fill material etc. to or over borrowareas and/or to or over areas on which fill has to be deposited shall be constructed by the Contractorat his cost. Such costs shall be deemed to have been included in the unit rates quoted by the Contractor. Such access in roads shall be maintained in good condition during all seasons to ensurecompletion of work according to time schedule.

16) CLEARING

Site clearing before filling shall be carried out as specified in the section "Earthwork in Grading, Excavation and Backfilling".

17) FILLING

a) SAND FILL

i. Sand fill shall be deposited to bring the grade level to desired elevation aftercompaction of fill.

ii. Sand fill shall be compacted, where so specified, by 12 tonne vibratory rollers as indicated in Clause 19.2.3 below. The fill material shall be compacted to the specifieddensity, where so specified.

iii. Compaction of sand fill by flooding the area shall be carried out where so specified. Inthis case, the Contractor should ensure that the fill material is not washed away. Thiswork shall be carried out as directed by the Engineer.

b) SOIL FILL

i) Approved soil fill consisting of ordinary soil, murrum, soil containing gravel, shingle etc.shall be deposited in layers not exceeding 200 mm. The Contractor should ensure that allclods of earth are broken down to a size not larger than 100 mm.

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ii) Where density of fill or use of rollers is not specified the fill shall be carried out as specified in Clause above.

iii) Where the fill material must be compacted by use of rollers procedure as specified in Clause 10.5 of section "Earthwork in Grading, Excavation and Backfilling" shall be followed.

iv) Where specified, the required density of fill shall be obtained by proper compaction.

18) DEWATERING

a) **SCOPE**: This section covers the general requirements of dewatering excavations in general.

b) All excavations shall be kept free of water. Grading in the vicinity of excavation shall be properly closed to prevent surface water running into excavated areas.

Contractor shall remove by pumping or other means approved by Engineer any water inclusive of rainwater and subsoil water accumulated in excavation and keep all excavations dewatered until the foundation work is completed and backfilled.

Sumps made for dewatering must be kept clear of the excavations / trenches required for further work. Method of pumping shall be approved by Engineer; but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing in due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction.

c) When there is a continuous inflow of water and quantum of water to be handled is considered in the opinion of Engineer, as large, well point system - Single stage or multistage, shall be adopted. Contractor shall submit to Engineer his scheme of well point system including the stages, the spacing, number and diameter of well points, headers etc., and thenumbers, capacity and location of pumps of approvals. Unless separately provided for in theSchedule of prices, the cost of dewatering shall be included in the item rate for excavation.

19) RAINWATER DRAINAGE

a) SCOPE: This section covers the drainage of rainwater in excavated areas.

b) Grading in the vicinity of excavation shall be such as to exclude rain/ surface water draining into excavated areas. Excavation shall be kept clean of rain and such water as the Contractor may be using for his work by suitably pumping out the same at no extra cost tothe Employer. The scheme for pumping and discharge of such water shall be approved by the Engineer.

c) Contractor shall ensure that the surface runoff outside the excavated pit/ working area shall be collected through a catch drain excavated around the working area and led awayto a natural stream, at no extra cost to the Employer. Contractor shall maintain the catchdrains in proper condition during the construction period at no extra cost to the Employer.

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SECTION C - PRE-CONSTRUCTIONAL ANTI-TERMITE TREATMENT

1) SCOPE

This specification covers the general requirements for Anti-termite Constructional Measures, chemical treatment of soils for the protection of buildings from attack by subterranean termites, chemicals to be used with their minimum rates of application and procedure to be followed while thebuilding is under construction.

2) APPLICABLE CODES

The following codes, standards and specifications are made a part of this specification. All specifications, standards, codes of practices referred to herein shall be the latest edition including all applicable official amendments and revisions. In case of discrepancy between this specification andthose referred to herein, this specification shall govern:

a) IS: 6313 Part - I - Code of Practice for Anti-termite Measures in Buildings Constructional Measures
b) IS: 6313 Part - II - Pre-constructional Chemical Treatment Measures
c) IS: 8944 - Specification for Chlorpyrifos Modifiable Concentrates
d) IS: 4015 Part - I - Guide for Handling cases of Pesticide Poisoning First Aid Measures
e) IS: 4015 Part - II - Symptoms, Diagnosis and Treatment

3) GENERAL

a) Contractor shall furnish all tools, plants. instruments, qualified supervisory personnel, labour, materials, any temporary works, consumables, any and everything necessary whether or no such items are specifically stated herein for completion of the job in accordance with specification requirements.
b) All work shall be done in the order of progress required by Employer construction programme.
c) Contractor shall take all necessary precautions to prevent any accident in connection with the performance of the work.
d) On final completion of all work, Contractor shall leave the entire premises within the site of his operation clean and free from all rubbish resulting from his operation.
e) The Employer reserves the right to inspect, check and direct any or all operations at any stage ofthe work and to require unsatisfactory work to be remedied at Contractor's expense.
f) No work shall be carried out under unsuitable weather conditions viz. when raining or when thesoil is wet due to rain or sub-soil water.
g) Chemicals shall be brought to site of work in sealed original containers. The materials shall be brought in, at a time, in adequate quantity to suffice for the work. The material shall be kept in cool and locked stores. The empties shall not be removed from the work site till the relevant item of work has been completed and permission granted by Employer/ Engineer.
h) Chemicals available in concentration forms with concentration indicated on the sealed containers only shall be used. Chemicals shall be diluted with water in required quantity before use, using graduated containers to achieve the desired percentage of concentration:

4) PRE-CONSTRUCTIONAL CHEMICAL TREATMENT

a) ESSENTIAL REQUIREMENTS

(i) Hand operated pressure pump with graduated containers shall be used to ensure uniform spraying of the chemical. Continuous check shall be kept ensuring that the specified quantity of chemical is used for the required area during the

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operation.

(ii) Condition of Formation

The treated soil barrier shall be complete and continuous under the whole of the structureto be protected. All foundations shall be fully surrounded by and in close contact with thebarrier of treated soil. Each part of the area treated shall receive the specified dosage ofchemical.

(iii) Time of Application

Soil treatment shall start when the foundation trenches and pits are ready to receive mass concrete in foundations. Laying of mass concrete shall start when the chemical emulsionhas been absorbed by the soil and the surface is quite dry. Treatment shall not be carriedout when it is raining, or soil is wet with rain or sub-soil water. The foregoing also appliesin the case of treatment to the filled earth surface within the plinth before laying the subgrade for the floor.

(iv) Disturbance

The treated soil barriers shall not be disturbed after they are formed. If by chance treatedsoil barriers are disturbed, immediate steps shall be taken torestore the continuity and completeness of the barrier system.

b) CHEMICALS, METHOD AND RATE OF APPLICATION

(i) a) Mound Treatment

Termite mounds within the plinth and contingent apron areas shall be destroyed by meansof insecticides in the form of water suspension or emulsion which shall be poured into themounds at several places after breaking open the earthen structure and making holes with crow bars. For a mound volume of about one (1) cum., four (4) litres of an emulsion inwater of one of the following shall be used:

0.50 percent Chlorpyrifos

b) Soil Treatment

Any one of the following chemicals (conforming to Indian Standards) in water emulsionshall be applied uniformly over the area to be treated.

Chemical	Concentration by weight
percentChlorpyrifos	1.0

(ii) Treatment of Column-pits, Wall-trenches and excavations

(a) The bottom surface and the sides (up to a height of about 300 mm) of the excavations made for column pits, wall trenches and shall be treated with the chemical atthe rate of 5 litres per sq. m of the surface area.

(b) After the column foundations and the retaining walls come up, the backfill in immediate contact with the foundation structure shall be treated at the rate of 15 litre persq. m of the vertical surface of the sub-structure for each side. If water is used for ramming the earth fill, the chemical treatment shall be carried out after the ramming operation is done by rodding the earth at 150 mm centres close to the wall surface and spraying thechemical with the above dose.

The earth shall be returned in layers and the treatment shall be carried out in similar stages. The chemical emulsion shall be directed towards the concrete or masonry surfaces of the columns and walls so that the earth in contact with these surfaces is welltreated with the chemical.

(c) In the case of R.C.C. framed structures with columns and plinth beams with concretemix 1:2:4 or richer, the treatment shall start at the depth of 500 mm below ground level forcolumns and plinth beams. From this depth the back-fill around the columns, beams andshall be treated at the rate of 15 litres/sq. m of vertical


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surface. The other details of treatment shall be as laid down in clause (b) above.

(iii) Treatment of Top Surface of Plinth Filling

The top surface of the filled earth within plinth beams/walls shall be treated with chemical emulsion at therate of 5 litres per sq. m of the surface before the sand bed/subgrade is laid. Holes up to 50 to 70 mm deep at 150 mm centres both ways shall be made with 12 mm dia. crowbar on the surface to facilitate saturation of the soil with chemical emulsion.

(iv) Treatment of Junction of Wall and Floor

To achieve continuity of vertical chemical barrier to inner wall surfaces from the ground level, small channel 30 x 30 mm shall be made at all the junctions of wall and columns with the floor (before layingthe subgrade) and rod holes made in the channel up to ground level 150 mm apart and the chemical emulsion poured along the channel at the rate of 15 litres / sq. m of the vertical wall or column surface soas to soak the soil right to the bottom. The soil shall be tamped back into place after this operation.

(v) Treatment of Soil Under Apron Along External Perimeter of Building

The top surface of the consolidated earth over which the apron is to be laid shall be treated with chemical emulsion at the rate of 5 litres / sq. m of the surface before the apron is laid, by making rod holes 75 mmdeep at 150 mm centres both ways.

(vi) Treatment of Soil Along External Perimeter of Building

After the building is complete, holes shall be made in the soil with iron rods along the external perimeterof the building at interval of about 150 mm and depth 300 mm and these holes filled with chemical emulsion at the rate of 7.5 litres/metre of perimeter of the external wall. If the earth outside the buildingis graded on completion of building, this treatment shall be carried out on completion of such grading. Ifthe filling is more than 300 mm the external perimeter treatment shall extend to the full depth of filling upto the original ground level to ensure continuity of chemical barrier.

(vii) Treatment for Expansion Joints

Anti-termite treatment shall be supplemented by treating through the expansion joint after the sub-gradehas been laid at the rate of 2 litres per linear meter of expansion joint.

(viii) Treatment of Soil Surrounding Pipes and Conduits

When pipes and conduits enter the soil inside the area of the foundations, the soil surrounding the pointsof entry shall be loosened around each such pipe or conduit for 150 mm and to a depth of 75 mm beforetreatment is commenced. When they enter the soil external to the foundations, they shall be similarly treated for over 300 mm unless they stand clear of the walls of the building by about 75 mm.

5 SAFETY PRECAUTIONS

i) All chemicals used for anti-termite treatment are poisonous and hazardous to health. These chemicalscan have an adverse effect upon health when absorbed through the skin, inhaled as vapours or spray mists or swallowed. Person using or handling these chemicals should be warned of these dangers andadvised that absorption through the skin is most likely source of accident poisoning. They should be cautioned to observe carefully the safety precautions given below.

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ii) These chemicals are usually brought to site in the form of emulsifiable concentrates. The containers should be clearly labelled and should be stored carefully so that children and pet cannot get at them. They shall be kept securely closed.

iii) Particular care shall be taken to prevent skin contact with concentrates. Prolonged exposure to dilute emulsions shall also be avoided. Workers shall wear clean clothing and wash thoroughly with soap andwater, especially before eating and smoking. In the event of severe contamination, clothing shall be removed at once and the skin washed with soap and water. If chemicals splash into eyes, they shall beflushed with plenty of soap and water and immediate medical attention shall be sought.

iv) The concentrates are oil solutions and present a fire hazard owing to the use of petroleum solvents. Flames shall not be allowed during mixing.

v) Care shall be taken in the application of chemicals to see that they are not allowed to contaminate wells or springs which serve as source of drinking water.

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SECTION D - CONCRETE AND ALLIED WORKS

1. SCOPE

i) This Specification covers the general requirements for ready mixed concrete and for concrete using on- site production facilities including requirements in regard to the quality, handling, storage of ingredients, proportioning, batching, mixing, transporting, placing, curing, protecting, repairing, finishing and testing of concrete; formwork; requirements in regard to the quality, storage, bending and fixing of reinforcement; grouting as well as mode of measurement and payment for completed works.

ii) It shall be very clearly understood that the specifications given herein are brief and do not cover minute details. However, all works shall have to be carried out in accordance with the relevant standards and codes of practices or in their absence in accordance with the best accepted current engineering practices or as directed by ENGINEER from time to time. The decision of ENGINEER as regards the specificationto be adopted and their interpretation and the mode of execution of work shall be final and binding on CONTRACTOR and no claim whatsoever will be entertained on this account.

2. APPLICABLE CODES AND SPECIFICATIONS

The following specifications, standards and codes, including all official amendments/ revisions and other specifications & codes referred to therein, should be considered a part of this specification. In all casesthe latest issue/ edition/ revision shall apply. In case of discrepancy between this specification and thosereferred to herein below or other specifications forming a part of this bid document, this specification shall govern.

2.1 MATERIAL

2.1.1. IS: 269 Specification for 33 grade ordinary Portland cement
2.1.2. IS: 455 Specification for Portland slag cement
2.1.3. IS: 1489 Specification for Portland pozzolana cement (Parts 1 & 2)
2.1.4. IS: 8112 Specification for 43 grade ordinary Portland cement
2.1.5. IS: 12330 Specification for sulphate resisting Portland Cement
2.1.6. IS: 383 Specification for coarse and fine aggregates from natural sources forconcrete
2.1.7. IS: 432 Specification for mild steel and medium tensile (Parts steel bars and harddrawn steel wires for 1 & 2) concrete reinforcement
2.1.8. IS: 1786 Specification for high strength deformed steel bars and wires for concretereinforcement
2.1.9. IS: 1566 Specification for hard drawn steel wire fabric for (Parts II) concretereinforcement
2.1.10. IS: 9103 Specification for admixtures for concrete
2.1.11. IS: 2645 Specification for integral cement waterproofing compounds
2.1.12. IS: 4900 Specification for plywood for concrete shuttering work
2.1.13. IS: 4926 Ready mixed concrete
2.1.14. IS: 12269 Specification for 53 grade ordinary Portland cement
2.1.15. IS: 8041 Specification for rapid hardening cement
2.1.16. IS: 12600 Specification for low heat cement
2.1.17. IS: 6909 Specification for super sulphated cement
2.1.18. IS: 12089 Specification for granulated ground blast furnace slag
2.1.19. IS: 6699 Specification for granulated ground blast furnace slag

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2.1.20. IS: 6073 Specifications for precast concrete masonry units (Part 1)Methods for specifying precast concrete masonry (Part 2)

2.2 MATERIAL TESTING

2.2.1 IS: 4031 Methods of physical tests for hydraulic cement (Parts 1 to 15)
2.2.2 IS: 4032 Method of chemical analysis of hydraulic cement
2.2.3 IS: 650 Specification for standard sand for testing of cement
2.2.4 IS: 2430 Methods for sampling of aggregates for concrete
2.2.5 IS: 2386 Methods of test for aggregates for concrete (Parts 1 to 8)
2.2.6 IS: 3025 Methods of sampling and test (physical and chemical) water used in industry(Part 1 to 51)
2.2.7 IS: 6925 Methods of test for determination of water-soluble chlorides in concrete admixtures

2.3 MATERIAL STORAGE

2.3.1 IS: 4082 Recommendations on stacking and storing of construction materials at site

2.4 CONCRETE MIX DESIGN

2.4.1 IS: 10262 Recommended guidelines for Concrete Mix Design
2.4.2 SP: 23 Handbook on Concrete Mixes

2.5 CONCRETE TESTING

2.5.1 IS: 1199 Method of sampling and analysis of concrete
2.5.2 IS: 516 Method of test for strength of concrete
2.5.3 IS: 9013 Method of making, curing and determining compressive strength ofaccelerated cured concrete test specimens
2.5.4 IS: 8142 Method of test for determining setting time of concrete by penetrationresistance
2.5.5 IS: 9284 Method of test for abrasion resistance of concrete
2.5.6 IS: 2770 Methods of testing bond in reinforced concrete

2.6 EQUIPMENT

2.6.1 IS: 1791 Specification for batch type concrete mixers
2.6.2 IS: 2438 Specification for roller pan mixer
2.6.3 IS: 4925 Specification for concrete batching and mixing plant
2.6.4 IS: 5892 Specification for concrete transit mixer and agitator
2.6.5 IS: 7242 Specification for concrete spreaders
2.6.6 IS: 2505 General Requirements for concrete vibrators: Immersion type
2.6.7 IS: 2506 General Requirements for screed board concrete vibrators
2.6.8 IS: 2514 Specification for concrete vibrating tables
2.6.9 IS: 3366 Specification for pan vibrators
2.6.10 IS: 4656 Specification for form vibrators for concrete
2.6.11 IS: 11993 Code of practice for use of screed board concrete vibrators

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2.6.12 IS: 7251 Specification for concrete finishers

2.6.13 IS: 2722 Specification for portable swing weigh batchers for concrete (single anddouble bucket type)

2.6.14 IS: 2750 Specifications for steel scaffoldings

2.7 CODES OF PRACTICE

2.7.1 IS: 456 Code of practice for plain and reinforced concrete

2.7.2 IS: 457 Code of practice for general construction of plain and reinforced concrete fordams and other massive structures

2.7.3 IS: 3370 Code of practice for concrete structures for storage of liquids (Parts 1 to 4)

2.7.4 IS: 3935 Code of practice for composite construction

2.7.5 IS: 2204 Code of practice for construction of reinforced concrete shell roof

2.7.6 IS: 2210 Criteria for the design of reinforced concrete shell structures and folded plates

2.7.7 IS: 2502 Code of practice for bending and fixing of bars for concrete reinforcement

2.7.8 IS: 5525 Recommendation for detailing of reinforcement in reinforced concrete works

2.7.9 IS: 2751 Code of practice for welding of mild steel plain and deformed bars used forreinforced concrete construction

2.7.10 IS: 9417 Specification for welding cold worked bars for reinforced concrete construction

2.7.11 IS: 3558 Code of practice for use of immersion vibrators for consolidating concrete

2.7.12 IS: 3414 Code of practice for design and installation of joints in buildings

2.7.13 IS: 4326 Code of practice for earthquake resistant design and construction of buildings

2.7.14 IS: 4014 Code of practice for steel tubular scaffolding. (Parts 1 & 2)

2.7.15 IS: 2571 Code of practice for laying in situ cement concrete flooring

2.7.16 IS: 7861 Part1 - Recommended practice for hot weather concreting Part2 – Recommended practice for cold weather concreting

2.7.17 IS: 3370 Code of practice for concrete structures for the storage of liquid (Part I to

2.8 CONSTRUCTION SAFETY

2.8.1 IS: 3696 Safety code for scaffolds and ladders (Parts 1 & 2)

2.8.2 IS: 7969 Safety code for handling and storage of building materials

2.8.3 IS: 8989 Safety code for erection of concrete framed structures

2.9 MEASUREMENT

a) IS: 1200 Method of measurement of building and engineering works (Parts 2 and 5)(Part 1 to 12)

3.0 GENERAL

3.1 ENGINEER shall always have the right to inspect all operations including the sources of materials, procurement, layout and storage of materials, the concrete batching andmixing equipment, and the quality control system. Such an inspection shall be arranged, and ENGINEER's approval obtained, prior to starting of concrete work. This shall, however, not relieve CONTRACTOR of

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any of his responsibilities. All materials, which do not conform to this specification, shall be rejected.

3.2 Materials should be selected so that they can satisfy the design requirements of strength, serviceability, safety, durability and finish with due regards to the functional requirements and the environmental conditions to which the structure will be subjected. Materials complying with codes/standards shall only be used. Other materials may be used after approval of the ENGINEER and after establishing their performance suitability based on previous data, experience or tests.

4.0 MATERIALS

4.1 CEMENT

4.1.1 Unless otherwise specified or called for by ENGINEER/EMPLOYER cement shall beordinary Portland cement conforming to IS: 269, IS: 8112 or IS: 12269.

4.1.2 The Portland pozzolana cement shall conform to IS: 1489 and it shall beused as directed by ENGINEER. Where Portland pozzolana or slag cements are used, it shallbe ensured that consistency of quality is maintained and there will be no adverse interactions between the materials and the finish specified is not marred.

4.1.3 Only one type of cement shall be used in any one mix unless specifically approved byENGINEER. The source of supply, type or brand of cement within the same structureor portion thereof shall not be changed without prior approval from ENGINEER.

4.1.4 Cement, which is not used within 90 days from its date of manufacture, shall be testedat a laboratory approved by ENGINEER and until the results of such tests are found satisfactory, it shall not be used in any work.

4.2 AGGREGATES

4.2.1 Aggregates shall consist of naturally occurring stones and gravel (crushed or uncrushed) and sand. They shall be chemically inert, strong, hard, clean, durable against weathering, of limited porosity, free from dust/silt/organic impurities/deleteriousmaterials and conform to IS: 383. Aggregates such as slag, crushed over burnt bricks,bloated clay ash, sintered fly ash and tiles shall not be used.

4.2.2 Aggregates shall be washed and screened before use where necessary or if directedby the ENGINEER.

4.2.3 Aggregates containing reactive materials shall be used only after tests conclusively prove that there will be no adverse effect on strength, durability and finish, including long term effects, on the concrete.

4.2.4 The fineness modulus of sand shall neither be less than 2.2 nor more than 3.2. If useof sand having fineness modulus more than 3.2 is unavoidable then it shall be suitableblended with crusher stone dust.

4.2.5 The maximum size of coarse aggregate shall be as stated on the drawings, but

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in no case greater than 1/4 of the minimum thickness of the member, provided that the concrete can be placed without difficulty so as to surround all reinforcement thoroughlyand fill the corners of the form. For most work 20mm aggregate is suitable. Where thereis no restriction to the flow of concrete into sections, 40mm or larger size is permitted.

4.2.6 In concrete elements with thin sections, closely spaced reinforcements or small cover,consideration should be given to the use of 10mm nominal maximum size.

4.2.7 Plums 160 mm and above of a reasonable size may be used where directed. Plums shall not constitute more than 20% by volume of concrete unless specified by ENGINEER.

4.3 WATER

4.3.1 Water used for both mixing and curing shall conform to IS: 456. Potable water is generally satisfactory. Water containing any excess of acid, alkali, sugar or salt shall not be used.

4.3.2 The pH value of water shall not be less than 6.

4.3.3 Seawater shall not be used for concrete mixing and curing.

4.3.4 The proposed admixtures shall comply with requirements of Specification for Admixtures for Concrete.

4.4 REINFORCEMENT

4.4.1 Reinforcement bars shall conform to IS: 432 and/ or IS: 1786 and welded wire fabric toIS: 1566 as shown on the drawing.

4.4.2 All reinforcement shall be clean, free from pitting, oil, grease, paint, loose mill scales,rust, dirt, dust or any other substance that will destroy or reduce bond.

4.4.3 Special precaution like coating of reinforcement may be provided with the prior approvalof ENGINEER.

4.5 SAMPLES AND TESTS

4.5.1 All materials used for the works shall be tested before use. The frequency of such confirmatory tests shall be decided by ENGINEER.

4.5.2 Manufacturer's test certificate shall be furnished for each batch of cement/steel and when directed by ENGINEER samples shall also be got tested by the CONTRACTORin a laboratory approved by ENGINEER at no extra cost to The Employer. However, where material is supplied by Employer, all testing charges shall be borne by The Employer, but transportation and preparation of material samples for the laboratory shall be done by CONTRACTOR at no extra cost.

4.5.3 Sampling and testing of aggregates shall be as per IS: 2386 under the supervision of ENGINEER. The cost of all tests, sampling, etc. shall be borne by CONTRACTOR. Forcoarse aggregate crushing value shall be tested.

4.5.4 Water to be used shall be tested to comply with clause 5.4 of IS: 456.

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4.5.5 CONTRACTOR shall furnish manufacturer's test certificates and technical literature forthe admixture proposed to be used. If directed, the admixture shall be got tested at anapproved laboratory at no extra cost.

4.6 STORING OF MATERIALS

4.6.1 All material shall be stored in a manner to prevent its deterioration and contamination,which would preclude its use in the works. Requirements of IS: 4082 shall be compliedwith.

4.6.2 CONTRACTOR will have to make his own arrangements for the storage of adequate quantity of cement even if cement is supplied by The Employer. If such cement is notstored properly and has deteriorated, the material shall be rejected. Cost of such rejected cement, where cement is supplied by The Employer, shall be recovered at issue rate or open market rate whichever is higher. Cement bags shall be stored in dry weatherproof shed with a raised floor, well away from the outer walls and insulated from the floor to avoid moisture from ground. Not more than 15 bags shall be stacked in anytier. Storage arrangement shall be approved by ENGINEER. **Storage under tarpaulins shall not be permitted**. Each consignment of cement shall be stored separately and consumed in its order of receipt. CONTRACTOR shall maintain record of receipt and consumption of cement.

4.6.3 Each size of course and fine aggregates shall be stacked separately and shall be protected from dropping leaves and contamination with foreign material. The stacks shall be on hard, clean, free draining bases, draining away from the concrete mixing area.

4.6.4 CONTRACTOR shall make his own arrangements for storing water at site in tanks of approved capacity. The tanks shall be cleaned at least once a week to prevent contamination.

4.6.5 The reinforcement shall be stacked on top of timber sleepers to avoid contact with ground/ water. Each type and size shall be stacked separately.

5.0 CONCRETE

5.1 GENERAL

5.1.1 Concrete grade shall be as designated on drawings. Concrete in the works shall be "DESIGN MIX CONCRETE" OR "NOMINAL MIX CONCRETE". All concrete works of up to grade M15 shall be NOMINAL MIX CONCRETE whereas all other grades, M20 and above, shall be DESIGN MIX CONCRETE.

5.2 DESIGN MIX CONCRETE

5.2.1 Design Mix Concrete are classified in three categories, viz. "Normal Concrete (M)", "Heavy Concrete (H)", "Super Heavy Concrete (SH)". Each class of concrete shall beidentified by a prefix and two numbers. Prefix "M" would denote Normal Concrete, prefix "H" would denote heavy concrete and prefix "SH" would

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denote super heavy concrete.The two numbers e.g. 25 - 40 would denote the crushing strength of cube at 28 days inN/sq.mm and maximum size of the coarse aggregates in millimetres respectively.

5.2.2 Normal concrete shall have a net dry unit weight of not less than 25 kN/cum, for the finished structure after curing, Heavy concrete shall have a net dry unit weight of not less than 36.30 kN/cum, for the finished structure after curing and special heavy concrete shall have a net dry unit weight of not less than 41 kN/cum for the finished structure after curing.

5.2.3 Mix Design & Testing

For Design Mix Concrete, the mix shall be designed as per any of four methods givenin SP: 23 to provide the grade of concrete having the required workability andcharacteristic strength not less than appropriate values given in IS: 456. The design mix shall in addition be such that it is cohesive and does not segregate during placement and should result in a dense and durable concrete capable of giving the specified finish. For liquid retaining structures, the mix shall also result in watertight concrete. The CONTRACTOR shall exercise great care while designing the concrete mix andexecuting the works to achieve the desired result.

5.2.4 The minimum grade of concrete shall be as per Table 5 of IS: 456 for various exposure conditions of concrete. For various environmental conditions, refer Table 3 of IS: 456.

5.2.5 The minimum cementitious content for Design Mix Concrete shall be as per Table 5 ofIS: 456 or as given below, whichever is higher. In case of PPC or OPC with fly ash addition at site the fly ash content shall not exceed 30%. For concrete with such cementthe minimum cementitious content (C+F) shall be as given in table below.

Grade of Concrete, M	Minimum Cement Content in kg/cum. of Concrete
20	300
25	320
30	340
35	360
40	360
45	400

The minimum cement content stipulated above shall be adopted irrespective of whether the CONTRACTOR achieves the desired strength with less quantity of cement. The CONTRACTOR's quoted rates for concrete shall provide for the above eventuality and nothing extra shall become payable to the CONTRACTOR on this account. Even in thecase where the quantity of cement required is higher than that specified above to achieve desired strength based

on an approved mix design, nothing extra shall become payable to the CONTRACTOR.

5.2.6 It shall be CONTRACTOR's sole responsibility to carry out the mix designs at his owncost. He shall furnish to ENGINEER for approval at least 30 days before concreting operations, a statement of proportions proposed to be used for the various concrete mixes and the strength results obtained. The strength requirements of the concrete mixes ascertained on 150 mm cubes as per IS: 516 shall comply with the requirementsof IS: 456.

Grade of Concrete M	Minimum Compressive Strength N/Sq.mm at 7 days	Specified Characteristic compressive strength N/sq.mm at28 days
15	10.0	15.0
20	13.5	20.0
25	17.0	25.0
30	20.0	30.0
35	23.5	35.0
40	37	40.0
45	30	45.0

5.2.7 A range of slumps recommended for various types of construction, unless otherwise instructed by the ENGINEER, shall be as given below:

Structure/Member	Slump in millimeters	
	Maximum	Minimum
Reinforced foundation walls and footings	75	25
Plain footings, caissons and substructurewalls	75	25
T. G. and massive compressorfoundations	50	25
Slabs, Beams and reinforced walls	50	25
Pumps & miscellaneous Equipment Foundations	75	25

Building columns	50	25
Pavements	50	25
Heavy mass construction	50	25
Structure/Member	**Slump in millimeters**	
	Maximum	**Minimum**
Liquid retaining/ conveying structures	50	25

(NOTE: These values are not meant for pumped concrete placed using slip formed technique.)

5.2.8 Where single size graded coarse aggregate is not available, aggregates of different sizes shall be properly combined. The contractors mix design shall show that combinedgrading of coarse aggregate meets the requirements of Table 2 of IS: 383 for graded aggregates.

5.3 BATCHING & MIXING OF CONCRETE

5.3.1 Proportions of aggregates and cement, as per approved concrete mix design, shall beby weight. These proportions shall be maintained during subsequent concrete batching by means of weigh batchers capable of controlling the weights within ±2% for cementand ±3% for aggregate. The batching equipment shall be calibrated at the frequency decided by ENGINEER.

5.3.2 Amount of water added shall be such as to produce dense concrete of required consistency, specified strength and satisfactory workability and shall be so adjusted toaccount for moisture content in the aggregates. Water- cement ratio specified for use by ENGINEER shall be maintained. Each time the work stops, the mixer shall be cleanedout, and while recommencing, the first batch shall have 10% additional sand and cement to allow for sticking in the drum.

5.3.3 Arrangement should be made by CONTRACTOR to have the cubes tested at his own expense in an approved laboratory or in field with prior consent of ENGINEER. Sampling and testing of strength and workability of concrete shall be as per IS: 1199, IS: 516 andIS: 456. It is preferable to cast additional cubes (minimum 3 specimens) for testing at 7days and 14 days.

6.0 NOMINAL MIX CONCRETE

6.1 MIX DESIGN & TESTING

Mix Design and preliminary tests are not necessary for Nominal Mix Concrete. However, works tests shall be carried out as per IS: 456. Proportions for Nominal Mix Concrete and w/c ratio may be adopted as per Table 9 of IS: 456. However, it will be CONTRACTOR's sole responsibility to adopt appropriate nominal mix proportions to achieve the specified characteristic strength.

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6.2 BATCHING & MIXING OF CONCRETE

Based on the adopted nominal mixes, aggregates shall be measured by volume. However, cement shall be by weight only. Appropriate correction shall be made for bulking of sand after testing.

7.0 READY MIXED CONCRETE

7.1 All specification as per IS: 4926 – "Specification for ready mixed concrete" shall be used.

7.2 The Contractor shall identify at least two sources of ready-mix concrete supplier and getit approved by ENGINEER prior to start of the Works. Any change in the source of theRMC, shall be got approved by the ENGINEER.

7.3 The design mix prepared by the RMC supplier shall be the responsibility of the Contractor. The testing of concrete as per Codal provisions and the specifications shallbe done by the Contractor same as the normal concreting works.

8.0 PRECAST CONCRETE

8.1 GENERAL

Precast concrete shall comply with the preceding Sections relating to Concrete as faras they are applicable. Precast concrete blocks shall comply with the requirements andrecommendations of BS 6073.

8.2 PRECASTING BED

All precast units shall be cast on, or their shutters supported from a suitably preparedlevel unyielding paved area.

8.3 MARKING

All units shall be suitably marked in a clean and legible manner with a reference number and the date of casting, which information shall be clearly visible when units are stacked. Reinforced precast members shall be clearly marked to indicate the upper face.

8.4 FORMWORK

The formwork shall be either steel or lined with steel, waterproof / laminated board or such other material as directed and approved by the ENGINEER. Forms shall be stronglyconstructed, closely jointed and smooth and shall be such as to ensure true sharp arises and a perfect surface. Forms shall be so designed that they can be taken apart and reassembled readily.

8.5 CASTING TOLERANCE

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The casting tolerance, unless otherwise ordered or directed, shall be within +3mm oftrue dimensions.

8.6 STRIKING FORMS

The method and time of striking the side shutters after casting the units will normally beleft to the discretion of the CONTRACTOR, but the ENGINEER may specify minimumtime in which case the CONTRACTOR must comply with the ENGINEER'S directions. In the event of any damage resulting from premature removal of shutters, or from anyother cause, the unit will be liable to rejection and replacement by the Contractor at his own cost, whether the Engineer has specified a minimum striking time or not.

8.7 LIFTING, STACKING AND REMOVAL

8.7.1 Precast units shall not be lifted, transported or used in the Works until they are sufficiently mature. The crushing tests on the test cubes, which are to be kept along with relevant the precast units, will be used to assess the maturity of the units.

8.7.2 Lifting, stacking and removal of precast units shall be undertaken without causing shock, vibration or undue stress to or in the units. The CONTRACTOR shall satisfy the ENGINEER that the methods he proposes for lifting, transporting and setting precast units will not overstress or damage the units in any way. In the event of overstress or damage due to whatever cause, the unit or units concerned will be liable to rejection. Rejected units shall be immediately broken up and removed from the site. The CONTRACTOR shall replace such rejected units at his own cost.

8.8 CURING

The top and sides of all precast units shall be kept covered constantly and in a damp condition with clean, potable fresh water for at least seven days after casting or for such further period as the ENGINEER may direct. It is preferable to have a curing pond forthis purpose.

8.9 PRECASTING RECORDS

Complete records shall be maintained of all precast work. Every unit shall have a reference number, date of casting, date of removal from bed and date and position of placing shall be recorded together with corresponding test cube reference number andresults.

8.10 CONTRACTOR shall submit a method statement to ENGINEER for approval, furnishing details of each stage of operation.

9.0 FORMWORK

9.1 Formwork shall be all inclusive and shall consist of but not limited to shores, bracings, sides of footings, walls, beams and columns, bottom of slabs, etc.

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including ties, anchors, hangers, inserts, false work, wedges, etc.

9.2 The design and engineering of the formwork as well as its construction shall be the responsibility of CONTRACTOR. However, if so, directed by ENGINEER, the drawingsand calculations for the design of the formwork shall be submitted to ENGINEER for approval.

9.3 Formwork shall be designed to fulfil the following requirements:

9.3.1 Sufficiently rigid and tight to prevent loss of grout or mortar from the concrete at all stages and appropriate to the methods of placing and compacting.

9.3.2 Capable of providing concrete of the correct shape and surface finish within the specified tolerance limits.

9.3.3 Capable of withstanding without deflection the worst combination of self-weight, reinforcement and concrete weight, all loads and dynamic effects arising from construction and compacting activities, wind and weather forces.

9.3.4 Capable of easily striking without shock, disturbance or damage to the concrete.

9.3.5 Soffit forms capable of imparting a camber if required.

9.3.6 Soffit forms and supports capable of being left in position if required.

9.3.7 Capable of being cleaned and/or coated if necessary, immediately prior to casting theconcrete; design temporary openings where necessary for these purposes and to facilitate the preparation of construction joints.

9.4 The formwork may be of lined timber, waterproof / plastic coated plywood, steel, plasticdepending upon the type of finish specified. Sliding forms and slip form may be used with the approval of ENGINEER. Timber for formwork shall be well seasoned, free from sap, shakes, loose knots, worm holes, warps and other surface defects. Joints betweenformwork and formwork and between formwork and structure shall be sufficiently tightto prevent loss of slurry from concrete using foam and rubber seals.

9.5 The faces of formwork meeting concrete shall be cleaned, and two coats of approvedmould oil applied before fixing reinforcement. All rubbish, particularly chippings, shavings, sawdust, wire pieces, dust etc. shall be removed from the interior of the forms before the concrete is placed. Where directed, cleaning of forms shall be done by blasting with a jet of compressed air at no extra cost.

9.6 Forms intended for reuse shall be treated with care. Forms that have deteriorated shall not be used. Before reuse, all forms shall be thoroughly scraped, cleaned, nails removed, holes suitably plugged, joints repaired, and warped lumber replaced to the satisfaction of ENGINEER. CONTRACTOR shall equip himself with enough quantity ofshuttering to allow for wastage to complete the job in time.

9.7 Permanent formwork shall be checked for its durability and compatibility with adjoiningconcrete before it is used in the structure. It shall be properly anchored to the concrete.

9.8 Wire ties passing through beams, columns and walls shall not be allowed. In their placebolts passing through sleeves may be used. Formwork spacers left in situ shall not impair the desired appearance or durability of the structure by causing spalling, rust staining or allowing the passage of moisture.

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9.9 For liquid retaining structures sleeves shall not be provided for through bolts nor shallthrough bolts be removed if provided. The bolts, in the latter case, shall be cut at 25 mm depth from the surface and the hole made good by cement mortar of the same proportion as the concrete just after striking the formwork.

9.10 Where specified or shown on drawings all corners and angles exposed in the finishedstructure shall have chamfers or fillets of 20 mm x 20 mm size.

9.11 Forms for substructure may be omitted when, in the opinion of ENGINEER, the open excavation is firm enough (in hard non-porous soils) to act as a form. Such excavationshall be slightly larger, as directed by ENGINEER, than that required as per drawing tocompensate for irregularities in excavation.

9.12 CONTRACTOR shall provide adequate props of adjustable steel pipes carried down toa firm bearing without overloading any of the structures.

9.13 The shuttering for beams and slabs shall be so erected that the side shuttering of beams can be removed without disturbing the bottom shuttering. If the shuttering for a columnis erected for the full height of the column, one side shall be built up in sections as placingof concrete proceeds or windows left for placing concrete from the side to limit the dropof concrete to 1.5 m or as directed by ENGINEER. CONTRACTOR shall temporarily and securely fix items to be cast (embedment/inserts) in a manner that will not hinderthe striking of forms) or permit loss of grout.

9.14 Formwork showing excessive distortion, during any stage of construction, shall be removed. Placed concrete affected by faulty formwork, shall be entirely removed and formwork corrected prior to placement of new concrete at CONTRACTOR's cost.

9.15 The striking time for formwork shall be as per IS: 456 and shall be determined based on the following requirements:

9.15.1 Development of adequate concrete strength;
9.15.2 Permissible deflection at time of striking form work;
9.15.3 Curing procedure employed - its efficiency and effectiveness;
9.15.4 Subsequent surface treatment to be done;
9.15.5 Prevention of thermal cracking at re-entrant angles;
9.15.6 Ambient temperatures; and Aggressiveness of the environment (unless immediate adequate steps are taken to prevent damage to the concrete). Before removing formwork of soffit of slabs/ beams compressive strength at 7/14/21 days shall be checked. The contractor shall obtain permission from the Engineer before decluttering.

9.16 Under normal circumstances (generally where temperatures are above 20 Deg. C) forms may be struck after expiry of the period given in IS: 456 unless directed otherwise by ENGINEER. For Portland Pozzolana/slag cement the stripping time shall be suitably modified as directed by the ENGINEER. It is the CONTRACTOR's responsibility to ensure that forms are not struck until the concrete has developed enough strength to support itself, does not undergo excessive deformation and resists surface damage and any stresses arising during the construction period.

10.0 REINFORCEMENT FABRICATION AND PLACEMENT

10.1 Reinforcing bars supplied in the form of bent coils shall be straightened cold without damage at no extra cost. No bending shall be done when ambient temperature is below5 Deg.C. Suitable preheating may be permitted if steel bar bending is to be done at below 0 Deg.C. Bars supplied in bent coils shall be straightened only by machine.

10.2 All bars shall be accurately bent gradually and according to the sizes and shapes shown on the drawings/ schedules or as directed by ENGINEER. Bar bending machines shallbe used to achieve desired accuracy.

10.3 Re-bending or straightening incorrectly bent bars shall not be done without approval ofENGINEER.

10.4 Reinforcement shall be accurately fixed and maintained firmly in the correct position using blocks, spacers, chairs, binding wire, etc. to prevent displacement during placingand compaction of concrete. The tied in place reinforcement shall be approved by ENGINEER prior to concrete placement. Spacers (PVC or Concrete) shall be of such material and design as will be durable, not lead to corrosion of the reinforcement andnot cause spalling of the concrete cover.

10.5 Binding wire shall be 16-gauge soft annealed wire. Ends of the binding wire shall bebent away from the concrete surface and in no case encroach into the concrete cover.

10.6 Substitution of reinforcement, laps/splices not shown on drawing shall be proposed byCONTRACTOR and approved by ENGINEER.

10.7 If permitted by ENGINEER, welding of reinforcement shall be done in accordance withIS: 2751, IS: 9417 and SP: 34 as applicable.

10.8 Tolerance on placement of reinforcement shall be as per Cl. 12.3 of IS: 456.

11.0 TOLERANCES

11.1 Tolerance for formed and concrete dimensions shall be as per IS: 456 and/ or ACI- 117-90, ACI- 347 unless specified otherwise.

11.2 Tolerance specified for horizontal or vertical building lines or footings shall not beconstrued to permit encroachment beyond the legal boundaries.

11.3 Tolerance for top of concrete of equipment's and structural steel foundations shall beas under:

11.3.1 Where grout thickness is less than or equal to 25mm: +5mm and –10mm.

11.3.2 Where grout thickness is more than 25mm: ±15mm.

12.0 PREPARATION PRIOR TO CONCRETE PLACEMENT

12.1 Before concrete is placed in position, the inside of the formwork shall be cleaned and mould oil applied, inserts and reinforcement shall be correctly positioned and securelyheld, necessary openings, pockets, etc. provided.

12.2 All arrangements-formwork, equipment and proposed procedure, shall be approved byENGINEER. CONTRACTOR shall maintain separate Pour Card.

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for each pour as per the format enclosed.

13.0 TRANSPORTING, PLACING AND COMPACTING CONCRETE

13.1 Concrete shall be transported from the mixing plant to the formwork with minimum timelapse by methods that shall maintain the required workability and will prevent segregation, loss of any ingredients or ingress of foreign matter or water.

13.2 In all cases concrete shall be deposited as nearly as practicable directly in its final position. To avoid segregation, concrete shall not be rehandled or caused to flow. Forlocations where direct placement is not possible and in narrow forms, CONTRACTOR shall provide suitable drops and "Elephant Trunks". Concrete shall not be dropped froma height of more than 1.5m as stipulated in clause 9.13.

13.3 Concrete shall not be placed in flowing water. Under water concrete shall be placed inposition by tremie or by pipeline from the mixer and shall never be allowed to fall freelythrough the water.

13.4 While placing concrete the CONTRACTOR shall proceed as specified below and ensure the following:

13.4.1 Continuously between construction joints and predetermined abutments

13.4.2 Without disturbance to forms or reinforcement

13.4.3 Without disturbance to pipes, ducts, fixings and the like to be cast in; ensure that suchitems are securely fixed. Ensure that concrete cannot enter open ends of pipes and conduits, etc

13.4.4 Without dropping in a manner that could cause segregation or shock

13.4.5 In deep pours only when the concrete and formwork is designed for this purpose and by using suitable chutes or pipes.

13.4.6 Do not place if the workability is such that full compaction cannot be achieved.

13.4.7 Without disturbing the unsupported sides of excavations; prevent contamination of concrete with earth. Provide sheeting if necessary. In supported excavations, withdrawthe linings progressively as concrete is placed.

13.4.8 If placed directly onto hardcore or any other porous material, dampen the surface to reduce loss of water from the concrete.

13.4.9 Ensure that there is no damage or displacement to sheet membranes.

13.4.10 Record the time and location of placing structural concrete.

13.5 Concrete shall normally be compacted in its final position within thirty minutes (Initial setting time) of leaving the mixer. Concrete shall be compacted during placing with approved vibrating equipment without causing segregation until it forms a solid mass free from voids, thoroughly worked around reinforcement and embedded fixtures andinto all corners of the formwork.

Immersion vibrators shall be inserted vertically at points not more than 450 mm apart and withdrawn slowly till air bubbles cease to come to the surface, leaving no voids. When placing concrete in layers advancing horizontally, care shall be taken to ensureadequate vibration, blending and melding of the concrete

between successive layers. Vibrators shall not be allowed to meet reinforcement, formwork and finished surfaces after start of initial set. Over-vibration leads to segregation and shall be avoided.

13.6 Concrete may be conveyed and placed by mechanically operated equipment after getting the complete procedure approved by ENGINEER. The slump shall be held to the minimum necessary for conveying concrete by this method. When concrete is to bepumped, the concrete mix shall be specially designed to suit pumping. Care shall be taken to avoid stoppages in work once pumping has started.

13.7 CONTRACTOR shall submit a method statement to ENGINEER for approval, furnishing details of pour sequence, thickness of each layer, mixing and conveying equipment's proposed etc. preferably with a sketch.

13.8 Except when placing with slip forms, each placement of concrete in multiple lift work shall be allowed to set for at least 24 hours after the final set of concrete before the startof subsequent placement. Placing shall stop when concrete reaches the top of the opening in walls or bottom surface of slab, in slab and beam construction and it shall be resumed before concrete takes initial set but not until it has had time to settle as determined by ENGINEER. Concrete shall be protected against damage until final acceptance.

14.0 PLACING OF CONCRETE BY PUMPING METHODS

14.1 GENERAL

14.1.1 Placing of concrete by pumping will be as specified or authorised by Engineer to achieve the required speediness of construction and maintain targeted schedules.

14.1.2 Pumping of concrete shall be done only after conducting pumpability trials to ascertainthe performance of fresh concrete on pumping in presence of the Engineer as per approved procedure. During pumping, concrete shall be conveyed either through rigid pipe or through flexible hose and discharged directly into the desired area. A steady supply of pumpable concrete is necessary for satisfactory pumping. Pumpable concrete requires properly graded aggregates, material uniformity, consistent batching and thorough mixing. Concrete pumps used shall be able to deliver concrete over a horizontal distance of about 400 m or of about 100 m in a vertical direction, (with intermediate figures for a combination of horizontal and vertical movements). They shall be used for concreting densely reinforced structures, internal structural elements of buildings and for large pours of concrete.

14.1.3 Placement of normal concrete by pumping will be permitted as specified or authorisedby the Engineer. The decision, whether to pump any mix shall rest entirely with the Engineer and no extra claims for payment on this account will be entertained. The pumping equipment, pipelines and accessories as well as proportioning of pumpable concrete shall generally confirm to the recommendations of ACI-304.2 (latest revision)

– Placing of concrete by pumping method - Proportioning of pumpable mixes gives certain guidelines on concrete mix. However, final selection of mix shall be as instructed by the Engineer.

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14.2 PUMPING EQUIPMENT

14.2.1 Requisite numbers of modern dependable concrete pumps capable of pumpingconcrete of specified quality at a rate required to meet the construction schedules, together with a balanced complement of pipelines, accessories, spare parts, power controlled placing booms, and experienced pump operators and maintenance staff shall be provided at locations and in a manner approved by the Engineer.

14.2.2 The pumping plant shall be completely installed on each occasion, with preliminary mock operation for a sufficient length of time prior to scheduled placement of a particular concrete pour, to enable the Engineer to conduct pumpability tests and necessary adjustments for the concrete mix, prior to use of the pumping for placement of concrete.

14.3 TYPE OF PUMP

14.3.1 The selection of the concrete pump shall be done as per the project requirement. The Contractor shall submit the concrete pump data sheets proving the suitability for the given project to ENGINEER for approval.

14.3.2 The concrete pump shall be selected on its best pumping capacity and the speedinessto be achieved in the project. The piston pumps of a net horizontal pumping capacity of30 m3/ hr or 20 m3/ hr or 15 m3/ hr or 10 m3/ hr can be utilised. The combination of various pumps to be used shall be decided by Contractor and shall submit the necessary documents and targeted progress to be achieved in line with the Time Period and Milestones.

14.3.3 These pumps shall have capacity to pump the concrete up to at a horizontal distanceof 400 m and capable of generating a minimum pressure of 80 bar. These parametersshall depend upon the building sizes, manoeuvrability and other construction features.These pumps shall consist of a receiving hopper with a bolted grill at top of capacity notless than 600 litres. The hoppers shall be provided with hydraulically driven re-mixingblades or other agitating devices to keep the concrete mixed continuously and maintainconsistency and uniformity. The pumps shall be provided with two cylinders with max.diameter not less than 150 mm, stroke of about 1200 mm and the number of strokes

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not exceeding 25 per minute. The outlet valves shall be located on the discharge lines. Type of inlet and outlet valves may vary depending on the manufacturer but they shallpreferably be of sliding-rod-flat-gate type. The piston shall be hydraulically driven. Primary power shall be supplied by gasoline, diesel or electric motor of requisite powerrating. Care shall be taken by the Contractor to ensure uninterrupted operation of the pumps during the entire period of concreting by providing adequate standby arrangements. The primary power and pump equipment shall be either truck or trailermounted, and not skid mounted.

14.4 PIPELINES AND ACCESSORIES

14.4.1 Rigid pipelines

Concrete transported to the placement area by pumping methods shall be pumped thorough rigid pipes or a combination of rigid and heavy-duty flexible hoses. Rigid pipeshall be made available in minimum 125 mm diameter size. Aluminum alloy lines shallnot be used for delivery of concrete. Rigid pipes shall be furnished in such lengths ascan be manually handled by a singleperson.

14.4.2 Flexible conduit (hose)

Flexible conduit shall be made of rubber, or spirally wound flexible metal, and plastic flexible conduits generally present greater resistance to movement of concrete and their performance is not the same as that of a rigid pipe and also larger sizes (100 mm to 123 mm) have a tendency to leak. Flexible conduits provided, shall be interchangeablewith rigid pipes and their use restricted to curves, difficult placement areas, and as connection to moving cranes or to water borne lines.

14.4.3 Couplings

The couplings provided to connect both flexible and rigid pipe sections shall be adequate in strength to withstand handling during erection of the pipe system, misalignments, and poor support along the lines. They should be nominally rated for atleast 3.45 Mpa and greater for rising over 30 mtr. The strength and tightness of jointsshall be guaranteed. Couplings shall be designed to allow replacement of any pipe section without moving other pipe sections and shall provide a full internal cross-section with no obstructions or crevices to disrupt the smooth flow of concrete.

14.4.4 Accessories

The pump and the distribution system for a concreting job shall use the accessoriesas listed below and they shall be approved by the Engineer.

(a) Rigid and flexible pipes in varying lengths, such as 3, 1.5, 0.9, 0.6 and 0.3 mlengths.

(b) Curved sections of rigid pipes such as large radius elbows at angles of 90 deg., 45deg., 22 deg. 30 min. and 11 deg. 15 min.

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(c) Swivel joints and rotary distributors.
(d) Pin and gate valves to prevent back-flow in the pipeline.
(e) Switch valve to direct flow into another pipeline.
(f) Connection devices to fill forms the bottom up.
(g) Temporary supports, rollers and other devices for protection of conduit over rock, concrete, reinforcement steel and forms. Lifting and leashing points.
(h) Extra strong coupling for vertical runs in inaccessible areas.
(i) Transition for connecting different sizes of pipes.
(j) Air vents for downhill pumping.
(k) Clean-out equipment.
(l) Adequate numbers of separate placement booms of various radius and reach, either stationary steel column mounted or tower crane mast mounted moving onrail tracks, or truck mounted shall be provided by the Contractor to match within concrete placement schedule and pumps. For maximum flexibility of operation, the separate placement booms shall be such that they can be easily lifted by the tower cranes provided. Their mounting arrangements shall be quick connecting type and interchangeable between tower crane masts, steel columns and truck mountings etc. The placement booms shall consist of three flanged parts incorporating a concrete pipeline with articulated inserts at boom joints and ending in a flexible hose. The boom shall be remote controlled.

14.5 THE PUMPING PLANT AND THE PIPE DISTRIBUTION SYSTEM

14.5.1 The concrete pumping plant apart from the receiving hopper and the pump shall alsobe provided with a water pressure valve, connecting pipes with needle valve, cleaningrods, outlets for drainage water and a high-pressure pump for flushing out the concretein pipeline.

14.5.2 The shortest way shall be selected in planning the direction of the concrete pipeline, and the number of bends (elbows) shall be as small as possible. Should a change bemade of the direction in plan of the pipelines or a change of their vertical profile, theseshall be arranged with easy transitions.

14.5.3 Before the pipeline is assembled all pipe, flanges shall be tested and carefully cleaned, packing rings cleaned or replaced, and the internal surfaces of all pipe section cleaned. Horizontal lengths of concrete pipelines shall be laid on supports, wooden trestles, scaffolding, staging etc. Vertical and inclined lengths of pipe shall be fastened by clampirons or stirrups to masts, or to the frame of the structure being erected. It isrecommended to replace vertical sections of the pipeline by inclined sections where possible. Sharp turns and bends at an angle of 90 deg. shall be avoided. Pipes shall besupported in such a manner that they do not disturb the forms during concreting.

14.5.4 A vertical section of the concrete pipeline shall not be arranged closer than 8 to 9 m from the concrete pump. Before a vertical section a valve shall normally be placed, to prevent back flow of the concrete when the pump stops or when the pipe is cleaned or replaced. When pumping vertically through the placer boom, a thrust block shall be provided at the base of the vertical riser to resist the

forces in the pipeline due to the pumping of concrete.

14.5.5 When pumping downwards, 15 m or more, it is desirable to provide an air release valveat the middle of the top bend.

14.6 LINE RESISTANCE AND LUBRICATION

14.6.1 When concrete is pumped through a straight section of a pipe or hose, it moves as acylinder riding on a thin lubricant film of a grout or mortar. At changes in direction or

cross-section some re-mixing occurs. In all cases at the start of pumping operation lubricating mortar is required, and this shall be a properly designed mortar of cement-sand grout (1:1) or a batch of the regular concrete with the coarse aggregate omitted.Except for a small portion of this mortar which may be used for bedding at the construction joint, it shall be wasted and not used in the concrete placement. It can beassumed that about 0.35 cu. m of mortar will lubricate a 125 mm diameter horizontal pipeline of about 300 m length and the lubrication shall be maintained if the pumping continues. For vertical or smaller lines less mortar will be required. The mortar shall have the same cement content as that of the concrete. The water cement ratio shall bedetermined by the placing condition and finally decided by the Engineer. In order to ensure that only minimum quantity of grout mortar is used to lubricate the pipeline, a rubber sponge ball shall be allowed to pass through the pipeline immediately before the first batch of grout mortar is pumped. This rubber ball shall be pushed by the followingmortar along the pipeline slowly and allowed to emerge at the open end. The cost of thelubricating mortar to be used, shall be deemed to have been included in the general rate structure for works in the schedule of items and nothing extra shall be payable.

14.6.2 It shall be considered when planning the pipeline that, in straight horizontal and vertical section of pipe and at bends, the resistance to the movements of concrete differ. For convenience in calculating the resistance of a concrete pipeline experimental co- efficient of equivalent length shall be used by means of which the equivalent length ofa horizontal concrete pipeline is to be obtained. In absence of the pump manufacturer's data, equivalent lengths of concrete pipeline as indicated in Table–8 may be used.

Table –8
EQUIVALENT LENGTH OF CONCRETE PIPELINES

Characteristics of a length of concrete pipeline	Equivalent length of horizontal concrete pipeline in meter
Bend in pipeline at an angle of 90 deg	12
Bend in pipeline at an angle of 45 deg	7

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Bend in pipeline at an angle of 22deg. 30 min	4
1 m of vertical concrete pipeline	8

The equivalent length of the concrete pipeline must be less than or equal to the rangeof feed in horizontal direction as specified by the pump manufacturer for the same rateof pumping. To obtain the least line resistance, the layout of the pipeline system shallcontain a minimum number of bends and preferably with no change in pipe size. If twosizes of pipes are required to be used, the smaller diameter shall be used at the pumpend and the larger at the discharge end. The contractor shall exercise care in handling of the pipeline, during assembly, cleaning and dismantling to lower the line resistance by preventing the formation of rough surfaces, dents in pipe section and crevices in couplings. If any pipe, bend, coupling and other accessories are defective or damagedby the Engineer, the same shall not be used in the concrete pipeline till such time the defect has been removed and the damage repaired to the entire satisfaction of the Engineer. Qualified chemical admixtures shall be used effectively to get workable concrete.

14.7 PROPORTIONING PUMPABLE CONCRETE

14.7.1 Basic Consideration

(a) Although the ingredients of concrete to be placed both by pumping and by other means are the same, more emphasis shall be laid on the quality control and proportioning of a dependable pumpable mix. Dependability is affected by the equipment and the operator, with the control of all the ingredients in the mixture, the batching and mixing operations, and the knowledge and experience of all thepersonnel from beginning to end.

(b) Concrete mixes for pumping shall be "plastic" at all times. Stiff mixes shall not beused for pumping as they do not pump well. Particular attention shall be given tothe mortar (cement, sand and water) and the amounts and sizes of coarse aggregates.

14.8 NORMAL WEIGHT AGGREGATES

14.8.1 Coarse Normal Weight Aggregates

The maximum size of angular coarse aggregate shall be limited to one-third of the smallest inside diameter of the hose or pipe based on simple geometry of cubical shapeaggregates. For well-rounded aggregates, the maximum size shall be limited to 40% ofthe pipe or hose diameter. Adequate provisions shall be made to eliminate over size particles in the concrete by screening or by careful selection of aggregate. Gradation of sizes of coarse aggregates shall correspond to Grades A and B of Table–9 and shall meet IS: 2386 requirements. If required certain fractional sizes shall be combined andblended

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to produce the required gradation. Greater emphasis shall be laid on uniformity of gradation throughout the entire job. The maximum size of the coarse aggregate hasa significant effect on the volume or amount of coarse aggregate that may be effectivelyused in a mix. As will be seen from Table–10 the quantity of coarse aggregate must be substantially reduced as the maximum size become smaller. Mixes consisting of too large a portion of coarse aggregate with less cement shall be avoided.

Table –9

Grading Requirement of Coarse Aggregates for Pumped Concrete

Grade - A (Maximum Size 40 mm)		**Grade –B** (Maximum Size 20 mm)	
Sieve Size	**Percent Passing Byweight**	**Sieve Size**	**Percent Passing Byweight**
50 mm	100	25 mm	100
40 mm	95 to 100	20 mm	90 to 100
20 mm	35 to 70	12.5 mm	20 to 55
10 mm	10 to 30	10 mm	0 to 15
4.75 mm	0 to 5	4.75 mm	0 to 5

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Table –10

Volume of coarse Aggregate per unit of volume of concrete

Max. Size	Volume of Dry-rodded Coarse Aggregate per unit volume of aggregates of concrete for different finenessmoduli ofsand			
	FMS = 2.40	FMS = 2.60	FMS = 2.80	FMS = 3.00
10	0.50	0.48	0.46	0.44
12.5	0.59	0.57	0.55	0.53
20	0.66	0.64	0.62	0.60
25	0.71	0.69	0.67	0.65
40	0.76	0.74	0.72	0.70
50	0.78	0.76	0.74	0.72

14.8.2 **Fine Normal Weight Aggregates**

Fine aggregate shall consist of natural sand, manufactured sand or a combinationthereof and shall be graded within the following limits.

Sieve Size	Percent passing by weight
9.5 mm	100
4.75 mm	950 to 100
2.36 mm	80 to 100
1.18 mm	50 to 85

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600 microns	25 to 60
300 microns	10 to 30
150 microns	2 to 10

Fine aggregates shall conform to the requirements of IS: 2386. Particular attention shall be given to those passing through finer screen sizes. For small line system (less than150 mm) 15 to 30 percent shall pass 300-micron sieve and 5 to 10 percent shall pass150-micron sieve. Sands which are deficient in either of these two sizes shall be blended with selected finer sands or inert material such as quarry dust to produce these desiredpercentages. The fineness modulus of sand meeting the above grading limits will fall between 2.13 and 3.37 with the median being 2.75. Pumpability of mixes will generallyimprove with a decrease in the fineness modulus value or in other words with the use of finer sands. Sands having a fineness modulus between 2.40 and 3.00 are generally satisfactory provided that the percentages passing 300 micron and 150-micron sizesmeet the previously stated requirements. It shall also be emphasized that for uniformity, the fineness modulus of the sand shall not vary more than 0.20 from the average valueused in proportioning. Table–10 is suggested as a guide to determine the amounts ofcoarse aggregate to be combined with sand of different fineness modulus. The foot note of Table–10 requires a reduction in the volume of coarse aggregate by 10 percent forpumping. This margin shall be considered as a safety margin for variations in sand gradation to reduce pumping pressure. Under conditions of good materials control anduncomplicated line systems, this reduction may not be required. Although in practice itmay not be possible to duplicate this recommended sand gradation exactly, sands having a gradation closer to the upper limit (fine sand) are more desirable for pumpingthan those near the lower limit (coarse sand). The fineness modulus of sand accordingto the recommended curve is 2.68 and the gradation meets all the requirements statedearlier.

14.9 WATER AND SLUMP

14.9.1 Water requirements and slump control for pumpable normal weight concrete are interrelated and extremely important considerations. The mixing water requirements fora mix shall be determined by the Engineer and modified to suit the fineness of sands,quality of admixtures, additives, cement replacements or other special materials beingused in the concrete.

14.9.2 The Contractor shall establish the optimum slump jointly with the Engineer for a pumpable mix at the discharge hose end and shall maintain control of that slump throughout the course of a job. Excess water shall not be added in the receiving hopperto make the concrete mix pumpable; instead attempt shall be made to obtain 'truly plastic mix' by proper proportioning.

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14.9.3 Slump of concrete may undergo change between initial mixing and final placement. Ifthe slumps at the discharge hose end are to be maintained within specified limits, it willbe necessary for the concrete to enter the pump at a higher slump to givethe requiredmobility during transport. Slump adjustments by re-proportioning of the constituents asmay be required shall be carried out by the Contractor jointly in consultation with the Engineer for every type of mix and for every new placement and set up of pump and pipelines.

14.10 CEMENT CONTENT

14.10.1 The determination of the cement content for a normal weight pump mix shall follow the same basic principles used for conventionally placed concrete. The water cement ratioshall be established by the Engineer based on exposure conditions, strength requirements or minimum cement consumption, whichever governs. However, becauseof slightly higher ranges of slump and ratios of fine to coarse aggregates, the pump mix may require an increase in the amount of cement above those pumpable concrete mass. The total quantity of fines passing through the 300-micron sieve including cement, finesand, stone dust etc. shall be in the range of 380 to 450 kg/cu.m of concrete.

14.10.2 Cement content in case of M-50 shall be maximum of 425 kg/m3 and shall be a mix with high range of workability i.e. 175 mm +/- 25 mm. All the contents shall be mixed based on the mix design & trial studies.

14.10.3 While establishing the cement content for normal weight trial mixes it will be necessaryto consider the capabilities of the pump and its operator for over strength proportioningin the laboratory to provide for field variations.

14.10.4 In case of pumping difficulties, it is desirable and economical to correct any deficienciesin the aggregates, especially in the sand instead of using extra quantities of sand. With well graded coarse and fine aggregates properly combined, the cement requirement for pumpable mixes shall closely resemble to those used in convential placed concrete.

14.11 ADMIXTURES

The use of poor aggregate grading or aggregate with continuous change in overall grading of the 'combinations' during concreting operation will make special admixturesquite useful in overcoming the main difficulty like blockage in pumping. These admixtures shall be incorporated in pumpable concrete to aim the following:

14.11.1 Increase in the range of mix designs which may be successfully pumped using water reducing admixtures/Super plasticizers with the approval of the Engineer.

14.11.2 Reducing the risk of pipeline blockages by preventing segregation of concrete mix.

14.11.3 To have satisfactory/specified performance both in fresh and hardened state.

Any admixture that increases workability in normal weight concrete may usually improve pumpability. The choice of type of admixture and the advantage gained from its use inconcrete to be pumped will depend on the characteristics of the pump mix and will befinally decided by the Engineer in consultation with the

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admixture manufacturer.

For improvement of pumpability the following admixtures are generally recommended. Such admixtures used shall be conforming to ASTM C-494/IS 9103.

(a) Water Reducing Admixtures/ Super Plasticizers

These cause reduction in water requirements at constant slump or an increase inslump at constant water-cement ratio. They can be designed to have no apparenteffect on setting time, or alternately to achieve varying degrees of acceleration orretardation in rate of hardening of the mixture. Most water reducing admixtures increase the pumpability of the concrete mix through plasticizing action.

(b) Air Entraining Admixtures

Air entrained concrete is considerably plastic and more workable than non-air entrained concrete. It can be pumped with less coarse aggregate segregation andhas less tendency for concrete to bleed. Start-up after shutting down is also generally easier due to reduced bleeding. For pumped concrete these limits shallbe obtained at the point of placement in the structure. To compensate for air content loss in the air entrained concrete higher entrainment of air may be required at the batching plant. The required adjustment of admixture dose shall be carried out by the Engineer after carrying out necessary air loss tests. An air content in the range of 3 to 5 % shall be preferred as higher ranges reduces the delivery capacity of pump systems due to increased compressibility of the concrete and reduces strength of concrete. If air- entraining plasticizer is used, typically 13 % minimumwater reduction is possible. Therefore, strength loss due to air entrainment will be compensated by using such air-entraining plasticizer.

(c) Finely Divided Mineral Admixtures

Contractor, if specifically approved by the engineer, can use mineral admixture. Inconcrete mixtures deficient in fines, the addition of a finely divided inert mineral admixture generally improves workability, pumpability, reduces the amount of bleeding and increases the strength. The effect on strength depends on the typeof mineral admixture used, conditions under which the concrete is cured, and theamount of admixture used. Water soluble polymers obtained from cellulosederivations may also be used as an admixture with a small dose of 60 to 150 gms/cu.m to increase viscosity of the mixing water and reduce the frictional resistance to flow and bleeding in the pipe system.

14.12 TRIAL MIXES

The trial mixes for pumping shall be prepared and tested in the Site laboratory by contractor in accordance with clause 14.13 of this specification. The ingredients, particularly the coarse and fine aggregates shall also be checked for the conformanceto the desired properties described, by the contractor. Table –10 may be used to selectthe volume of coarse aggregate per cu. m. of

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concrete. In using this table, it is recommended that the highest probable fineness modulus of sand be used rather thanthe average fineness modulus to ensure consistent performance during pumping. Foradditional plasticity, 10% reduction in coarse aggregate quantities shall be considered. Experience with the use of local aggregate and their uniformity shall also be considered in the proportioning concepts.

14.13 MIX DESIGN FOR PUMPABLE CONCRETE

Taking the above factors into account, the concrete shall first be designed for normal placement conditions and then modified as necessary to suit pumping. The following procedure shall be adopted:

14.13.1 Design the mix for specified characteristic strength and workability.

14.13.2 Check and ensure combined grading of aggregates i.e. as uniform grading as possible. This requirement is vital as gaps or partial gaps are the basic reasons for poor water retention property and segregation under pressure.

14.13.3 Determine the optimum sand content for the required workability and increase sand content by reducing volume of coarse aggregate per unit volume of concrete by about 10% as a degree of protection against undersanding due to batch variations.

14.13.4 Recheck the minimum cement content for durability.

14.13.5 Examine the total fines content i.e. cement and fine aggregates passing through 300-micron sieve and readjust the mix, if necessary. A very rich mix with fine sand will be asproblematic as coarse sand with lean mix.

14.13.6 Re-appraise the grading if the particle shape of any fraction is such as may cause excessive voids. Re-adjust as required, if necessary, examining the void ratio of various combinations, using void meter to achieve minimum voids at the expense of 'enough fines' content.

14.13.7 If dissatisfied with Cl. 14.13.1 to Cl. 14.13.6 as above, consider what remedial action may be taken to overcome the troublesome factor. For example, the following two situations may occur

14.13.8 If the sand has coarser fraction it is worth considering the addition of a proportion of finer sand, or alternately if the sand has finer fraction, the addition of coarse fraction may be considered. Addition or reduction of cement may help, but the correct solutionis to overcome the gap in overall grading as stated above.

14.3.9 In a 20 mm aggregate max. size, if there is an excess of 10 to 4.75 mm fraction, and this fraction is flaky with unduly large surface area, either increase the sand content toreduce the possibility of segregation and to reduce the inter-practical stresses, or (better) re-grade using single sized aggregates.

14.3.10 At the trial mix stage small variations can be made preferably in the light of the pressures registered and observed performances through the pump. In certain cases, admixturesmay be economically and beneficially used to improve or eliminate circumstances thatcannot readily be overcome by other means.

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14.14 TESTING FOR PUMPABILITY

No mix shall be accepted for use on a pumping job until an actual test under field condition has been completed. Testing a mix for pumpability involves duplication of theanticipated job condition from beginning to end. The batching and conveying by truck mixers shall be the same as will be used; the same pump and operator shall be present. The pipe and hose layouts shall simulate the actual condition as far as practicable. Prior use of a mix on another job may furnish evidence of pumpability but only if conditions are duplicated. Before commencing a new concreting job, the contractor shall carry outpumpability tests in consultation with the Engineer. Concrete used in such tests shall not be used in the actual construction, unless specifically permitted by the Engineer.

Following parameter shall be established by pumpability trials:

14.14.1 Inset compressive & split tensile strength of concrete by
a) Curing the sample at Site by sprinkling water.
b) Curing the sample at Laboratory in curing tanks.

14.14.2 Wet sieve analysis of concrete to ensure that proportions of ingredients before and afterpumping are same.

14.15 FIELD PRACTICES

14.15.1 Proper planning of concrete supply, pump location, line layout, placing sequence andthe entire pumping operation shall be done by the Contractor and got approved by theEngineer on every occasion before commencement of concreting job. The pump shallbe as near the placing area as practicable, and the entire surrounding area must haveadequate bearing strength to support the concrete delivery trucks, thus assuring a continuous supply of concrete. For important concrete placements and large jobs, adequate standby power and pumping equipment shall be provided as replacement, should break down occur.

14.15.2 Direct communications shall be maintained between the pump operator, concrete placing crew and batching plant. The placing rate shall be estimated so that concrete can be operated at an appropriate delivery rate. As a final check, the pump shall be started and operated without concrete to ascertain that, all moving parts are operating properly. As stated previously, the grout mortar shall be pumped into the line to provideinitial lubrication for the concrete. As soon as concrete is received, the pump shall be run slowly until the lines are completely full and the concrete is slowly moving. Once the pumping is started, the operator shall ensure that the hopper of the pump is not emptied beyond a certain level, as air may enter the pipeline and cause choking. Continuous pumping should be ensured. If a delay occurs because of concrete delivery, form repairs, or other factors, the pump shall be slowed down to maintain some movementof the concrete till normal supply is resumed. For longer delays, the concrete in the receiving hopper shall be made to last if possible, by moving the concrete in the linesoccasionally with one stroke of the pump. In confined areas, attempt shall be made bythe Contractor to run a return line back to the pump, so that concrete can be re- circulated during delays.

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14.15.3 The Contractor shall ensure that obstructions are not found in the pipe due to interruption in the feed of the concrete by more than 30 to 45 minutes.

14.15.4 Minor blockages shall be cleared by operating a few strokes of the pump in reverse momentarily and then by returning to normal forward pumping. If this fails, a successionof reverse and forward strokes shall be carried out to remove the blockage. Should thisfail also, the blockage may be due to air-lock and the entrapped air must be removed.

14.15.5 Attempt to push through the obstructions by repeatedly starting the pump will result incompaction of the concrete and complicate the removal of the concrete in the pipe. Blockages in the pipe are usually discovered by the sound when the pipe is struck. Toremove the obstruction, the concrete pipe shall be taken apart at the assured positionand cleaned. Then the pumping process shall be started all over again.

14.15.6 This method of checking the blockage and setting it right shall bedone with great speedas excessive delay will cause setting of concrete in the pipeline downstream of the chokeand will lead to further blockage. When the blockage is being found out and remedied, the pump shall periodically be given one or two strokes forward to keep the concrete inmotion. If blockage occurs in the placer boom, a pipe joint near the base of the placerboom shall be opened and the boom made vertical to drain the pipeline by gravity.

14.15.7 Cleaning blockages are time consuming and as such major blockages shall best be avoided by ensuring a pumpable mix. Concrete that is either under or over sanded, short of fines, gap graded, has an excess of a size, or excessively wet or dry will be rejectedby the pump either by blockage or by hard pumping involving excessive pressures.

14.15.8 The termination of pumping operations shall be carefully planned to utilize the concretedormant in the pipeline and the hopper when the pump is stopped and to avoid wastage.

14.15.9 When the form is nearly full, and there is enough concrete in the line to complete the placement, the pump shall be stopped, and a go-devil be inserted and forced throughthe line to clear it out. Water under pressure shall be used to push the go- devil. The go-devil shall be stopped about one metre from the end of the line, so that the water inthe line will not spill over into the placement area. After flushing, water in the pipe shallbe removed by drain cock which shall be located for this purpose in the lowest part ofthe line. After all concrete has been removed from the lines, all lines and equipment shall be immediately cleaned thoroughly.

14.16 QUALITY CONTROL

14.16.1 Contractor shall ensure that workmanship and plant shall be maintained at peak efficiency. Degree of control on all the concrete operation from selection of the ingredients to the final testing of specimen shall be in line with the assumptions made in mix design with respect to the standard deviation and co-efficient of variation.


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14.16.2 The Contractor shall ensure that any compromise in quality is not done for the pumpedconcrete. To be pumpable, a high level of quality control for the assurance of uniformity must be maintained. Sampling at both the truck discharges and point of final placementshall be done by the Contractor and the Engineer jointly, as frequently as the Engineerdesires to determine, if any change in the slump air content, and other significant mix characteristics occur take necessary corrective actions.

14.16.3 The Contractor shall engage experienced supervision at all levels. The placing crew shall be experienced and qualified and each operation shall be well planned and properly scheduled.

14.16.4 All the crew engaged in each of the concrete activities shall demonstrate in the presence of the Engineer, their skills and capabilities to produce the final product as specified.

15.0 MASS CONCRETE WORKS

Sequence of pouring for mass concrete works shall be as approved by ENGINEER. CONTRACTOR shall exercise great care to prevent shrinkage cracks and shall monitorthe temperature of the placed concrete if directed.

16.0 PLACING TEMPERATURE OF CONCRETE

16.1 Placing temperature of concrete should be maintained as specified in Bill of Quantitiesor as directed by ENGINEER, to avoid shrinkage cracking

16.2 Mixing water shall be kept cool by storing it under cover. Chilled water or crushed ice as part of the mixing water to achieve the specified placing temperature shall be used. For chilled water, it is recommended that the contractor install and maintain refrigeration facility of required capacity. The contractor shall also build and maintain well insulatedadequate capacity storage tank for cold water with insulated connected piping. To supplement this refrigeration facility, the contractor will have to have ice plant or use commercial ice subject to approval of the ENGINEER. The full quantity of crushed iceshall be stored in cold storage 24 hours in advance of the start of concreting. The temperature in cold storage shall not be more than – 2oc. The contractor should studythe placing temperature condition and work out plant capacity commensurate with theconstruction schedule requirements and submit his scheme along with the tender.

16.3 Ice when used as replacement for a portion or all the mixing water shall be produced from water which meets the requirements of clause 4.3. Ice when used shall be in flakes of size 3mm or below or crushed condition and the crushed ice shall be such as to passcompletely, 10mm sieve.

17.0 CURING

17.1 Curing and protection shall start immediately after the compaction of the concrete toprotect it from:

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17.1.1 Premature drying out, particularly by solar radiation and wind;

17.1.2 Leaching out by rain and flowing water;

17.1.3 Rapid cooling during the first few days after placing;

17.1.4 High internal thermal gradients;

17.1.5 Low temperature or frost;

17.1.6 Vibration and impact which may disrupt the concrete and interfere with its bond to thereinforcement.

17.2 All concrete, unless directed otherwise by ENGINEER, shall be cured by use of continuous sprays or ponded water or continuously saturated coverings of sacking, canvas, hessian or other absorbent material for the period of complete hydration with aminimum of 7 days. The quality of curing water shall be the same as that used for mixing.

17.3 Where a curing membrane is directed to be used by the ENGINEER, the same shall beof a non-wax base and shall not impair the concrete finish in any manner. The curing compound to be used shall be got approved from the ENGINEER before use and shallbe applied with spraying equipment capable of a smooth, even textured coat.

17.4 Curing may also be done by covering the surface with an impermeable material such as polyethylene, which shall be well sealed and fastened.

17.5 Extra precautions shall be exercised in curing concrete during cold and hot weather as per Clause no. 8.3 of IS: 7861(Part II) and Clause no. 8.2 of IS: 7861(Part I) respectively.

17.6 Curing arrangement shall be subjected to ENGINEER's approval.

18.0 CONSTRUCTION JOINTS AND KEYS

18.1 Construction joints (location and type) shall be as shown on the drawing or as approvedby ENGINEER. Concrete shall be placed without interruption until completion of work between construction joints. If stopping of concreting becomes unavoidable anywhere,a properly formed construction joint shall be made with the approval of ENGINEER.

18.2 Dowels for concrete work, not likely to be taken up soon, shall be coated with cementslurry and encased in lean concrete as indicated on the drawings or as directed by ENGINEER.

18.3 Before resuming concreting on a surface which has hardened all laitance and loose aggregates shall be thoroughly removed by wire brushing and/ or hacking, the surfacewashed with high pressure water jet and treated with thin layer of cement slurry for vertical joints and a 15 mm thick layer of cement sand mortar for horizontal joints, theratio of cement and sand being the same as in the concrete mix.

18.4 When concreting is to be resumed on a surface, which has not fully hardened, all laitance shall be removed by wire brushing, the surface wetted, free water removed, and a coat of cement slurry applied. On this a layer of concrete not exceeding 150 mm thickness shall be placed and well rammed against the old

work. Thereafter work shallproceed in the normal way.

18.5 Approved epoxy Bonding agent, for bond between old (say 28 days or more) and newconcrete may also be used as per manufacturer's specifications.

19.0 FOUNDATION BEDDING

19.1 All earth surfaces upon which or against which concrete is to be placed, shall be well compacted and free from standing water, mud or debris. Soft or spongy area shall becleaned out and back filled with either soil-cement mixture, lean concrete or clean sandcompacted as directed by ENGINEER. The surfaces of absorptive soils shall be moistened.

19.2 Concrete shall not be deposited on large sloping rock surfaces. The rock shall be cut toform rough steps or benches by picking, barring or wedging. The rock surface shall bekept wet for 2 to 4 hours before concreting.

20.0 BASE CONCRETE

20.1 The thickness and grade of concrete and reinforcement shall be as specified inthe itemof work.

20.2 Before placing the blinding concrete of 1:4:8 mix, 50/75mm thick as per the item of work, the subbase of rubble packing shall be properly wetted and rammed. Concrete for thebase shall then be deposited between the forms, thoroughly tamped and the surface finished level with the top edges of the forms. Two or three hours after the concrete has been laid in position, the surface shall be roughened using steel wire brush to removeany scum or laitance and swept clean so that the coarse aggregates are exposed. The surface of the base concrete shall be left rough to provide adequate bond for the floorfinish to be provided later.

21.0 FINISHES

21.1 GENERAL

The formwork for concrete works shall be such as to give the finish as specified. The CONTRACTOR shall make good as directed any unavoidable defects consistent withthe type of concrete and finish specified; defects due to bad workmanship (e.g. damaged or misaligned forms, defective or poorly compacted concrete) will not be accepted. CONTRACTOR shall construct the formwork using the correct materials andto meet the requirements of the design and to produce finished concrete to required dimensions, plumbs, planes and finishes.

21.2 INTEGRAL CEMENT FINISH ON CONCRETE FLOOR

In all cases where integral cement finish on a concrete floor has been specified, the toplayer of concrete shall be screened off to proper level and tamped with tamper havingconical projections so that the aggregate shall be forced below the surface. The surface shall be finished with a wooden float and a trowel with

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pressure. The finish shall be continued till the concrete reaches its initial set. No cement or cement mortar finish shall be provided on the surface. Where specified, a floor hardener of appropriate thickness as approved by the ENGINEER shall be supplied and used as recommended by the manufacturer.

22.0 REPAIR AND REPLACEMENT OF UNSATISFACTORY CONCRETE

22.1 Immediately after the shuttering is removed, all the defective areas such as honeycombed surfaces, rough patches, etc. shall be brought to the notice of ENGINEER who may permit patching of the defective areas or reject the concrete work. ENGINEER'S decision on rejection of concrete work shall be final.

22.2 All through holes for shuttering shall be filled with cement mortar for full depth and neatly plugged flush with surface.

22.3 Rejected concrete shall be removed and replaced by CONTRACTOR at no additionalcost to The Employer.

22.4 For patching of defective areas all loose materials shall be removed and the surface shall be prepared as directed by the ENGINEER.

22.5 Bonding between hardened and fresh concrete shall be done either by placing cementmortar or by applying epoxy. The decision of the ENGINEER as to be the method of repairs to be adopted shall be final and binding on the CONTRACTOR and no extra claim shall be entertained on this account. The surface shall be saturated with water for24 hours before patching is done with 1:5 cement sand mortar. The use of epoxy for bonding fresh concrete shall be carried out as directed by ENGINEER.

22.6 CONTRACTOR shall submit a method statement for such repairs to ENGINEER forapproval.

23.0 VACUUM DEWATERING OF SLABS

Where specified floor slabs, either on grade or suspended, shall be finished by vacuumdewatering including all operations such as poker vibration, surface vibration, vacuum processing, floating and troweling as per equipment manufacturer's recommendation. The equipment to be used shall be subject to ENGINEER'S approval.

24.0 HOT WEATHER REQUIREMENT

24.1 Concreting during hot weather shall be carried out as per IS: 7861 (Part I).

24.2 Adequate provisions shall be made to lower concrete temperatures which shall notexceed 40 °C at the time of placement of fresh concrete.

24.3 Where directed by ENGINEER, CONTRACTOR shall spray non-wax-based curingcompound on unformed concrete surface at no extra costs.

25.0 COLD WEATHER REQUIRMENTS

25.1 Concreting during cold weather shall be carried out as per IS: 7861 (PART 2).

25.2 The ambient temperature during placement and up to final set shall not fall below 50°C. Approved anti-freeze/accelerating additive shall be used where directed.

25.3 For major and large-scale concreting works the temperature of concrete at times of mixing and placing, the thermal conductivity of the formwork and its insulation and stripping period shall be closely monitored.

26.0 LIQUID RETAINING STRUCTURES

26.1 The CONTRACTOR shall take special care for concrete of liquid retaining structures, underground structures and those other specifically called for to guarantee the finish and water tightness.

26.2 The minimum level of surface finish for liquid retaining structures shall be of moth type. All such structures shall be hydro tested.

26.3 The CONTRACTOR shall include in his price hydro-testing of structure, all arrangements for testing such as temporary bulk heads, pressure gauges, pumps, pipelines, etc.

26.4 Any temporary arrangements that may have to be made to ensure stability of the structures shall also be considered to have been considered while quoting the rates.

26.5 Any leakage that may occur during the hydro-test or subsequently during the defect'sliability period or the period for which the structure is guaranteed shall be effectively stopped either by cement/epoxy pressure grouting, geniting or such other method as may be approved by the ENGINEER. All such rectification shall be done by the CONTRACTOR to the entire satisfaction of the EMPLOYER/ENGINEER at no extra cost to The Employer.

27.0 TESTING CONCRETE STRUCTURES FOR LEAKAGE

27.1 Hydro-static test for water tightness shall be done at full storage level or soffit of cover slab, as may be directed by ENGINEER, as described below:

27.1.1 In case of structures whose external faces are exposed, such as elevated tanks, the requirements of the test shall be deemed to be satisfied if the external faces show nosign of leakage or sweating and remain completely dry during the period of observationof seven days after allowing a seven day period for absorption after filling with water.

27.1.2 In the case of structures whose external faces are submerged and are not accessiblefor inspection, such as underground tanks, the structures shall be filled with water andafter the expiry of seven days after the filling; the level of the surface of the water shallbe recorded. The level of water shall be recorded again at subsequent intervals of 24 hrs. over period of seven days. Backfilling shall be withheld till the tanks are tested. Thetotal drop in surface level over a period for seven days shall be taken as an indicationof the water tightness of the structure. The ENGINEER shall decide on the actual permissible nature of this drop in the surface level, considering whether the structuresare open or

closed and the corresponding effect it has on evaporation losses. Unless specified otherwise, a structure whose top is covered shall be deemed to be watertightif the total drop in the surface level over a period of seven days does not exceed 40 mm.

27.1.3 Each compartment/segment of the structure shall be tested individually and then all together.

27.2 For structures such as pipes, tunnels, etc. the hydrostatic test shall be carried out by filling with water, after curing as specified, and subjecting to the specified test pressurefor specified period. If during this period the loss of water does not exceed the equivalent of the specified rate, the structure shall be considered to have successfully passed thetest.

28.0 OPTIONAL TESTS

28.1 If ENGINEER feels that the materials i.e. cement, sand, coarse aggregates, reinforcement and water are not in accordance with the specifications or if specified concrete strengths are not obtained, he may order tests to be carried out on these materials in laboratory, to be approved by the ENGINEER, as per relevant IS Codes. The Employer shall pay only for the testing of material supplied by the Employer, otherwise CONTRACTOR shall have to pay for the tests. Transporting of all material tothe laboratory shall however be done by the CONTRACTOR at no extra cost to the Employer.

28.2 In the event of any work being suspected of faulty material or workmanship requiring itsremoval or if the works cubes do not give the stipulated strength, ENGINEER reservesthe right to order the CONTRACTOR to take out cores and conduct tests on them or doultrasonic testing or load testing of structure, as per relevant IS specifications. All thesetests shall be carried out by CONTRACTOR at no extra cost to the Employer. Alternately ENGINEER also reserves the right to ask the CONTRACTOR to dismantle and re-do such unacceptable work at the cost of CONTRACTOR.

28.3 If the structure is certified by ENGINEER as having failed, the cost of the test and subsequent dismantling/reconstruction shall be borne by CONTRACTOR.

28.4 The quoted unit rates/prices of concrete shall deem to provide for all tests mentioned above.

29 GROUTING

For details of grouting, refer GROUTING specification.

30.0 QUALITY CONTROL

30.1 Alternatively, if CONTRACTOR has his own QC formats, he may adopt them subjected to such modifications considered necessary by ENGINEER.

30.2 In either case CONTRACTOR shall submit his detailed Quality Assurance Plan, along with the bid. This would be reviewed, appropriately modified and approved by CONSULTANT after the award of contract.

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31.0 INSPECTION

All materials, workmanship and finished construction shall be subject to continuous inspection and approval of ENGINEER. Materials rejected by ENGINEER shall be expressly removed from site within 3 working days and shall be replaced by CONTRACTOR immediately at no extra cost to The Engineer.

32.0 CLEAN-UP

Upon the completion of concrete work, all forms, equipment, construction tools, protective coverings and any debris, scraps of wood, etc. resulting from the work shallbe removed and the premises left clean.

33.0 ACCEPTANCE CRITERIA

33.1 Any concrete work shall satisfy the requirements given below individually andcollectively for it to be acceptable.

33.1.1 Properties of constituent materials;
33.1.2 Characteristic compressive strength;
33.1.3 Specified mix proportions;
33.1.4 Minimum cement content;
33.1.5 Maximum free water/cement ratio;
33.1.6 Workability;
33.1.7 Temperature of fresh concrete;
33.1.8 Density of fully compacted concrete;
33.1.9 Cover to embedded steel;
33.1.10 Curing;
33.1.11 Tolerances in dimensions;
33.1.12 Tolerances in levels;
33.1.13 Durability;
33.1.14 Surface finishes;
33.1.15 Special requirements such as:

a) Water tightness
b) Resistance to aggressive chemicals
c) Resistance to freezing and thawing
d) Very high strength
e) Improved fire resistance
f) Wear resistance
g) Resistance to early thermal cracking

33.2 ENGINEER's decision as to the acceptability or otherwise of any concrete work shall be final and binding on the CONTRACTOR.

33.3 For work not accepted, ENGINEER may review and decide whether remedial measures are feasible to render the work acceptable. ENGINEER shall in that

case direct the CONTRACTOR to undertake the remedial measures. These shall be expeditiously andeffectively implemented by CONTRACTOR. Nothing extra shall become payable to CONTRACTOR by The Employer for executing remedial measures.

CONCRETE POUR CARD

(a) CLIENT: DATE: POUR NO:
(b) PROJECT: STRUCTURE:
(c) CONTRACTOR:
(d) MAX AGGREGATE SIZE: mm SLUMP: mm
(e) DRG. NO:
(f) START/COMPLETION TIME:
(g) CONCETE GRADE/QUANTITY: M / M3 MIXING TIME:

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