Tender S.U.R.E. VOLUMES I & II - are the first comprehensive guidelines for design-cum-tendering of city roads in India, and include all aspects of urban roads - what’s under, on, and above the roads.

Tender S.U.R.E. Guidelines have been formally endorsed by the Government of Karnataka as the design and execution standards for urban roads. The first set of Tender SURE roads in Bangalore have been designed and coordinated by Jana Urban Space.

The Tender SURE approach is transformational in three ways: brownfield urban design for roads that considers motorised and non-motorised mobility without land acquisition; integration of five core multi-agency service networks that run under the road, and overcoming the challenges of an inefficient and opaque system for execution.

In the clamour created by the size and scale of urbanisation, we cannot lose sight of the fact that people don’t live in abstract cities, they experience their lives in neighbourhoods, outside the homes they choose to live in, on the streets where they walk or drive to drop their children off to school or get to work, at the markets where they shop for groceries. How India copes with urbanisation will ultimately be about the details.

Those Indians fortunate enough to have travelled outside the country, look with envy and awe at the pedestrian boulevards of Paris, cycling streets of Amsterdam, transport of Hong Kong, iconic skylines of New York, all against other roads lined with shops and shawls. However, these cities that we so admire and that cause such pride among their local residents, emerged out of attention to detail in their planning and implementation.

We need to invest similarly in the details of our cities.

Today this vital network is completely fragmented and fractured, broken and bereft of planning, leading to ever-increasing traffic jams, potholes, and accidents.

Tender SURE tackles the cacophony of India’s urban road woes - providing a systematic, disciplined way to finally address the details of design, procurement, and execution of our city roads.

About the Author

Swati Ramanathan is the Co-Founder of Jana Group, and Chairperson of Jana Urban Space Foundation. She has over two decades of extensive experience in urban planning, urban design and urban policy in India.

An Advisor to National and State Governments, Ms Ramanathan works on significant urban planning policy reforms, urban developing urban plans, and urban design projects.

Ms Ramanathan has been recognized for her work on urban planning and transformations, including Young Asian Leader by the Asia Society.

Ms Ramanathan has worked in leading architectural firms in the U.S. and U.K before her return to India to work on urban change. She is a BS from India, and an MS from Pratt Institute, New York.

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Jana Urban Space
Foundation
www.janausp.org

Fourth Floor, MNC Building, Thimmiah Road, Vasanth Nagar, Bangalore - 560052
Ph: +91-80-40790400 | Fax: +91-80-41277104

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Jana Urban Space is a Professional Services Social Enterprise (PSSE), delivering transformational, world-class work on the spatial dimension of India’s cities.

Jana USP has four inter-disciplinary Studios -
- Urban Planning Studio;
- Urban Design Studio;
- Spatial Mapping & Analytics Studio;
- Architecture and Design Studio.

The multiple studios reflect Jana USP’s systems-driven approach to addressing urban Spatial challenges.

Jana Urban Space is a not-for-profit entity.

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India Urban Space Foundation
June 2011
Based on the Tender S.U.R.E. Guidelines, Government of Karnataka allocated 200 crores in the 2012 budget, to redevelop key roads in Bangalore as per Tender SURE Guidelines.

Two parallel projects are currently underway in accordance to the Tender SURE Guidelines in Bengaluru - the first set of Tender SURE roads have been awarded to RNS, for five roads to be taken up directly under the BBMP design and execution supervision (Nrupanthunga Road, KG road, etc). The second set of seven roads are contracted out to NAPC, under the design and supervision of Jana Urban Space (St Marks Road, Cunningham Road etc).

The execution of the Tender SURE project has undergone complex challenges from inception. Many of these challenges were due to the design integration efforts needed across multiple civic agencies: this was the first time that different agencies were coming together to make joint decisions, and that too, in a time-bound manner. As a result of all this, the field and design support to the contractor to enable good execution, was unimaginably complex. The learning process was also a factor, given the pioneering nature of the project.

Based on the success of phase 01 of the project, the Chief Minister of Karnataka has announced 50 more Tender S.U.R.E roads in the 2016-2017 budget. When the list of roads was announced, residents of many areas complained about being left out of the Tender SURE project.

If public demand and political response to such demand, are considered as the ultimate test of any idea in a democracy, Tender SURE has proven its merit through this rite of passage.
Before Tender S.U.R.E - St.Marks Road, named after the St.Marks Cathedral is part of the original British Cantonment, historically significant to the city, and now part of the central business district of Bangalore and an important movement corridor connecting North and South. Before Tender S.U.R.E the road was plagued with poorly placed fixtures and constantly leaking pipes, pot holes travel lanes of varying widths, discontinuous footpaths, and disorganised parking creating chaotic situations for all modes of movement.

After Tender S.U.R.E - St.Marks Road has uniform vehicular travel lanes, each 3M wide with a shyness of 500mm on either side, allowing for smooth flow of vehicles at steady speeds and designated parking. There is a cycle track on one side of the road and safe continuous footpaths on both sides of the road. Landscape strips separate the non motorised movement from the vehicular travel lanes. Organised underground utilities, clean geometric design, well spaced utilities, and a legible wayfinding system have made St.Marks Road a landmark destination for Bangalore.
Swati Ramanathan  
Chairperson,  
India Urban Space Foundation  
Trustee Member,  
Bangalore City Connect Foundation

Three factors have ensured the success of the automobile and 2-wheeler industry in urban India – rising aspirations and income levels of people; expanding cities that geographically spread out work, home, schools and play; and a limited public transport network. However, the success of this sector has snowballed into unwelcome consequences for the quality of life and for the environment in three ways: pollution of the environment, the ever-increasing consumption of non-renewable energy, and a wrenching, everyday crisis on our urban roads.

Individualised modes of motor transport have responded to the aspirations of an economically empowered middle class, and the failure to provide public transport alternatives.

A look back in history of India’s urban settlements shows that traditional patterns of road networks responded to the use of that time - roads and lanes were used as networks for localised movement, community interaction, and thriving markets. These patterns created compact city forms and mixed-use neighbourhoods where work and home were closely located. With the advent of automobiles and the far-flung growth of the major cities, these patterns have been replaced with an equally far-flung and haphazard road network. Walking and cycling as a means of mobility, have been sidelined at an alarming rate. Individualised modes of motor transport have responded to the aspirations of an economically empowered middle class, and the failure to provide public transport alternatives.
Ensuring that the benefits of motorized transport are harnessed, even as their negatives are minimized, will need many changes including public policy and behavioral changes. However, none of these will make any impact unless the actual urban road network itself becomes an enabler for these ideas, rather than an impediment, which is what they are today. Therefore, a logical starting point for any meaningful change in urban mobility, is to improve our urban road network. This critical network suffers from a five-fold failure in India’s cities:

1. **First**, our city roads are not planned in a clear, networked hierarchy of connectivity.
2. **Second**, they are not planned to integrate public transport networks: local buses, city buses, rail, and mass rapid transit.
3. **Third**, they do not provide a continuous network of pedestrian and cycling pathways, thereby ignoring the mobility needs of above 30% of the population.
4. **Fourth**, they are constantly under assault by multiple agencies with no planning or coordination between each other. Network utilities beneath and above the roads – drains, telecom lines, power lines, sewage, water, electric poles, transformers – are haphazardly laid, resulting in a sense of chaos and un-usability of much of the road and footpaths.
5. **Fifth**, they have a poor life cycle, with inadequate quality assurance on execution, and maintenance.

Rakesh Mohan, former RBI Deputy governor, describes the road policy as a vicious cycle of “build, neglect, rebuild”, in the August 2011 report of the National Transport Development Policy Committee. Dr Mohan who headed the Committee, said the committee calculated the value of replacement of poor roads at a whopping 900,000 crores. While the estimations are for rural and secondary roads, urban roads are prey to the very same issues.

Despite the importance of our urban roads, why is it that we are not getting this critical network infrastructure right? Two critical gaps stand out: one, the lack of design specifications; two, poor procurement / maintenance contracts.

The pot-holes on our roads reflect the pot-holes in the process. Confusing specifications, lack of design standards and the fragmentation of works to multiple small contractors are the current norm. We see the result in the poor outcomes of road works repeatedly - cosmetic surgery that lasts for a few days and washes out in the first rain.

TENDER S.U.R.E. addresses both these gaps in the current system of city road works execution, in two volumes. The first volume contains recommendations for design standards for a range of existing road widths and intersections. Importantly, this volume also details
standards for the networked utilities that are housed beneath the road surface. The second volume of Tender SURE is a Typical Contractor Agreement (TCA), intended as a guideline for the municipality in preparing road contracts and inviting requests for proposals (RFPs). The TCA aims to provide clarity of works specifications, execution, quality, contractual obligations, etc. The TCA also aims to bring in transparency in the tendering and bidding process. The TCA is expected to provide clarity to the contractors, ease the procurement issues for the municipality, aid engineers to oversee execution, and over time, build capacity for quality execution and maintenance of urban roads.

There are multiple documents addressing various components of the above-some are in great detail, and others with a limited focus and hence fragmented in nature. The intent of Tender SURE is not to reinvent the wheel - after all, world-over governments are managing to build good roads in their cities. We have studied all the documents we could lay our hands on, visited road engineering and transport departments of other countries and adapted these to our local context and needs, with deliberate intent to use our own existing templates and standards where possible.

The Tender SURE Volumes pull everything together, combining broad brush with judicious detail - laying the ground for improving the quality of urban roads, and networked infrastructure.

We need to make our city roads the enablers for our urban mobility ideas, rather than impediments to improvement. If we get the design and procurement right, we can have a balanced growth of our cities, embracing development and change, even as we give local streets and neighbourhoods back to communities. Roads today are a daily source of vexation to all. Focusing on our city roads - the most critical of urban networks - Tender SURE can systematically enable urban transformation, one road at a time.
How to use Tender SURE

Tender Sure is divided into two documents:
1. **VOLUME I** is a reference for design standards and specifications
2. **VOLUME II** is a template of a Typical Contractor Agreement (TCA)

**VOLUME I**

Specifications for Urban Roads Execution, has 5 chapters.

**Chapter 1** makes the case for systematic planning of the road network - especially in new extensions of existing cities and for new towns and cities – in a hierarchy of road widths based on the two primary uses: as a means of efficient access to dwellings and destination points within neighbourhoods; and as a means of mobility for all modal types and users.

**Chapter 2** describes elements of the road and road intersections, providing 16 design plates for various intersection types. Particular emphasis is laid on road calming design interventions to increase safety for pedestrians and cyclists. The chapter discusses details of utilities under the road surface and street fixtures above the road.

**Chapter 3** contains drawing plates for easy reference. There are two sets of plates: one for the RoW specifications; and the second for design details. While the final design for any roadwork will necessarily require factoring in actual conditions on the ground, typical plans for RoW widths between 2m to 80 m are provided in 34 RoW specification plates. The RoW design plates provide dimension standards for utilities and fixtures.

**Chapter 4** provides detailed material specifications for the road surface, eliminating to a large extent, the current need for referencing multiple technical documents.

**Chapter 5** estimates the life cycle costs over a twenty-year period, of implementing road works in the current manner as compared to the Tender SURE roads.
There are 7 Annexures that include checklists for road works execution, to be used by the municipal administration and engineers, as well as local residents.

**VOLUME II**

Typical Contract Agreement, is aimed at eliminating ambiguity for the contractor about the technical, planning and design specifications. The current practice of references to multiple documents that require complicated searches is simplified into one single contract that contains everything.

The Typical Contract Agreement requires that contractors be provided with clear survey measurements of proposed site of road works along with the RFPs, as well as detailed drawings design and engineering specifications of work to be executed.

The TCA improves quality of delivery by aiding the following: enforcing material purchase from government-accredited list of suppliers; encouraging EPC contractors as well as smaller contractors that commit to quality execution; empaneling contractors based on technical capability; improving Quality Check(QC) guidelines, and Operations &Maintenance(O&M) requirements; ensuring integration of information between civic agencies by requiring a project plan and sign-off on the same from all concerned departments such as water and sanitation, electricity, police, public transport, before embarking on the project; and defining a participative process from the local residents for monitoring execution, in line with the guidelines of the recent National Urban Transport Policy (NUTP).

Tender SURE recommends that the same processes of survey, specifications, testing, QC and O&M, are followed by the municipality, for works executed as internal works. Tender SURE also recommends setting a cap on the percentage of total annual urban roads expenditure to be done as internal works outside of a tendering process.
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- **AASHTO** American Association of State Highway Transport Officials
- **BBMP** Bruhat Bengaluru Mahanagara Palike
- **BDA** Bangalore Development Authority
- **BIS** Bureau of Indian Standards
- **BMLTA** Bangalore Metropolitan Land Transport Authority
- **BRTS** Bus Rapid Transit System
- **CBR** California Bearing Ratio
- **CDP** Comprehensive Development Plan
- **DBC** Direct Buried Cable
- **DULT** Directorate of Urban Land Transport
- **GoI** Government of India
- **GoK** Government of Karnataka
- **GSB** Granular Sub Base
- **HSRL** High Speed Rail Link
- **HYSD** High Yield Strength Deformed (steel)
- **IRC** Indian Road Congress
- **ITDP** Institute for Transportation & Development Policy
- **KTPP** Karnataka Transparency in Public Procurements
- **KBS** Karnataka Building Specification
- **KSRB** Karnataka Standard Rate Analysis for Buildings
- **KRBS** Karnataka Roads and Bridges Specification
- **LCC** Life Cycle Cost
- **LOS** Level of Service
- **MSA** Million Standard Axles
- **MRTS** Mass Rapid Transit System
- **MoRTH** Ministry of Road Transport and Highway
- **MoSRTH** Ministry of Shipping, Road Transport and Highway
- **NHAI** National Highway Authority of India
- **NMT** Non-motorised transport (pedestrians, cyclists, bullock carts, etc.)
- **NMV** Non-motorised vehicles (rickshaws, cyclists, bullock carts, etc.)
- **PHPDT** Peak Hour Peak Direction Traffic
- **ORR** Outer Ring Road
- **PWD** Public Works Department
- **PCU** Passenger Car Unit
- **R-o-W** Right of Way
- **ROB** Road Over Bridge
- **RUB** Road Under Bridge
- **RMC** Ready Mix Concrete
- **SPV** Special Purpose Vehicle
- **SDBC** Semi dense bituminous concrete
- **SWD** Storm Water Drain
- **SL** Street Light
- **SWM** Solid Waste Management
- **SR book** Schedule of Rates book
- **Tender SURE** Tender Specifications for Urban Road Execution
- **TMT** Thermo Mechanically Treated Steel
- **TPH** Total Petroleum Hydrocarbon
- **UR** Urban Roads
- **WBM** Water Bound Macadam
- **WMM** Wet Mix Macadam
Indian roads are under 5 classifications defined by Ministry of Road Transport & Highway (MoRTH) viz, National Highways (NH), State Highways (SH), Major District Roads (MDR), Other District Roads (ODR) and Village Roads (VR). Urban roads were not part of the formal classification until the year 2002, when the Ministry of Road Transport and Highway (MoRTH) recognized that the urban roads (UR) require distinction, and began classifying urban roads separately. However, there is no clear data on the quantum and costs of urban roads since they are clubbed into an aggregate data that includes major district roads and rural roads. This aggregate accounts for 94% of the total road length as indicated in Table 1.1. Of this, 50% is paved (SASEI ‘05, World Bank) suggesting that this accounts for the MDR and UR. It is important to understand the share of the urban road component in order to estimate the requirements of city roads accurately. Assuming that MDR is twice the length of State Highways, this suggests that urban roads are at least a third of the total which is over a million kms in length. Given the large share of the pie, urban roads have fallen woefully short on attention of both government and market. Government has allocated miniscule infrastructure capital, and neglected the need for standards and specifications, while the infrastructure players have displayed neither innovation nor entrepreneurship.

**Table 1.1**: Road Network in India
(Source - MoRTH web, accessed Oct. 2010)

<table>
<thead>
<tr>
<th>Category of road</th>
<th>Length in Km</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Highways</td>
<td>65,569</td>
<td>2</td>
</tr>
<tr>
<td>State Highways</td>
<td>1,30,000</td>
<td>4</td>
</tr>
<tr>
<td>Major Dist. Road, Rural road &amp; Urban road</td>
<td>31,40,000</td>
<td>94</td>
</tr>
<tr>
<td>Total road network</td>
<td>33,40,000</td>
<td></td>
</tr>
</tbody>
</table>

*Urban Roads estimation: over a million km. in length; 33% of total roads.*
The manuals for roads currently referred to in India mainly pertain to highways and rural roads. The MoRTH standardized the procedure and process for building a road and published the "Specifications for Road and Bridge Works" in 1973 that got revised thrice. The latest edition is in the year 2001. This is based on a system of road classification, building and maintenance, from a time when India was predominantly rural in nature. The Indian Road Congress (IRC) has published a set of guidelines for roads, but these too do not adequately address the requirements for building and managing the urban road network.

The reality is that urban roads have been neglected thus far. No specific standards have been devised for building, space allocation, or a hierarchical classification. In contrast to rural areas, urban areas have a higher density of population and street and highway networks and visitors. The existing guidelines and road specification primarily focus on national and state highways, major district roads and village roads. Field-planners, engineers and contractors adopt these standards while implementing urban road projects, but interpret them subjectively with great variation and inconsistency.

The economic development of the country and the consequent surge in the demand for transport services, necessitated expansion as well as improvement of the road network. This was undertaken in a planned manner at both centre and state levels.

Recognizing the need to develop arterial routes to link the Union capital with the state capitals, major seaports and other highways, the National Highways Act, 1956 was enacted. In 1957, the chief-engineers (road and bridges development) of the central and the state governments met in Bombay. Having taken into account the size of area, population, regional levels of development and future needs, the engineers presented a 20-year Road Development Plan (1961-81) in 1958 which is popularly known as the Bombay Plan.

The Plan anticipated an increase in road length from 6.10 lakh km in 1960 to 10.50 lakh km in 1981. The Plan target was to achieve a density of 32.5 km of roads per 100 sq. km of area, 44 km for developed agricultural areas, 19 km for semi-developed and 12 km for underdeveloped areas at an estimated cost of Rs 5,200 crore, including Rs 630 crore for village roads.

The Bombay Plan set a target of 8.88 lakh km of major district roads, other district roads and classified village roads. This target was exceeded in 1978 with the construction of 9.7 lakh km of roads. The target of 98,000 km of state highways could only be achieved a decade later. Of the target of 52,000 km only 34,619 km was achieved till 1 April, 1997.
Another Road Development Plan (1981-2001), known as the Lucknow Plan of the Indian Road Congress, has made a case for 66,000 km of National Highways by 2001 A.D.

The National Transport Policy Committee, set up in 1978 under the chairmanship of B. D. Pandey, submitted its report in May 1980. It recommended 37 roads with a 12,655 km length for inclusion in the National highway network. Out of these, only 11 roads, aggregating 3,595 km length, were completed over a span of one-and-a-half decades.

The Government of India instituted an Asian Development Bank-aided study in February 1990 on Development of Long-Term Plan for Expressways in India. The study was completed in 1991 and it has recommended development of 10,020 km of expressways by 2015 at an estimated cost of Rs 58,000 crore.

– from TCI web; accessed Oct, 2010

With such a vacuum in national urban road design specifications, some states (Andhra Pradesh, Gujarat and Rajasthan), cities (Chennai, Ahmadabad) and development authorities are creating their own reference documents. A clear articulation of specifications for urban roads, will go a long way in standardizing planning and design specifications in the country.

1.2 >>
Planning the Urban Road Network

Our cities have grown constantly over a period of time with changing boundaries. This unplanned development has resulted in a random road network. A planned approach to urban roads is the transition of the national / state / district highways, into a hierarchy of roads inside the city based on function. For example, a national / state highway cannot link to the city road network through an urban local road. It must transition into a ring road or a major arterial road of the city. The arterial road must be a trunk for sub-arterial roads, which links various collector roads. The collector roads would link neighbourhoods and transition movement from one local neighbourhood to another local neighbourhood or from a neighbourhood to a business district, through the sub-arterial / arterial network. The road network must also provide for mass public transport systems on major arterial and sub-arterial trunks, linked to air and rail stations. Collector and local roads must cater to local movement through feeder transport systems in neighbourhoods. Such a planned network of connectivity ensures mobility between all parts of the city.
Within neighbourhoods, providing a network of local roads that optimizes access is critical. If the only way to get to a local shopping area is through a convoluted road network, people will tend to use private vehicles. However if the network of roads provides easy travel routes that increases access, people will be more likely to walk or cycle. Access is intimately related to the block size or spacing between the local road networks.

Sub local roads provide access to individual dwellings and are not meant for through traffic. They are meant for pedestrian access in a higher density block with smaller sub-divisions. A planned network hierarchy of urban roads will define the space allocation and widths of these roads, and the allocation of land use within the network.

In India, IRC has recently revised the Engineers Pocketbook for Highway Construction to include classification and definitions of urban roads (table 1.2). The classification largely follows similar international peer documents.

UDPFI provides a similar road classification with similar widths. Both these can serve as base guidelines for new extensions or new growth centers. However existing city conditions with dense and multi-hub developments require specialised attention to include traffic management, public transit, over- and below-ground utilities, and parking. These elements are rarely factored into the planning for urban roads.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial</td>
<td>50 to 60m</td>
</tr>
<tr>
<td>Sub-Arterial</td>
<td>30 to 40m</td>
</tr>
<tr>
<td>Collector Street</td>
<td>20 to 30m</td>
</tr>
<tr>
<td>Local Street</td>
<td>10 to 20m</td>
</tr>
</tbody>
</table>

High land market values, changing land use, and increasing density have not only expanded existing towns and cities, they have also changed the existing city landscape – larger plots have been replaced with hi-rise apartments, land use has changed to include commercial businesses. Development controls have resulted in many of the old residential areas being slowly converted to commercial, retail and office developments. The streets are unable to cope with the added traffic pressure in many pockets of our cities. This densification of the urban cores has resulted in a burgeoning of traffic on the existing road network.
New extensions to cities add to the pressure on the core city roads. Invariably these new extensions are laid out without planning their integration into the existing road network, or providing intelligent zoning based on the carrying capacity of the roads. This results in new extensions that are inadequately connected to high destination nodes, and inadequately linked to the rest of the city. In addition, new extensions are often not porous in their local access between points within the neighbourhood. Hence the difference between ‘as the crow flies’ and what one has to actually travel on the road network between places, is often in many multiples due to poor access and lack of porosity provided by the road network. This issue of access is especially relevant for the “local” and “collector” roads linking neighbourhoods.

These are the two elements in planning road networks for new extensions: **mobility** and **access**. A clear network of roads that provides easy access between places must accompany a clear hierarchy of roads for mobility. Such a network reduces the distances to travel and incentivizes walking and cycling in neighbourhoods over motor vehicles. The third element that impacts both existing and new parts of the city, is the standardized specifications for urban roads in the network. Urban roads across the city are rendered inefficient due to uneven right-of-ways, frequent intersections on major thoroughfares, unchecked parking, encroachments, etc. causing traffic bottlenecks and delays. Hence standardization of specifications for road design is the third critical element.

The road network in all new urban extensions must be designed to achieve mobility, access and standardization. However, it is only the aspect of standardization of roads that can be addressed in existing cities. This chapter focuses on the **standardization for roads**.

In determining the planning standards and execution specifications, the first step is to define the hierarchy of the road network that will determine its required usage. The hierarchy used is based on principles of planning and efficient land-use for creating an optimal connectivity. This can be modified based on the carrying capacity appropriate for the density of the city. The resulting network of streets integrates public transport, non-motorized transport and private transport. In other words, the hierarchy is based on the function that a particular road supports (in existing urban areas) or is expected to support (in new extensions).

Once the hierarchy and use are arrived at, planning the road design for the range of RoWs (Right-of-Ways) is the next step.


## 1.3. INTRODUCTION

### a. Arterial Roads

The arterial road network should provide for uninterrupted flow of traffic radiating out of the city and serve as connectivity to major activity hubs in the city and outside to the highways. Continuity is essential and guidelines such as IRC, UDPF recommend that arterial roads should be spaced 1.5 km apart in CBD and at 8 km in sparsely developed outskirts of the city. Although arterial network is for higher speed, the speed limits in the core city should be regulated as per the need of the land use adjacent to the road.

Arterial roads serve high trip density corridors. Significant intra-urban travel such as between central business district and outlaying residential areas, or between major suburban centers takes place on this network. Roads connecting two National Highways, State Highways, and Ring Roads would also be considered as Arterial Roads. Parking may be restricted. Pedestrian and NMT facilities need to be separated from the main traffic and grade separated crossings should be provided.

### b. Sub-arterial Roads

These are functionally similar to arterials with medium density traffic and lower speeds compared to arterial roads. These may have lower requirements for mass mobility and will provide greater access than arterial streets. Sub-arterial streets may be spaced at 1 to 2 km distance with spacing of intersections at 500 m distance.

### c. Collector Roads

Collector roads aggregate traffic from local roads network within residential neighbourhoods, commercial roads, and industrial areas, and link this traffic to sub-arterial roads. Full access may be allowed on these streets from abutting properties. Parking restrictions may be applied during the peak hours. As collector streets connect with sub-arterial and arterial streets some of the collector streets would carry higher volumes.

### d. Local Roads

These are primarily access networks for individual dwellings and residential developments. Majority of trips in urban areas either originate from or terminate on these streets. Local streets may be residential, commercial of industrial, depending on the predominant use of the adjoining land. They must allow for streamlined parking and safe and comfortable cyclist and pedestrian movement. Heavy traffic and commercial traffic is to be restricted on local roads, and adequate traffic calming measures designed for each stretch and intersection.
e. Sub-Local Streets / Access Streets (conservancies)

In many of the older parts of the city as well as some newly developed fringe areas, residential roads are very narrow with only 2 to 3 m wide right-of-way. These roads however form a very significant network of access to individual dwellings and pockets of dense settlements in majority of old as well as some new residential layouts.

Sub-Local Street is 2 to 5 m wide R-o-W, with shared access to pedestrian, bicycle and vehicular access to two and three wheeler traffic. R-o-W width recommended is 3 m.

In some of Bangalore’s older neighborhoods such as Chamarajapete, Malleshwaram and Basavanagudi narrow lanes were reserved as conservancies and used for utilities such as drainages sewage and in recent past for electrical poles, and transformers. Over time as the original large lots have been subdivided the conservancies are being used as access roads for the property subpart facing the conservancies.

1.5 >> Right-of-way Design Specifications

Once the hierarchy and use is defined, planning and designing for the range of R-o-Ws (Right-of-Ways) is required.

The table below indicates the primary function by the road type on two parameters: mobility and access as discussed in the previous sections. As can be seen in the table, the collector road is central for both mobility and access, linking individual neighbourhoods to the larger network of mobility in the city, while providing the access to the lower order roads that provide access within the neighbourhood.

The six key design priorities defined are marked against each road type, base on their key functional priority: pedestrians; cyclists; public transport; parking; and traffic calming measures.

As can be seen in the table, pedestrian and cyclists are prioritised across all five road types, public transport is prioritised on the higher order roads namely arterial, sub-arterial, and collector. Parking is restricted on higher order roads, but may be provided for on judiciously on collector and residential streets within the neighbourhood to facilitate residents and provide restricted parking to visitors. While maintaining traffic flow is essential in the arterial and sub-arterial networks of the city, traffic calming measures are an essential feature for safety in neighbourhoods and are indicated for collector and local streets.
These priorities are indicative and may be re-defined based on specific ground requirements.

<table>
<thead>
<tr>
<th>Road Element</th>
<th>Arterial</th>
<th>Sub Arterial</th>
<th>Collector</th>
<th>Local</th>
<th>Sub Local</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority</td>
<td>Mobility</td>
<td>Mobility + Access</td>
<td>Access</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Footpath</td>
<td>● ●</td>
<td>● ●</td>
<td>●</td>
<td>●</td>
<td>Shared Path</td>
</tr>
<tr>
<td>Bicycle Path</td>
<td>● ●</td>
<td>● ●</td>
<td></td>
<td>●</td>
<td>Shared Path</td>
</tr>
<tr>
<td>Public Transport*</td>
<td>● ●</td>
<td>● ●</td>
<td></td>
<td></td>
<td>Minimal</td>
</tr>
<tr>
<td>Parking</td>
<td>Bicycle</td>
<td>Minimal</td>
<td>●</td>
<td>●</td>
<td>Prohibited</td>
</tr>
<tr>
<td>2-3 wheelers</td>
<td>Should be avoided</td>
<td>●</td>
<td>●</td>
<td>Prohibited</td>
<td></td>
</tr>
<tr>
<td>4 wheelers</td>
<td>Should be avoided</td>
<td>●</td>
<td>●</td>
<td>Prohibited</td>
<td></td>
</tr>
<tr>
<td>Traffic Calming Measure</td>
<td>●</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* footpath and bicycle paths need to be adequately separated from the main travel area for safety

HIGH LAND MARKET VALUES, CHANGING LAND USE, AND INCREASING DENSITY HAVE NOT ONLY EXPANDED EXISTING TOWNS AND CITIES, THEY HAVE ALSO CHANGED THE EXISTING CITY LANDSCAPE
CHAPTER 2
PLANNING SPECIFICATIONS

In redoing existing roads, the functional priority and design feature decisions should begin with goal setting based on stakeholder inputs (citizens, utilities and other agencies) to assess needs, limitations, and modal preferences, and analysis of adjacent land uses.

In this section various components of urban roads such as travel lanes, public transport lanes, footpath, and bicycle paths are detailed out. Other elements such as on-street parking, bus bays, loading-unloading bays, access control—entry-exit points have also been considered. In addition above grade street fixtures—streetlights, signs/signage, landscaping and below grade utility network—SW drains, sewer, electricity and telecommunication lines, and other public utility services are discussed.

2.1 >> Planning Specifications for Right-of-Way

R-o-W components

There are five elements specified in the RoW design.
1. Footpath
2. Cycle path
3. MRTS lanes
4. Traffic Lanes
5. On-street parking

Traffic area includes travel lanes, medians, and turn lanes. Planted or raised medians divide the traffic in opposite directions. Right turning lanes are located by the centre/median. The traffic area can be extended into the parking/bicycle area when left running lanes need to be provided.

The key factors that govern traffic lanes are classification of road, desired speed and the expected volume of traffic.

Travel lane is the portion of the road pavement allocated to a single line movement of vehicles; it is indicated on the pavement by painted longitudinal lines or embedded markers. In the Indian context a linear management of movement appears to have limited success due to the large volumes, inadequate capacity and more importantly heterogeneous nature of vehicles mix plying the roads. Enforcement is aided by good design and the drive lanes need some standardization. In particular the road design entails a level of certainty in terms of the operational widths. The key factors that govern the width of traffic lane are classification of road, desired speed and the volume of traffic expected. Wider the lane widths, higher would be the allowable
Vehicular speed. A point to note, is that a travel lane will not be efficient when its width changes frequently and unexpectedly.

Lane width design is dependent upon three factors: type of vehicles allowed; desired speed of movement; available space. The higher order roads may have greater traffic lane width and the lower order roads may be restricted to the minimum lane width. Uniform lane width must be designed into all RoW planning specifications.

Range of lane width: **2.75 m - 3.7 m**

Local roads and sub-local roads provide greater access and pedestrian movements. Heavy goods vehicles and trucks are not to be allowed in local and sub-local roads. Traffic calming measures are adopted in these roads. Narrower lane widths can suffice the needs of low volume/low speed residential area. For local and access roads, and places where R-o-W width varies, a uniform lane width of 2.75 m may be considered. Additional packing of space within the R-o-W should be included in the pedestrian area or landscaping area. Roads expected to have buses operating on it such as collector road, travel lane(s) must be able to accommodate bus movement (a minimum of 3 m wide lanes). On arterial and sub-arterial roads the typical lane width is 3.5 m.

<table>
<thead>
<tr>
<th>Road Classification (Typical)</th>
<th>Traffic Lane Width</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max (M)</td>
</tr>
<tr>
<td>Arterial (48m)</td>
<td>3.50</td>
</tr>
<tr>
<td>Sub Arterial (30m)</td>
<td>3.50</td>
</tr>
<tr>
<td>Collector (21m)</td>
<td>3.50</td>
</tr>
<tr>
<td>Local (10m)</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Table 2.1: Optimal and minimal lane widths for Urban Roads
**Turn lanes** need to be provided near major intersections for exclusive movement of right and left turning vehicles. In such places space for the medians is used. The length of the turn needs to be calculated based on the turning traffic volume.

**Level of service (LoS)** of a road depends on the carrying capacity of the road, which is dependent on the efficiency of available travel lanes. If the volume of the traffic on any particular lane increases more than its carrying capacity, or the travel lane is not completely available for through traffic, that road offers poor level of service to the traffic flow. Table 2.2 highlights the relationship between speed of travel and level of service achieved for the different types of urban roads.

<table>
<thead>
<tr>
<th>Road Classification (Typical)</th>
<th>Design Speed (kmph)</th>
<th>Vehicular Speed based on Level of Service (kmph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial (44m)</td>
<td>80</td>
<td>A 80</td>
</tr>
<tr>
<td>Sub Arterial (30m)</td>
<td>60</td>
<td>A 60</td>
</tr>
<tr>
<td>Collector (21m)</td>
<td>50</td>
<td>A 50</td>
</tr>
<tr>
<td>Local (10m)</td>
<td>30</td>
<td>A 30</td>
</tr>
</tbody>
</table>

2.1.1 >> Road marking

**Road Marking** is critical and highly under-valued tool in Indian cities for guiding and controlling traffic on a urban roadway. The markings serve as a psychological barrier and signify the delineation of traffic path and its lateral clearance from traffic hazards for safe movement of traffic. Painted road markings have the advantage of conveying the required information to the user without distracting his/her attention from the travel lanes during poor visibility due to dust or heavy rains.

**Travel lane markings** in and around the vicinity of an intersection guide orderly movement of traffic around congestion points. The type of road marking used in an intersection is the function of several variables such as speed of traffic, availability of space, etc. Lane marking details are indicated in the plan drawings overleaf.

Road markings are in the shape of lines, patterns, words or devices, set into applied or attached to the carriageway or kerbs and kerb-sides.
2.1.1.1 >>
Edge Line Marking

Pavement edge lines indicate the edge of the carriageway and the limit of the traffic lane. The edge line is indicated as a single continuous line placed about 15 cm from the edge. The width of the line is 15 - 20 cm.

2.2 >>
R-o-W—
Public Transport Lanes

As a general principle, provisioning for mass transit and regular public transit should be made in the planning stage in terms of space availability. The related infrastructure can be provided when required.

Due to the vehicle size and turning radius requirements, local operation is more suitable for collector roads and local. Space allocation for BRT/MRT, bus-bays is required in the design of arterial and sub-arterial streets, and bus stops at regular intervals on collector/local roads. On the roads that are designated as dedicated transit corridors, separate bus lanes need to be marked with corresponding signage.

Feeder bus network should be considered on local roads, where smaller buses are more suitable.
2.2.1 >> Mass Rapid Transit Modes

Mass rapid transit modes could be bus, light rail or heavy rail systems. Commuter Volumes supported:
BRTS and LRTS: 8,000 pphpd
MRTS: 15,000 pphpd

**Metro Rail System or MRTS** is a passenger railway in an urban area with a high capacity and frequency, and grade separation from other traffic. Rapid transit systems are typically located either in underground tunnels or on elevated rails above street level. To build elevated rails on urban road, 9m of space is required in the centre of RoW, during construction. Post construction the space utilized by piers of MRT corridors provides for landscaping and recharging of ground water.

**Light Rail Transit System or LRTS** is an electric short rail system operating with single cars at grade on streets with exclusive RoW lane, below grade in subways, or above grade structures. They cater to mid to high commuter volumes.

2.2.2 >> Bus Transit

**Bus Rapid Transit System or BRTS** is a term applied to a rapid public transportation system using buses to provide faster, more efficient service than an ordinary bus line, but with the service quality of a rail system. Often this is achieved by making improvements to existing infrastructure, vehicles and scheduling. The goal of these systems is to approach the service quality of rail transit while still enjoying the cost savings and flexibility of bus transit.

Due to high speed achieved by this system, it is provided close to the median. Space required is 3.5 m per lane on either side of the median.
Due to high speed achieved by this system, it is provided close to the median. Space required is 3.5 m per lane on either side of the median. A station is provided at every 2 km which 3-4 m wide. Hence BRT lane width ranges from 7 m on continuous section to 11 m at BRT station. Pedestrian access to the station should be provided through a raised intersection to ensure safety. Space for BRT may be provided in all sub-arterial and arterial roads. The BRT lanes provided need to be dedicated lanes without merging any other traffic.

**Local Bus Routes:** A local bus transit operates on fixed routes and schedules and in most Indian cities is the only transit option available. Routes can be most efficient when designed in a “hub and spoke” manner with routes radiating from the Central Business District area (CBD). Sometimes they may be designed in a series of parallel routes on a grid road network.

**Trunk routes** operating on arterial and sub-arterial roads, and linking areas of high trip generation, may be assigned for higher bus service or BRTS. Cross city routes can be designed to link parts of the city without going into the CBD.

**Bus stops:** The length of the bus stop is to be determined by the
number of buses expected to use the stop at any given time. The bus stop should include a stable platform with a minimum width of 1.2 m and a shelter with space to incorporate related facilities such as route maps, trip planners. The bus stop area where passengers alight and embark should be clear of trees, utility poles, wires, fire hydrants.

Bus stops can be located kerb side, with extended kerbs or in bus bays. On collector roads where on-street parking is not provided, kerb side bus stops can be provided. Bus shelters for such stops should not be built on the footpaths such that they occupy the entire footpath. The minimum functional width of 1 m must be maintained for the pedestrian throughout.

The table below indicates the recommended distances between various elements of public transport system for a commuter access.

<table>
<thead>
<tr>
<th>Public Transport Matrix</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Road Type</strong></td>
<td><strong>Bus Stops m</strong></td>
<td><strong>Bus Bays</strong></td>
<td><strong>Transit Hubs</strong></td>
<td><strong>Feeder Bus Stop</strong></td>
<td><strong>Bus Rapid Transit</strong></td>
</tr>
<tr>
<td>Arterial</td>
<td>500</td>
<td>2 km</td>
<td>4.7 sq km</td>
<td>1 - 1.5 km</td>
<td>2 km</td>
</tr>
<tr>
<td>Sub Arterial</td>
<td>500</td>
<td></td>
<td></td>
<td>500 m</td>
<td>1 - 1.5 km</td>
</tr>
<tr>
<td>Collector</td>
<td>400</td>
<td></td>
<td></td>
<td>300 - 400 m</td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>400</td>
<td></td>
<td></td>
<td>300 - 400 m</td>
<td></td>
</tr>
</tbody>
</table>

**Bus stop locations & clearance lengths:**

Nearside: just before an intersection — clearance of 35 m
Farside: just after an intersection - clearance of 42 m
Mid block: between two intersections - clearance of 25 m

Bus stops close to the intersection can lead to traffic queues and sight
distance issues, but are more desirable from the commuter point of view for the ease of transfers. Mid-block stops may be better near a congested intersection, but may lead to frequent mid-block pedestrian crossing incidents. The advantages and disadvantages of these choices must be analysed based on the ground conditions in consultation with the transit authorities.

2.2.3 >> Bus Bays

A **hail-and-ride bus stop** blocks the ongoing traffic resulting in congestion, especially on narrow roads during peak hours. To achieve free flow of traffic on main travel lane, a bay is provided outside the main travel lane for buses to stop for the passengers. This reduces traffic blocks and increases passenger safety.

**Transport Hubs**

A transport hub is a place where route or mode interchange is made available for passengers. Public transport hubs include train stations, rapid transit stations, bus stops, tram stop and airports. In most Indian cities, a hub is the merging place of inter-city buses; intra-city buses; intra-state transport service; parking lot for private vehicles; and control rooms. It is decentralized forms of bus stations which is planned and all major mergers of corridors of a city.

A transit hub attracts other intermediate public transit (IPT) like auto, taxi, feeder and other para-transit vehicles. Sufficient space should be allocated near these hubs to accommodate all IPT. All hubs must have dedicated entry and exit. Parking restrictions must be enforced on all roads that lead to the hub.

2.3 >> R-o-W & On-street Parking

With more and bigger cars on urban roads everyday, the impact is not just on traffic movement, but on street congestion that hampers pedestrian movement and access to dwellings. The issue of parking is reaching alarming proportions. There are four causes for this:

1. **Parking** is either free or at a nominal cost.
2. Violations in parking rules such as double-parking, hap-hazard parking, and parking in no-parking areas, go unpunished. This leads to a culture of violating traffic laws. Violations in space parking requirements in buildings also go unchecked and unpunished.
3. **Big retail and commercial developments** either do not provide adequate parking for their customers, and/or the roads providing access in and around the development do not have the carrying capacity for the traffic they generate.
4. **Poor planning** that does not link land use to trip generation and parking requirements. Parking policies for buildings and streets need to be simplified so that there is no scope for negotiation, and such that they are easy to monitor.
Considerations for provision of parking type:

1. *Free* public parking: residents obtain permits, and visitors have off-peak parking
2. *Paid* public parking: in designated areas and streets, around transit stops and high traffic destinations
3. *Paid* private parking: through PPPs using hi-tech for multilevel parking, in CBD areas and key high traffic centres, around major rail stops, and where pedestrian use is desirable.

Mini routes with mini public transport modes can be chalked around key public transit and pedestrian areas, which also include a parking location where commuters can park their vehicles.

This section is limited to specifications for on-street parking, and does not go into any details on policy recommendations

Parking lane width for parallel parking should be **2.75 m x 6 m** which may be reduced to **2 m x 5 m** where available space is limited. Where additional parking capacity is desired and sufficient carriageway width is available, angled parking may be adopted. Standard dimensions required for different angles of parking is as indicated overleaf:

Parking policies for buildings and streets need to be simplified so that there is no scope for negotiation, and such that they are easy to monitor.

For every **1000 sqm** of built up residential space approved, parking of **10 cars**, and every fraction thereof, can be the minimum standard

For every **1000 sqm** of built up commercial space approved, parking of **20 cars**, and every fraction thereof, can be the minimum standard
This includes all parking: private, paid, and public.
The recommended minimum space standard for cars with standard dimensions, in private buildings, including circulation is as follows:

- 20 sqm surface parking
- 23 sqm parking under stilts
- 28 sqm parking in basements

1 car parking space = 4 two-wheeler space = 10 cycle space
A typical two-wheeler parking space is 1.2 m x 2.5 m. In places with space constraints this can be reduced to 1 m x 2 m.

While deciding the specific locations for on-street parking and the number of parking spaces should be provided, due consideration should be given to loss in road capacity in permitting parking. Parking area should be designated after providing space for pedestrians, green strip and cyclists. Parking should not be allowed 100 m into intersections to reduce conflicts and to give additional travel lane width for vehicular movements. Provision of footpaths should be an uncompromised priority, with suitable safeguards against illegal parking on them. The table overleaf gives the type of parking recommended for urban roads.
### Table 2.5 >> Road Types & Parking

<table>
<thead>
<tr>
<th>Urban Road Type</th>
<th>Angle</th>
<th>4 wh</th>
<th>2 wh</th>
<th>4 wheeler parking on commercial areas</th>
<th>2 wh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial (48m)</td>
<td>Parallel</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parallel</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>45</td>
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<td>60</td>
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<tr>
<td></td>
<td></td>
<td>90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub Arterial (30m)</td>
<td>Parallel</td>
<td>30</td>
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<td>Local (10m)</td>
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<td>Sub Local (3m)</td>
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</tbody>
</table>

### 2.4 >>

**R-o-W and Pedestrian Area**

**Non-Motorized Transport (NMT)** must be given greater weight-age while designing urban mobility. **Mobility** is allowing people to move from one place to another, safely and conveniently, considering socio-economic conditions, characteristics of the area and accessibility to other modes. Therefore it is important to develop a comprehensive mobility plan that accommodates motorized and non-motorized transport (NMT). Slow moving non-motorized transport modes, like bullock-carts, cycle rickshaws and hand-drawn carts are not touched upon in Tender SURE.
2.4.1 Footpaths

The space by the side of the road identified for pedestrian walking purposes is usually referred as ‘pedestrian pavement/ walkway/ footpath. Pedestrian area includes space for footpath, landscaping, street furniture, signage, and above-grade utilities. This area may also be shared by bicycle users. The pedestrian area is closely linked with the travel lanes and on-street parking. The width of the ‘pedestrian pavement’ can vary based on the number of pedestrians using the road. From uneven granite slabs to interlocking pavers of various shapes (circular, hexagonal, eye-sections, colored and grey) and just simple rough concrete slabs, there are many choices and designs that have evolved in the last twenty years.

Recommended minimum width for pedestrian walkway/footpath and bicycle track is **1.5 m**. They should have well maintained surface with a cross fall within the range of **2.5 to 3 %**. Except sub-local 2m and 3m R-o-W (Refer drawing plate 19, page 158), footpath is provided on either side of the road in all scenarios.
Minimum footpath width is maintained at 1.5m and maximum is 3m. Where additional width in the RoW is available, this can serve as landscaping or foot path extensions for small markets or hawking areas.

**Kerb** is a key element that divides travel lanes and pedestrian walkway. The main purpose of kerb stone is to protect and strengthen pavement edge, to control drainage, clearly defining the edge to vehicle operators. It may be made of plain cement concrete. Height of a kerb usually varies from 15 cm to 25 cm. There are various types of kerb designs that accommodate various needs such as ‘L’ type kerb which includes a gutter. Kerbs are painted with either alternating black and white stripes 500 mm wide or chequered black and white design of same width.

Kerbs need to be dropped to facilitate mobility of persons with physical challenge. Footpaths are ramped to the street level along with the kerb ramps. Kerb ramp should be flared on either side of the ramped footpath and gradient of the flared side should not be steeper than 1:10. The ramp should not project onto a roadway.

Alternatively raised pedestrian crossings may also be provided to facilitate crossing. *(Refer subsection 2.6 Traffic Calming measures).*
A dedicated space is provided adjacent to the kerb for landscape elements such as shrubs and flower plants, trees, street furniture such as, street bench, trash bins, and above-grade utility fixtures such as light poles and signage etc. This strip will not only act as divider between pedestrians and vehicles but it also improves aesthetical features of the road. Strip dimension varies based on the available footpath width and clear walkway designed for pedestrians. Minimum width given for landscaping strip is 0.4 m in local road and can be 1 m and more in higher order roads.

<table>
<thead>
<tr>
<th>Distance from the Kerb (m)</th>
<th>Traffic signs</th>
<th>Street light</th>
<th>Tree/plants</th>
<th>Dust bins</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>0.5</td>
<td>0.7</td>
<td>0.2</td>
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</tr>
</tbody>
</table>

Image 2.14 >>
Green strip on a Local Road (Walton Road), Bangalore
The **bicycle** is a core mode of urban transport. It is desirable to re-design R-o-Ws prioritising bike lanes in all arterial, sub-arterial and collector roads by

1. **Narrowing existing travel lanes**
2. **Removing a travel lane**
3. **Removing parking**
4. **Covering drains and extending the footpath**

For bicycle track a **1.5 m** minimum width is maintained on collector roads and in sub-arterial and arterial road **2 m** width is provided. Since speed of travel (refer Table 2.2) is less on local and some collector roads, a dedicated lane may not be needed.

**Features of Bicycle track**

1. **A** minimum width of **1.5 m** for one-way movement and **2.5 m** for two-way movement continuity to allow for reasonable speeds
2. **A** smooth surface material—asphalt or concrete. Paver blocks are to be avoided. Manhole covers should be avoided and, if unavoidable, should be level with the surrounding surface
3. **Elevation above the carriageway** (e.g. **+150 mm**) that allows for storm water runoff
4. **A** buffer of **0.5 m** between the bicycle track and parking areas or the travel lane is provided
5. **At** property access points, the bicycle track remains at the same level and vehicle access is provided by a ramp in the buffer
6. **Bollards** to block access to motorbike users

As shown in Plan 2.16 a dedicated space may sometimes be provided for cyclists to halt ahead of private lanes at an intersection. Dedicated signals at intersection gives priority to cyclists after BRTS.
Intersections are critical areas of pedestrian congregation and require safe and efficient crossing facilities while ensuring minimum delay to vehicular traffic. Skywalk bridges/foot-over-bridges forms a very important aspect for overall improvement of transport infrastructure in the city and helps pedestrians to improve their safety and mobility.

**Design considerations for pedestrian underpasses, bridges and subways**

The flow should not normally exceed **20 persons per 300 mm width per minute** on level or up to **1:20 gradient** and **14 persons per 300 mm width per minute** on stairs or ramps steeper than **1:20**. A dead width of **0.75 m** is usually allowed adjoining any display windows in subway.

The gradients of continuous ramps should not be steeper than **1:10**. If a landing is provided at mid – height, a maximum slope of **1:7** can perhaps be allowed. A minimum height of **2.3 m** and a width of **2.45 m** should be provided for subways up to about **23 m** length, and for longer subways the dimensions need to be increased to **2.6 m height and width** of **2.75 m**.

In order to overcome the drawbacks of pedestrian subway, the middle portion of the junction may be raised.
2.5 >> Road Intersection

**Intersection** is a point at which two or more roads cross. This area is designated for movement to turn directions. Overall traffic flow depends on the performance of the intersections.

Intersection design needs to be based on factors such as: users, geometric configuration, volume of travel, capacity of roads and traffic control requirements.

1. **Number of roads converging**
   The number of roads converging governs the configuration and shape of the intersection. Typically there are three or four legs in any intersection; however intersections with 5 or 6 legs are also formed where three roads converge.

2. **R-o-W widths of intersecting roads**
   In urban road hierarchy, traffic flows from sub-local to local or collector; local to collector; collector to sub-arterial and sub-arterial to arterial.

   Intersection formed due to local + local and local + collector roads might not require treatment as neighborhood traffic would be low. But when two major R-o-Ws intersect, detailed designing is required.

3. **Intersection design based on amount of traffic**
   Traffic management at intersections:
   (i) Traffic < 3000 vehicles/hr - Calming measures
(ii) 3000 - 6000 vehicles/hr - Mini traffic circle or rotary
(iii) 6000 - 8000 vehicles/hr - Signalised intersection
(iv) 10,000 & above vehicles/hr - Grade separators

Table 2.6 indicates the type of intersection design to adopt based on the traffic generated.

<table>
<thead>
<tr>
<th>Intersection formed due to merging of</th>
<th>Mini Traffic Circle (slightly more than rotary)</th>
<th>Rotary with single circulatory lane (3000 veh per hr)</th>
<th>Rotary with Double circulatory lane (3000 veh per hr)</th>
<th>Signalised (up to 10000 veh per hr)</th>
<th>Grade Separator (Above 10000 veh per hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial + Arterial</td>
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<tr>
<td>Arterial + Sub Arterial</td>
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<tr>
<td>Arterial + Collector Street</td>
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<td>Sub Arterial + Sub Arterial</td>
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<tr>
<td>Sub Arterial + Collector</td>
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<tr>
<td>Collector + Collector</td>
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<tr>
<td>Collector + Local</td>
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<tr>
<td>Local Street + Local Street</td>
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</tbody>
</table>

2.5.2. Types of intersection

2.5.2.1. Simple intersections
An intersection where the R-o-W widths of all converging legs are the same and additional space for turning traffic is needed or cannot be provided due to constraints of adjacent land use. This type of intersection is suitable for locations where two local road meets another or with a low volume collector road. Pedestrian crossing distance in this type of intersection is the lowest of all intersections.

2.5.2.2. Intersections with additional turning lanes
In certain locations with high-volume traffic, additional lanes need to be provided to accommodate turning traffic and to create additional capacity for through traffic. This is achieved by utilizing the space in the medians, utility corridors or by flaring. Crossing distance and time for pedestrians increase in this type. This needs to be factored in the design to create adequate pedestrian refuge areas and traffic controlling.
2.5.2.3. Channelised Intersections

Raised islands and/or road marking are used to ‘channelise’ or designate vehicular paths in the intersections. Channelisation helps in control, direction or division of vehicular paths for better traffic management of motorised and non-motorised vehicles. Locations for traffic control devices, utilities should also be factored in the design. The channel islands and median spaces should provide refuge areas for crossing pedestrians, since channelised intersections generally tend to be on wider R-o-Ws.

2.5.2.4. Roundabout intersections

Roundabouts channel movement of traffic in one direction around a central island. The vehicles from the converging roads move around the central island in clockwise direction in an orderly manner and weave out of the rotary movement into their desired direction. A roundabout may be for three-leg or four-leg or multi-leg intersection. The central island is generally circular in shape, but can also be oval or dumbbell shaped. A roundabout intersection has less conflict points than a traditional intersection and is also considered safer.
**Mini traffic circles** are types of roundabouts characterized by a circle of small diameter and traversable islands (central island and splitter islands). Mini-circles offer most of the benefits of regular roundabouts with the added benefit of a smaller footprint. As with roundabouts, mini-circles are a type of intersection rather than merely a traffic calming measure, although they may produce some traffic calming effects. They are best suited to environments where speeds are already low and environmental constraints would preclude the use of a larger roundabout with a raised central island.

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**2.5.2.5. Grade Separated Intersection**

Grade-separated intersections can be used in locations where high volume through traffic needs be given preferential treatment. The grade-separated intersections are required when two major roads meet—arterial with arterial or sub-arterial, where volumes are high. There are various types of interchange-designs such as ‘trumpet interchange’, ‘diamond interchange’, ‘cloverleaf interchange’ and ‘rotary interchange’. These are conventional interchanges that require large space which is scarcely available in any Indian cities and construction duration is longer. Much of the time is spent on preparing ground for RCC, casting and curing. As it requires more time, alternate routes for movement are required.

Dense city centers needed a technology that is quick, effective and causes minimal disruption to traffic. Urban local bodies in recent times have shown a preference for pre-cast elements with push-box
technique, because these are simple, quick and economical. In pre-cast technology major part of the construction work is done outside the worksite. RCC pre-cast elements can be made well before the work begins at the worksite and then brought to the pre-prepared construction site and placed in to position. Push box technique, originally developed from pipe jacking technology. Jacked box tunneling is generally used in soft ground at shallow depths and for relatively short lengths of tunnel. Images to the right show use of pre-cast elements to construct underpass.

Image 2.21 >>
Jacked Box Tunnelling
(imagesource: http://indianrailways.informe.com/forum)

Image 2.22 >>
Under Pass construction on Hosur Road, Bangalore using pre-cast elements and soil nailing techniques

2.5.3 >>
Treatments of intersections
(See drawing plates Pg 66-81)

Majority of accidents happen at intersection because of blind spots especially at free left turns. Speed control measures need to be adopted to cut the speed. In vicinity of residential neighborhoods, institutions, transit centers and hospitals, appropriate TCM should be provided. (See drawing plates Pg 66-81)

The treatment method adopted in Bangalore is one-way system and dividing the roads with a median. A study conducted by Vivian Robert and A.Veeraragavan, Department of Civil Engineering, Bangalore University, suggests that, the conversion of two-way roads into one-way roads has led to a significant reduction in the number of accidents. Fatal accidents have reduced by 32%, injury accidents have reduced by 34% and property damage accidents have reduced by 18% on the roads selected for the study.

The erection of median barricades on certain roads in Bangalore city are believed to have led to a significant reduction in the number of accidents. Fatal accidents have reduced by 40%, injury accidents have reduced by 43% and property damage accidents have reduced by 43%
on the roads selected for the study.

2.5.3.1 >>
Sight distance at intersection

Sight distance is measured along the major roadway from the center of the entrance lane of the minor roadway to the center of the near approach lane (right or left) of the major roadway.

The intersection sight distance is a major control for the safe operation of roadways. Sight distance at intersection plays very important role, mainly at uncontrolled intersection, so as to provide the driver to cross the intersection without causing delay or accident. The uncontrolled intersection sight distance requires that drivers approaching an uncontrolled intersection on a cross street must have sufficient sight distance across the intersection corners to adjust speeds or stop.

No distinction is made between daytime and night time conditions of vision at intersections, assuming that headlights of cars approaching the intersection will be seen across the corner area, and the headlight beams would usually indicate their presence before they actually come into view.

At signalized intersections, the first vehicle stopped on one approach should be visible to the driver of the first vehicle stopped on each of the other approaches.
Table 2.7 indicates visibility distances (meter) along major road of the intersection; the visibility distance is measured from the intersecting point of through sight of major road and minor road.

<table>
<thead>
<tr>
<th>Speed (kmph)</th>
<th>SSSD (m)</th>
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<tbody>
<tr>
<td>20</td>
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<td>25</td>
<td>25</td>
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<td>30</td>
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<td>70</td>
<td>90</td>
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<tr>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

2.5.3.2 Signalized Intersection

A traffic signal is traffic control device operated manually, electrically or mechanically by which traffic is alternately directed to stop and proceed. The traffic signal passes on its information using a universal color code red, amber and green.

LEGEND:
P - Primary signal
S - Secondary signal

Notes:
1. Signal poles are located 60 cm from edge of footpaths
2. In case of streets where central median not provided, secondary may be located on the right FP.
3. Distance between primary and secondary should be 12m min and 36m max.

The signal sequence indication varies from country to country, in India practice we have amber period of 2 seconds as a transition interval between termination of related green movement and exhibition of red indication or vice versa.

Traffic signal is installed at two locations, one on the footpath towards left of approaching vehicles (termed as primary signal) and other on...
the opposite side of the road (termed as secondary signal). Signal poles are installed at a distance of 0.6 m from the kerb. In instances where a central median is not available, the secondary signal may be located on the right footpath.

The signal poles shall be installed in pits of 900 mm x 900 mm x 1050 mm deep embedded in M20 concrete to a minimum of 300 mm below ground level and 300 mm above ground level. The circular area of embedding concrete shall have a minimum diameter of 450 mm. All the cables supplying power to the controller and signal heads shall run through RCC ducts when these are required to cross the travel lanes. The ducts are of 150 mm internal diameter and laid at a depth of about 750 mm from the level of the travel lanes.

2.5.4. Marks for intersection

In addition to the warning lines on approaches to intersections, directional arrows should be used to guide drivers in advance approaching busy intersections. Because, of the low angle at which such markings are viewed, these are elongated in the direction of the traffic flow to provide adequate legibility. For speeds up to 50 kms per hour the arrows should be 3.5 m in length. For higher speeds, the length should be 5 m.

2.5.4.1 Arrow markings, stop line, box marking and bicycle waiting area

Markings for cyclist crossing should be provided wherever a cycle track crosses a road. The cycle track crossing should ideally be adjacent to a pedestrian crossing when such a crossing is also provided. Rectangular box space is provided for bicyclists to wait during signals. The waiting area provided with a width of travel lane width and one bicycle length or 3 m breadth.
2.5.4.2  >>  Stop Line

**Stop lines** are solid white lines provided transversely to the carriageway and used to indicate the point behind which vehicles are required to stop in compliance with the STOP sign, Traffic Signal or Traffic police. The width of stop line as per current Indian practice for urban and suburban roads are **20 cm**.

Stop lines are ordinarily located not less than **1 m** and not more than **3 m** in advance and parallel to the nearest boundary of pedestrian crossing marking.
Pedestrian crossings are marked at all intersections where there is substantial conflict between vehicle and pedestrian movements. The location of the pedestrian crossing should be selected properly to ensure adequate visibility, sufficient space on footway for the pedestrian to wait and freedom from obstructions. As per current IRC standard the minimum width of the pedestrian crossing should be 2 m and the maximum width should be 4 m and the marking bands should be 0.5 m in width and 0.5 m apart.
2.5.4.5 >>
Box Marking

A **box junction** is a traffic control measure designed to prevent gridlock at busy road junctions. The surface of the junction is marked with a criss-cross grid of diagonal painted lines and vehicles may not enter the area so marked unless their exit from the junction is clear. Drivers MUST NOT enter the box until your exit road or lane is clear. However, one may enter the box and wait when you want to turn right, and are only stopped from doing so by oncoming traffic, or by other vehicles waiting to turn right.

2.6 >>
Traffic calming measures

**Traffic calming measures (TCM)** on roads - such as changing alignment, introducing barriers, etc. - reduce traffic volume/speed. This improves the road safety and livability standards, especially to residential neighbourhoods.

Average reduction in traffic volume using TCMs are indicated in Table 2.8.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>TCM</th>
<th>Avg % reduction in traffic volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Speed Humps</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Speed Tables</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Traffic Circles</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>Narrowings</td>
<td>45</td>
</tr>
<tr>
<td>5</td>
<td>Full Closures</td>
<td>60</td>
</tr>
<tr>
<td>6</td>
<td>Half Closures</td>
<td>80</td>
</tr>
<tr>
<td>7</td>
<td>Diagonal Diversers</td>
<td>90</td>
</tr>
</tbody>
</table>

2.6.1. Full street closures

are barriers placed across a street to completed close the street to through-traffic, usually leaving only sidewalks open. They are good for locations with extreme traffic volume problems and several other measures have been unsuccessful.
2.6.2 Half closures are barriers that block travel in one direction for a short distance on otherwise two-way streets. They are good for locations with extreme traffic volume problems and non-restrictive measures have been unsuccessful.

2.6.3 Diagonal diverters are barriers placed diagonally across an intersection, blocking through movements and creating two separate, L-shaped streets. Like half closures, diagonal diverters are often staggered to create circuitous routes through the neighborhood as a whole, discouraging non-local traffic while maintaining access for local residents. They are good for inner-neighborhood locations with non-local traffic volume problems.

Star diverter and truncated diagonal diverters are improvised forms of conventional diagonal diverters.
2.6.4. **Median barriers** are islands located along the centerline of a street and continuing through an intersection so as to block through movement at a cross street.

2.6.5. **One-way**
When the volume on a particular stretch goes beyond the capacity of road creates congestion and frequent blockades for the traffic flow. In such cases, the traffic is allowed in one single direction.

2.6.6. **Speed humps**
are rounded raised areas placed across the carriageway. The profile of a speed-hump can be circular, parabolic, or sinusoidal. They are generally 3.5 m long and 12 to 15 cm high-speed humps are suggested 5 m ahead on a minor road meeting a major road.
2.6.7. Speed tables
are flat-topped speed humps often constructed with brick or other textured materials on the flat section. The profile of speed tables is trapezoidal. Generally, the top width of the speed table would be around 3 m and bottom width is 6 m. Speed tables are good for locations where low speeds are desired but a somewhat smooth ride is needed for larger vehicles.

2.6.8. Raised crosswalks are speed tables outfitted with crosswalk markings and signage to channelize pedestrian crossings, providing pedestrians with a level street crossing. Also, by raising the level of the crossing, pedestrians are more visible to approaching motorists. Raised crosswalks are good for locations where pedestrian crossings occur at haphazard locations and vehicle speeds are excessive.

2.6.9. Raised intersections are flat raised areas covering an entire intersection, with ramps on all approaches and often with brick or other textured materials on the flat section. They usually rise to the level of the sidewalk, or slightly below to provide a "lip" that is detectable by the visually impaired. By modifying the level of the intersection, the crosswalks are more readily perceived by motorists to be "pedestrian territory". Raised intersections are good for intersections with substantial pedestrian activity, and areas where other traffic calming measures would be unacceptable because they take away scarce parking spaces.
2.6.10. **Traffic circles** are raised islands, placed in intersections, around which traffic circulates. They are good for calming intersections, especially within neighborhoods, where large vehicle traffic is not a major concern but speeds, volumes, and safety are problems.

2.6.11. **Roundabouts** require traffic to circulate counterclockwise around a center island. Unlike traffic circles, roundabouts are used on higher volume streets to allocate right-of-way between competing movements.

2.6.12. **Chicanes** are kerb extensions that alternate from one side of the street to the other, forming S-shaped curves. Chicanes can also be created by alternating on-street parking, either diagonal or parallel, between one side of the street and the other. Each parking bay can be created either by restriping the roadway or by installing raised, landscaping islands at the ends of each parking bay.

Good for locations where speeds are a problem but noise associated with speed humps and related measures would be unacceptable.
2.6.13. Neckdowns are kerb extensions at intersections that reduce the roadway width from kerb to kerb. They "pedestrianize" intersections by shortening crossing distances for pedestrians and drawing attention to pedestrians via raised peninsulas. They also tighten the kerb radii at the corners, reducing the speeds of turning vehicles. They are good for intersections with substantial pedestrian activity and areas where vertical traffic calming measures would be unacceptable because of noise considerations.

2.6.14. A center island narrowing (midblock median) is a raised island located along the centerline of a street that narrow the travel lanes at that location. Center island narrowings are often landscaped to provide a visual amenity. Placed at the entrance to a neighborhood, and often combined with textured pavement, they are often called "gateway islands." Fitted with a gap to allow pedestrians to walk through at a crosswalk, they are often called "pedestrian refuges."

Center Island Narrowing is good for entrances to residential areas, and wide streets where pedestrians need to cross.

2.6.15. Forced Turns: Forced Turn Islands are raised islands that block certain movements on approaches to an intersection. They are good for local street connections to main streets where through traffic volume along the continuing local street is a problem, and main streets where left-turns or through movements out of the side street are unsafe. (Image overleaf)
Table 2.9 emphasizes on various traffic calming measures that should be adopted in hierarchy of urban roads.

<table>
<thead>
<tr>
<th>Road Element</th>
<th>Arterial</th>
<th>Sub Arterial</th>
<th>Collector</th>
<th>Local</th>
<th>Sub Local</th>
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<tbody>
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<td>Parking</td>
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</tr>
<tr>
<td>2 wheelers</td>
<td>Should be avoided</td>
<td>•</td>
<td></td>
<td></td>
<td>Prohibited</td>
</tr>
<tr>
<td>4 wheelers</td>
<td>Should be avoided</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic Calming Measure</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• footpath and bicycle paths need to be adequately separated from the main travel area for safety

* Raised intersection is a physical traffic calming measure in which intersection is raised about 150mm from the road level that effectively cuts the speed there by allowing pedestrian to cross safely in intersections.

Signal Synchronisation

Traffic Control Signals within 1km of one another along major route or in a network of intersecting major routes should be operated in coordination, preferably with inter-connected controllers. However, co-ordination need not be maintained across boundaries between signal systems which operate on different time cycles.

When a signal indicates a stop aspect at a junction, a queue of vehicles is formed behind the stop line. When the signal changes to green, the vehicle starts moving in the platoon. If this platoon is made to meet a green aspect at the next junction, no delay is caused to the vehicles. This principle of linking adjacent signals so as to a secure maximum benefits to the flow of the traffic is called coordinated control of signal. In general, the coordinating of signals is aimed at giving a progressive movement to traffic in a specified direction at a predetermined speed. In practice, it is usually found that about 60 percent of the vehicles are able to clear the intersection in the corridor.
### Table 2.10
**Details of Time, Speed and Distance**

<table>
<thead>
<tr>
<th>Speed (kmph)</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
<th>600</th>
<th>700</th>
<th>800</th>
<th>900</th>
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<tbody>
<tr>
<td>20</td>
<td>18</td>
<td>36</td>
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<td>162</td>
<td>180</td>
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<tr>
<td>25</td>
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<td>29</td>
<td>43</td>
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<td>72</td>
<td>86</td>
<td>101</td>
<td>115</td>
<td>130</td>
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</tr>
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<td>45</td>
<td>54</td>
<td>63</td>
<td>72</td>
<td>81</td>
<td>90</td>
</tr>
</tbody>
</table>

---

### 2.7 Key recommendations for Universal Access on Urban Roads

Universal access for differently-abled citizens – including old people and children – is a critical feature of the road network. Texture, sounds, ramps and special allocations for parking are elements that promote universal access. **Tactile paving** is a system of textured surface on footpaths, stairs and train station platforms that assist the visually challenged. The diagram below shows the tactile paver set into the footpaths.

---

**Image 2.49**
**Tactile pavers on an urban road footpath**

**Key features of tactile pavers**

1. **5 mm** raised strips (as shown in the image overleaf) within the tactile tile.
2. **Tiles** to have a contrasting colour (preferably canary yellow)

3. **Warning** (dot/blistered block refer fig below) strip around obstacles, drop-offs, corners, junctions or other hazards at **300mm** distance around the hazard.

4. **The tactile paving used at pedestrian crossings is blistered** (warning tiles). It should be laid across the entire footpath at a crossing and be **600 mm** wide.
5. A distance of **600 mm** (refer to image 2.51) to be maintained from the edge of footpath/boundary wall/any obstruction.

---

**Key specifications**

a. *At* grade crossings must be provided in pedestrian priority areas and streets, with wheelchair access.

b. *Raised* crossings should be designed with a minimum width of **2.4 m** (as other crossings) and built at the same level as the footway.

c. *Grade separated* crossings should be provided on high speed roads (>30km/h).

d. *If* grade separators provided at a high pedestrian and NMT priority zone (e.g. near to Metro or BRT stations,) the pedestrians and NMT must be kept at grade.

e. *Mid block crossing* must be provided at regular intervals as per the following standards: pedestrian crossing must be provided at all T junctions.

f. *At* grade crossings with wheelchair access must be marked clearly and in detail (at grade/FOB, etc) and should have auditory signals.

g. *At* grade crossings with wheelchair access must be provided in pedestrian priority areas and streets.
g. Grade separated crossings should be provided on high speeds roads (above 30km/h).

h. Provide appropriate crossings with dished kerbs marked with tactile paving.

i. Kerb ramp to be 1200mm wide, minimum 900mm, with maximum gradient of 1:20.

j. Maximum height of the edge of a kerb ramp to be 20 mm.

k. Prevent vehicles from blocking sightlines at crossing.

l. Avoid underground services access covers at crossings.

m. Pedestrian refuges for the disabled and elderly pedestrians on all roads with four lanes or more.

n. Traffic islands and medians should be able to accommodate the length of a pram or wheelchair and pusher. The recommended width is 2 m.

o. At staggered pelican crossings including those without guardrails, two courses of tactile paving to link the two kerb edges to be provided while the rest of the central reserve should be paved normally.

p. Pedestrian crossing dimensions for universal access is listed in the table below:

<table>
<thead>
<tr>
<th>Pedestrian crossing design for universal access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramp slope</td>
</tr>
<tr>
<td>Gutter slope</td>
</tr>
<tr>
<td>Flare slope</td>
</tr>
<tr>
<td>Lip at roadway</td>
</tr>
<tr>
<td>Ramp width</td>
</tr>
<tr>
<td>Landing width</td>
</tr>
<tr>
<td>Cross fall on landing and approach</td>
</tr>
<tr>
<td>Width of tactile warning surface</td>
</tr>
</tbody>
</table>

2. Table Tops and crossing features for universal access

Table Top – road raised to footpath/walkway level at crossing or with leveled or kerb ramp to follow below:

a. 50 – 100 mm in height (no higher than 75 mm on a bus route)

b. Spacing between 70-100 m

c. Typically 4-10 m long (on a bus route, the flat of a speed table should be at least 7 m long, so that the full wheelbase of a bus is on the top at one time).

d. Ramp gradients 1 in 12 to 1 in 20.

e. Suitable for roads used by low floor buses.
3. **Mid block crossings to be provided at regular intervals**

**Residential Areas:**
Spacing Range: Every **80-250 m**
Coordinated with entry points of complexes:
Location of bus/train stops, public facilities, etc.

**Commercial / mixed use areas**
Spacing range: Every **80-150 m**

4. **Crossing design**

The recommended minimum width of a street crossing is **1200 mm**. Central islands may be used to convert 2-way roads into two separate one-way roads, which are easier to cross. Islands can also calm traffic and reduce vehicle speeds. Centre islands should be at least **2 m** wide across the direction of the road to cater for wheelchair users, with a cut through at the surface level of the crossing, at least **5 m** wide along the length of the road.

The safety of a crossing can be significantly improved by extending the footway out across any parking lanes (see image 2.9). This has the triple purpose of reducing the width of roadway to be crossed, slowing vehicular traffic and improving the ability of pedestrians and drivers to see each other. Crossings should be laid out with ample space, especially at the top of the kerb ramp to allow easy passage for pedestrians who are not crossing the road.

It is important to use consistent, predictable standards. For instance, the traffic signal pole should always be on the left (or the right) of the crossing; and the push button at the same height (about **1000 mm** above the ground).
5. Traffic signal cycles
   a. The red phase should keep traffic stopped for minimum 12 seconds for a 7.5 m crossing to allow wheelchair users and aged pedestrians to cross.
   b. Signals to be activated by the pedestrian using a push button box (Pelican signal) at mid-block crossings. The signals have a beep which sounds during the first part of the green phase to indicate when it is safe to cross the road. The push button box should be located consistently at crossings. The push button box should have Braille buttons and raised alphabets for different signals, for example 's' for stop and 'g' for go and so on.
   c. A large diameter (up to 50mm) raised button that can be activated by a closed fist will be usable by most people. Traffic signal poles and push buttons should also be colour contrasted.
   d. At signalized intersections audible signals to be provided to aid visually challenged pedestrians and children.

6. Parking for Accessibility
Where parking is provided, give special allocation to persons with impaired mobility, so they may park their cars as convenient to entrances as possible.
   a. Two accessible parking lots with overall minimum dimension 3600 mm x 5000 mm, should be provided.
   b. It should have the international signage painted on the ground and also on a signpost/ board put near it.
   c. There needs to be directional signs guiding people to the accessible parking.
Arterial x Arterial - 3-leg intersection

Signal Phase Diagram
Sub-Arterial x Arterial - 3-leg intersection

Signal Phase Diagram
Sub-Arterial x Sub-Arterial - 3-leg intersection

Junction Ahead: Pedestrian Crossing
Chevron (0.3 x 0.3 m)

No Stopping
Chevron (0.3 x 0.3 m)

Pedestrian Crossing
Junction Ahead

No Stopping

Junction Ahead: Pedestrian Crossing
Chevron (0.3 x 0.3 m)

No Stopping

Pedestrian Crossing: Junction Ahead

Signal Phase Diagram
INTERSECTION DESIGN SPECIFICATIONS

Collector x Collector - 3-leg intersection

SIGNAL PHASE DIAGRAM
INTERSECTION DESIGN SPECIFICATIONS

Collector x Sub-Arterial - 3-leg intersection

SIGNAL PHASE DIAGRAM
Local x Collector - 3-leg intersection
Local x Local 3-leg intersection
INTERSECTION DESIGN SPECIFICATIONS

Arterial x Arterial - 4-leg intersection

SIGNAL PHASE DIAGRAM
INTERSECTION DESIGN SPECIFICATIONS

Sub-Arterial x Sub-Arterial - 4-leg intersection

SIGNAL PHASE DIAGRAM
Collector x Sub-Arterial - 4-leg intersection

SIGNAL PHASE DIAGRAM
Local x Collector - 4-leg intersection
2.8 Street Fixtures

(Refer plates 21 & 22, Pg 160 & 161)

Apart from carriage way, footpath, R-o-W comprises of above ground street fixtures like, street lighting, signs and signage, traffic signals, bus stops, parking, street furniture, bollards, waste disposal units and fire protection systems.

2.8.1 Streetlights

Streetlights provide night vision and safety for pedestrians and motorists alike. In recent times, the sodium vapour lamps are being replaced by the energy efficient LED lamps. Apart from consumption charges, most of the city corporation spends around INR 600 to 1000 per street light per annum as maintenance cost.

Thumb rule of illumination (refer fig below) generated by a street light on x and y axis is (1 x height) and (3 x height). The number of street lights required for a particular street is calculated by dividing the road length by spacing between each light.

Five types of street lighting is adopted based on the site conditions, they are as follows:

1. Single-sided: Can be used only for local and sub local streets. The mounting height should be kept equal to width of carriage way and should be spaced at 3.5 to 4 times that of height.

2. Staggered: This is the most widely adopted street lighting in urban conditions. By staggering the spacing and mounting it on both sides of the street, the illumination is more even. Staggered streetlights are utilised in roads with three or more travel lanes.
Height of street light should be equals to width of carriage way and should be spaced at $3$ to $3.5$ times height.

3. **Central**: Central mounting is adopted in highways and arterial roads, the major benefit of having lights in the central median is that, more light reaches the carriageway and footways. The mounting height should be $0.8$ times the width of the carriageway and should be spaced at $3$ to $3.5$ times the height.

4. **Opposite**: Adopted in collector or sub-arterial street networks where there is no median. The mounting height should be $0.5$ times the width of the carriageway and should be spaced at $3$ to $4$ times the height.

Table 2.12 indicates the recommended mounting locations for streetlights and their design dimensions based upon the street type. (Also refer images 2.77 - 2.80)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Street type</th>
<th>Recommended</th>
<th>Spacing (in m)</th>
<th>Staging Height (in m)</th>
<th>Drawing type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sub-local</td>
<td>Single-sided</td>
<td>10</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Local</td>
<td>Single-sided</td>
<td>10</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Collector</td>
<td>Staggered/opposite</td>
<td>15</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Sub-arterial</td>
<td>Central</td>
<td>30</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Arterial</td>
<td>Central+opposite</td>
<td>30</td>
<td>$12+6$</td>
<td></td>
</tr>
</tbody>
</table>

2.8.2 >> **Bollards**

(Refer plates 23 & 24, Pg 162 & 163)

Bollards are used in two ways:
To protect pedestrian areas and public spaces from motorised vehicular movement.
To restrict access to heavy duty vehicles into residential areas.
The recommended spacing between bollards is 1.2 m – 1.5 m which is sufficient to deter motorcyclists while allowing wheelchair/prams access.

Waste bins may be provided at every 30 m in commercial areas and may be mounted on adjacent street poles. In residential areas, waste bins are not advisable due to foul smell and leads to mosquito breeding.

In recent times, most Indian cities have adopted household waste collection at the doorstep.
2.8.4 >> Public Toilets

The Ahmedabad BRT paper by CEPT university recommends 1 toilet block at every 1 km. These may be located along collector/sub-arterial roads. Public toilets need to be integrated into the road design such that they are easily accessible and aesthetically integrated with the public environment. The toilets should not be placed on the pedestrian/cyclists’ path.

Provision of space for toilets may be made on R-o-Ws with pockets of extra space, on collector, sub-arterial and arterial roads, and at public spaces of high traffic. This will require an explicit public policy and budget.

2.8.5 >> Fire Protection System
(Refer image 2.75-2.80)

Fire Protection Systems are essential in densely populated areas. Ideally, there should be a dedicated water distribution network system for fire-fighting purposes. However in Indian cities so far, this is not the case, and it is only possible to connect the fire hydrants to the main water supply networks.

Fire hydrants must have two 65 mm (2-1/2-inch) hose outlets and one 115m (4-1/2-inch) suction connection with national standard fire hose threads. Wet-barrel hydrants are preferable in areas where there is no danger of freezing. Hydrants must be aboveground type. Hydrants must be installed adjacent to paved areas, accessible to fire department apparatus. Hydrants must not be closer than 1 m (3 ft) nor farther than 2.1 m (7 ft) from the roadway shoulder or kerb line. Hydrants must be installed with not less than 150 mm (6-inch) connection to the supply main, and valve provided at the connection. Barrels must be long enough to permit at least 450 mm (18-inch) clearance between the centers of the 115 mm (4-1/2-inch) pump connection and grade.
Spacing Requirements

1. **Hydrant** spacing must not exceed 182 m (600 ft) for housing developments without sprinkler protection. Hydrant spacing must not exceed 305 m (1,000 ft) for housing developments with sprinkler protection.

2. **Hydrants** located adjacent to parking areas or bollards must protect other vehicle traffic areas. The bollards must be located so they are not directly in front of an outlet.

2.8.6 >>

Street Furniture

**Street benches** may be housed in utility strips without causing an obstruction for the pedestrians/cyclists at regular intervals where people can rest and interact.

Street furniture and other street design elements that are static (including utility boxes, street lighting, trees, parking, bulb-outs), need to be aligned properly in order to leave adequate clear width for the mobility of pedestrians, cyclists, and motor vehicles.

![Typical design of a street bench](image)

1. **On** a 3 m wide footpath, furniture and amenities should be provided sparingly and along the tree line while maintaining a minimum of 1.5 m clear space for walking.
2. A parking or service lane discontinued in the vicinity of a bus stop provides space for street vending and furniture.

3. On a shared street, furniture can be placed on islands that double as traffic calming elements.

2.8.7 >> Transformers & Electrical RMUs

RMUs, telecom boxes and transformers litter urban roads, hindering all mobility, especially for pedestrians. Out of 28,704 transformers in Bangalore, 22,410 (78%) transformers are located on public roads and footpaths. Urban public utility departments must be legally bound to conform to standards that protect the rights of pedestrians and other road users.
The proliferation of billboards in the urban centres is reaching epidemic proportions and it is important to set up specific standards that regulate the advertisements and hoardings to make the urban public spaces clutter-free. In comparison to the developed nations, India lags far behind in controlling the display of garish advertisements and hoardings despite the fact that most of these are illegal. In western cities, there are severe restrictions and proper control regulations including skyline assessment to safeguard the natural landscape and preserve its natural beauty. Though the revenue generated by the billboards and advertisements cannot be ignored, its contribution to the increasing visual pollution and related traffic hazard is of serious concern. Thus it becomes imperative to develop design standards for all public advertising that takes the following into consideration:

1. **Zone wise demarcation of the city and specifying the type and size of advertisements that can be displayed in a particular zone.** Areas of special historic and architectural interest, institutional areas and public parks should be devoid of any advertisements.
2. **The size, design, location and degree of illumination of advertisements should take into consideration the character of the area so that the advertisements do not adversely affect the visual appeal of the area.**
3. **Restriction should be imposed in displaying advertisements on R-o-Ws and traffic junctions/circles that can pose a serious pedestrian/traffic hazard.**
4. **The illumination arrangement of the advertisements should not cause any disturbance to traffic.** Bright glaring and blinking advertisements should be restricted near traffic junctions or places where they can cause a visual distraction to drivers.
5. **Procedure should be developed for proper skyline assessment, as done in the western cities, to define a rationale for permitting advertisement and hoardings.**
6. **The advertisements displayed should be maintained in a proper and safe manner.**
7. **Illegal hoardings should be removed and only those permitted by the Corporation should be allowed to be displayed.** In Indian cities,
the number of illegal hoardings far exceed the ones that are permitted, thus this requires removal of the illegal hoardings in a phased manner.

8. Penalty clauses should be specified in the standards and any violation to the standards should be heavily fined.

While the specific standards are left to each municipality to devise, the following specifications may be used by the municipality to assess the applications for the erection of advertising signs:

1. Advertising signs are not permitted in areas where they are likely to cause a visual distraction to motorists, obscure or compete with road signs, interfere with sight lines or detract attention at a junction.
2. The erection of advertising signs and free standing hoardings are not permitted on the major urban routes.
3. Signs are not generally permitted in residential areas, on or near buildings of historic/architectural merit, in amenity areas or where they could interfere with protected views.
4. Signs, which are attached to buildings, are preferable to those on free-standing hoardings. Box type signs are prohibited and spotlighting is in general more acceptable than internal illumination.
5. Advertising signs should be sympathetic in design and colour both to their surroundings and to the buildings on which they are displayed.
6. The size and scale of advertising signs should not conflict with existing structures in the vicinity. Signs should not interfere with windows or other features of a façade or project above the roofline.
7. Signs should be integrated with the streetscape and not be visually intrusive or numerous.
8. Signage above first floor sill level should be severely restricted to avoid clutter.
9. All external lighting should be subdued and directed away from the public roadways.

### 2.8.9 >> Traffic Signage

(Refer plates 55 & 26, Pl 164 & 165)

Traffic signs for India are prescribed in Motor Vehicles Act, 1988. State governments are responsible to install traffic signs as prescribed in the act.

**Importance of traffic signs:**

1. **Road safety rules.**
2. **Speed and direction of movement allowed**
3. **Warnings of potential hazards**
4. **Destination, direction and distance to destination.**
Commonly used signs and markings:

Some of the important commonly used signs, as per IRC:67-2001, are listed below:

1. **Mandatory / Regulator Signs**: The most recognizable sign on any road is the stop sign. The sign is always bright red and octagon-shaped. It is generally positioned at intersections, and drivers are required to come to a complete stop behind the line or crosswalk that it protects. Pedestrians have the right-of-way at a stop sign.

   - ‘Stop’ and ‘Give Way’ signs
   - ‘No Parking’ and ‘No Stopping’ signs
   - ‘Speed Limit; and Vehicle Control’ signs
   - ‘No Overtaking’ signs
   - ‘Compulsory Direction Control and other signs

A yield sign is a triangular sign with the word "yield" lettered on it on a white background. It is placed at an intersection at which a driver is not required to stop, but instead must proceed cautiously. Yield signs are also placed at the point where cars merge onto the freeway. STOP or GIVE sign to be located at the point where vehicle is required to stop or as near it as possible, approximately 1.5 m - 3 m. Where there is a pedestrian crossing the stop sign is to be erected 1.2 m in advance of the pedestrian crossing or stop line.
2. **Cautionary/warning signs**: Warning signs are placed at different places on the road to let drivers know of an upcoming change in driving conditions. These signs are shaped like a diamond and provide instruction regarding a change in the speed limit or a sudden curve in the road. These signs serve to warn drivers, but they do not regulate any specific action.

- Curve signs
- Narrow Bridge / Narrow road
- Road widens
- Gap in median
- Pedestrian crossing
- School
- Men at work
- Cross road / side road
- T-Intersection / Y-Intersection
- Major road ahead
- Roundabout
- Unguarded Railway Crossing
- Speed Breaker
- Reduced carriageway

Usually the warning signs should be placed at the distance of 50 m in advance from the intersection. Junctions where additional emphasis is required because of high speeds and/or high accident rates, warning signs may be located at 200m distance in advance.
3. **Informatory Signs:**
Signs that convey messages of information, guide motorists with landmarks and directions to destinations.

a) **Direction and place identification signs**
Advance direction signs
Destination sign
Place/City identification

b) **Facility Information signs**
Public telephone
Filling Station (Petrol Pump)
Hospital
Resting Place

c) **Other useful information signs**
Airport
Bus stop

The general color scheme for the traffic signs shall be as mentioned in **IS:5.** The colors shall be durable and uniform of an acceptable hue when viewed in daylight or under normal headlights at night. (Refer to IRC 67 or BATF/BBMP road signage manual 2000.)

<table>
<thead>
<tr>
<th>Sl.no</th>
<th>Colour</th>
<th>Standard</th>
<th>Particular</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Blue</td>
<td>No. 166: French Blue</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Red</td>
<td>No. 537: Signal Red</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Green</td>
<td>No. 284: India Green</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Orange</td>
<td>No. 591: Deep Orange</td>
<td></td>
</tr>
</tbody>
</table>

ii. **Location of Traffic Signs**

The signs shall be so placed that motorists and pedestrians can recognize them easily and in time. Normally the signs shall be placed on the left hand side of the road. As per the IRC standards, the signs should be erected not less than **60 cm** away from the edge of the kerb in case of kerbed roads and at a distance of **2-3 m** from the carriageway edge in case of unkerbed roads. Mounting height suggested is **1.5 m** for unkerbed roads and **2 m** for kerbed roads.

The signs shall be so placed that they do not obstruct vehicular traffic on the carriageway, and if placed on the shoulder/footpath/refuge island, should not obstruct pedestrians.
iii. Orientation of Signs

The signs shall be placed at right angles to the line of the approaching traffic. Signs relating to parking of vehicles and stop signs are to be placed at an angle between 30 and 45 degrees to the direction of traffic flow while ensuring there is no glare effect. On horizontal curves, the signage is to be determined with regard to the course of the approaching traffic.

Signage faces may be tilted upward/downward at road gradients visible to approaching traffic.

iv. Traffic control and surveillance cameras

Many developed countries use surveillance camera systems to capture public miscreants involved in illegal action/crime. These surveillance camera systems also serve to capture traffic violations, unusual events and occurrences. Traffic Management Centres (TMC), run by the traffic police, are vital centres to monitor, evaluate and redirect traffic flows. TMCs are linked to a network of surveillance cameras strategically placed at road intersections, high traffic/accident areas, public gathering space, etc.

Electric wiring and supply is a key requirement for continuous data flow and this can be linked to the traffic light network where possible.
The 4 key networked utilities that run alongside the road network in main trunks, distributor arteries, and last-mile links, are: water, drainage, sewage, and power. To these four key utilities is added the ICT network termed as the fifth utility. In some countries, cooking and heating gas supply is provided through a networked utility. In India, however, this is not a common practice.

Urban roads are constantly cut up by various agencies installing or servicing these networks. Given this peculiar vulnerability of roads, there are two interventions recommended:

1. **First**, to provide dedicated space and easy access to below-grade utilities;
2. **Second**, to specify road surfaces that facilitate easy repair and maintenance. (see table 2.13)

<table>
<thead>
<tr>
<th>Road type</th>
<th>Expected frequency of cuts to road</th>
<th>Recommended Surface</th>
<th>Ease of maintenance to servicing network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-local</td>
<td>High</td>
<td>Cobble-stone</td>
<td>Good, low cost</td>
</tr>
<tr>
<td>Local</td>
<td>Very high</td>
<td>Cobble-stone</td>
<td>Good, low cost</td>
</tr>
<tr>
<td>Collector</td>
<td>Moderate</td>
<td>Asphalt</td>
<td>Fair, mid-cost</td>
</tr>
<tr>
<td>Sub-arterial</td>
<td>Low</td>
<td>Asphalt/Concrete</td>
<td>Difficult, high cost</td>
</tr>
<tr>
<td>Arterial</td>
<td>Low</td>
<td>Concrete</td>
<td>Difficult, high cost</td>
</tr>
</tbody>
</table>

Table 2.13 >> Road types and recommended surfaces
2.9.1 Sewer/Drainage, Water Supply Lines

Sewage lines are to be laid at a substantial depth below grade and ideally located away from water and rainwater drainage networks to avoid accidental contamination.

Sewer and drain lines are to be laid at an appropriate incline that encourages gravitational flow from local to trunk lines within the networked hierarchy.

Water lines are maintained under pressure and are to be laid away from the road traffic areas so as to avoid damage to the surface due to any leakages.

The Indian Roads Congress (IRC: 98-1988) recommends a depth between 2.0 m to 6.0 m for a 'trunk sewer line' and a depth of 1.0 m to 1.5 m for a 'trunk water line' and 0.6 m to 1.0 m for 'service water line'.

Roads also serve as a channel for rainwater directing it into shoulder drains below the footpath leading to the side drains which then directs the water through culverts below the road surface and then onto the main storm water drains.

It is important that rainwater is properly channeled away from the road surface since water erodes the bitumen surface of the road creating damage and potholes. The kind of inlet that is required for a particular area needs to be arrived at after detailed hydraulic design for the road. Once the storm water is collected from the street surface by an inlet, it is directed into the storm water drainage system. The storm water drainage system comprises of laterals, main trunk, outfalls and other appurtenances. The storm water thus collected must be protected from contamination of urban waste and open...
sewage let into these storm water drains and only then discharged into lakes.

Water lines are no longer to be located under road surfaces since they need frequent access for repairs and maintenance. Instead, a dedicated space must be earmarked by the side of the traffic area alongside the drain with access points at valves and line junctions. 

2.9.1.1 >> Swales

Swales are linear depression of channels that provide for stormwater collection and conveyance. Swales may simply be grass-lined or more densely vegetated and/or landscaped. They direct stormwater across grass or similar ground cover and through the soil, slowing the movement of water.

Swales can reduce storm water run-off volumes and peak flows. Grass or other vegetation (such as rushes) is used to carry out this function. Examples of swale use are in road medians and verges, car park run-off areas, parks and recreation areas. Swales are simple to maintain and can fit well in any urban design.

The length of the swale is generally equivalent to that of the contributing impervious area. The runoff enters the dry conveyance swale as lateral sheet flow and the total contributing drainage area cumulatively increases along the length of the swale.

Bores or aquifers may also be set at regular intervals along the swale trench. A portion of the filtered stormwater may be conveyed to these aquifers and stored beneath the site for subsequent reuse for landscape irrigation.
Swales are recommended beyond 48m width of the road. It must be provided all along the length of the road, however the components of the swale need proper design and planning. Following are the components of a swale:

1. **Inflow points**: Stormwater flow entry, via pipe outlet or surface runoff
2. **Side Slopes**: Total channel width. Slope less than 4:1 for mower access and to prevent scour
3. **Channel Base**: Low flow path, may have gravel or rip rap reinforcing to prevent erosion
4. **Underdrain (if present)**: Usually perforated pipe buried under channel to capture filtered flow and connected to stormwater system
5. **Plants and soil**: Grass or other low lying plants in permeable soil for filtering stormwater
2.9.2  >>  Electricity

Electricity cables are of different types, Low Tension (LT) cables and High Tension (HT) cables. These cables should be located away from water supply lines, ICT lines and trees to prevent short circuits, electrical interference and damage by tree roots. The width of electrical ducts will vary between 0.7 m to 1.1 m depending on the number of cables they are meant to house. They must be laid at a minimum depth of 0.65 m up to a depth of 1.1 m with a minimum earth cover of 0.65 m.

Overhead, high-risk HT cables must be placed with care, away from pedestrians and traffic areas ideally over medians and along the side of the road network with restricted access to the land below.

2.9.3  >>  Gas Pipelines and those carrying combustible materials

Pipes carrying combustible materials should be located far away from electricity cables and sources of heat. The Indian Roads Congress (IRC) recommends laying of such pipe lines at a depth of 2.0-3.0 m in IRC: 98-1988 with the following technical specifications:

1. The pipelines are generally to be laid at a depth of 1.2 m in the form of steel pipes having a diameter of 12 inches to 16 inches.
2. The life of these pipes is around 30 years and should be replaced after that.
3. Optical fibers are laid in the trench along with the gas pipelines to monitor the gas supply network.
4. Isolation valves are provided at every 2.5 km for maintenance, so that the particular stretch could be isolated from the rest of the network for maintenance purpose.
5. There is a future proposal for the isolation valves to be operated through remote control from a central control station.
6. Gas lines may be laid below the existing utilities.
7. Distribution lines from the trunk lines are made of Polyethylene and have a pressure rating of maximum 26 bars.
8. Gas lines should not be laid parallel to High Tension (HT) lines. In case HT lines are in the proximity, the gas pipe lines are at a minimum
case HT lines are in the proximity, the gas pipe lines are at a minimum of 400-500 mm away from the HT lines.

9. The trench size required to be dug for laying gas lines is **300 mm x 300 mm**.

10. An RCC utility duct **300 mm x 300 mm** in size is usually provided to cross lines beyond an existing roadway.

The optical fibres are conventionally laid down by two methods:

The **conventional trench method** is used to lay OFC cables below sandy surface, away from the main carriageway. The trench is usually 1.65 m below the road surface, with minor variations in depth because of local site conditions.

The **direct buried cables (DBC)** are laid at a depth of 165 mm below the road surface. The cables are laid in a continuous stretch with access provided at every 4 km for service requirements. Within each 4 km stretch, pool boxes at a distance of 1 km spacing provide access to the OFC lines.

IRC-98 guidelines emphasize the need for constructing ducts to place networked utilities below the road surface. The IRC guidelines recommend advanced planning to earmark the position of each utility line expected along the road, and to provide space in a manner such that work on any utility does not interfere with other services or the safe functioning of the road.

While forming new layouts the concept of common utility duct or multi utility duct is recommended, based on the type of road; the RCC duct size and prevailing conditions. These ducts are to be laid at the outer edges of the travel lane area. The recommended depth for the utilities are provided in Table 2.14.
Ducts are designed based on number of variables like, topography, type of road, footpath width, type of soil, available slope, etc. A quick schematic reference for below-grade utilities is shown in the Image 2.75 and organised by the classification of urban road types.
Image 2.76 >>
1m wide footpath
Utilities – SWD, Power line, OFC, local water supply, sewer line

Image 2.77 >>
1.5m wide footpath
Utilities – SWD, Power line, OFC, local water supply, sewer line

Note: the utilities guidelines for each side can be mixed and matched to the width of the footpath on the ground
Image 2.78 >>
2m wide footpath
Utilities – SWD, Power line, OFC, local water supply, sewer line

Image 2.79 >>
2.5m wide footpath
Utilities – SWD, Power line, OFC, local water supply, sewer line

Image 2.80 >>
3m wide footpath
Utilities – SWD, Power line, OFC, local water supply, sewer line
Finland, London, Amsterdam have shown progressive leadership in addressing the issues of networked infrastructure for their cities by constructing an entire underground tunnel system for these networks below the road surface. Such a dedicated system of corridors beneath the R-o-W provides space for all utility networks and ease of maintenance for individual service providers of: water, sewage, electricity, storm water, ICT and gas. Depending on the site specifications and the need, such corridors can vary in dimension. Precast elements laid at a minimum depth of 1.2 m below the road surface are generally used. The corridors have a gallery arrangement where cables and pipelines are vertically stacked and mounted against the walls. Ducts are provided for individual plots as last-mile connectivity thereby dramatically reducing any need for digging up the road surface for new connections.

Special scenario: Water Line and Sewer mains on same side. In such cases, precautions need to be taken by constructing RCC separator walls.

(Refer plate 33, Pg 172)
### R-o-W Design Plates

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Table 3.1 >> R-o-W allocation for existing roads: All dimensions are in meters

- T: Typical R-o-W for new urban roads;
- *BRTS on Sub Arterial Road is an option that can also be utilized as a dedicated bus lane*
- *Road widths mentioned above are excluding medians.*
- *Travel lane includes Service lane.*
- *Alt = Alternate Parking*
**2m, 3m, 5m - Sub-local Roads**

**NOTE:** 2 to 5 m wide RoW as per space availability, with shared access for pedestrian, bicycle. Motorised traffic access restricted to two and three wheeler vehicles.
6m LOCAL ROADS

- Footpath
- Cycle lane
- Parking
- Travel lane
- BRTS/LRTS
- Landscape

6.986 in

2.0  3.0  1.0
6.0
10m Local road without parking (typical)
10A m  Local road with parking

- Footpath
- Cycle lane
- Parking
- Travel lane
- BRTS/LRTS
- Landscape

(fp par tl fp)
i. Travel lanes: 6m wide travel lanes for traffic flow.
ii. Pedestrians: 2m wide footpath on either side with a cross fall of 2.5%.
iii. Cyclists: travel lanes may be used by cyclists as well, with adequate traffic calming measures for safety.
iv. Parking: 2-wheeler and parallel car parking on one travel lane as desirable.
v. Landscaping: Any extra RoW width to be utilized for upgrading the experience of the road with appropriate hardscape and landscape.
21 m Collector

- Footpath
- Cycle lane
- Parking
- Travel lane
- BRTS/LRTS
- Landscape

1. Travel lanes: 12m wide travel lanes
2. Public Transport: local and feeder bus service
3. Parking: restricted timing, alternate side parallel parking
4. Pedestrians: 2m wide footpath on either side with a cross fall of 2.5%, pedestrian crossing at every 250m-300m distance.
5. Cyclists: 2m wide cycle track on either side, level with travel lanes. Median of 0.25m to divide travel lane and cycle tracks
6. Landscaping: All extra RoW width to be utilized for upgrading the experience of the road with appropriate hardscape and landscape.
30m Sub-Arterial Roads (Typical)

i. Travel lanes: 11m wide travel lanes for traffic flow and extreme ends for slow moving vehicles and buses.

ii. Public Transport: 8m wide space provided in the centre of R-o-W to accommodate BRT/LRT. Stops may be provided at every 1.5km - 2km distance. Station width could range from 3m – 4m (refer BRT drawing sheet).

iii. Parking: On street parking to be avoided on high traffic sub-arterial roads.

iv. Pedestrians: 3.0m wide footpath on either side with a cross fall of 2.5%. If the sub-arterial road is passing through dense urban settlements, pedestrian crossing to be provided at every 250m-300m distance. Underpass crossing with ramps is preferred, providing pedestrian comfort.

In urban fringe where access is controlled, pedestrian crossing to be at 500m distance.

v. Cyclists: 2m wide cycle track, at level with travel lane. Median of 0.5m to divide travel lane and cycle tracks.

vi. Landscaping: A utility strip of 0.5m-0.7m to house shrubs and street furniture. All extra RoW width to be utilized for upgrading the experience of the road with appropriate landscape.
48m Arterial Roads with service lane (Typical)

1. Travel lanes: 22 m wide travel lanes with extreme ends for slow moving vehicles and buses. Service Roads of 11 m provided on either ends for local traffic and access.
2. Public Transport: 8 m wide space may be provided in the centre of R-o-W for future needs of mass rapid transport systems, like, Bus Rapid Transit, Metro Rail, Light Rapid Transit and dedicated bus lanes.
3. Parking: Service roads may be utilized for parking if so desired as well as for repairs and emergency stops.
4. Pedestrians: 2.5 m wide footpath on either side with a cross fall of 2.5%. If the arterial road is passing through dense urban settlements, pedestrian crossing to be provided at every 250m-300m distance. Underpass crossing with ramps is preferred, providing pedestrian comfort. In urban fringe where access is controlled, pedestrian crossing to be at 1000m distance.
5. Cyclists: 2.5 m wide cycle track on either side.
80m Arterial Roads

- Footpath
- Cycle lane
- Parking
- Travel lane
- BRTS/LRTS
- Landscape
Traditional system of road drainages still serving the ancient city - Cusco, Peru

DESIGN DETAIL PLATES
PLATES

Plate 1 - BRTS Station
Plate 2 - Bus Stop
Plate 3 - Bus stop
Plate 4 - Bus bay details
Plate 5 - On-street Car parking
Plate 6 - Parking Details - Bicycle
Plate 7 - Parking Details - Bicycle
Plate 8 - Parking Details - Two-wheeler
Plate 9 - Utility strip/Planting strip details
Plate 10 - Signal location in an intersection
Plate 11 - Multi-use Pole Dimensions
Plate 12 - Road Directional Markings
Plate 13 - Arrow road markings
Plate 14 - Chevron road markings
Plate 15 - Centre line Marking
Plate 16 - Details of edge line marking
Plate 17 - Details of edge line marking
Plate 18 - Lane marking
Plate 19 - Street fixtures
Plate 20 - Drop kerb
Plate 21 - Street light
Plate 22 - Street light embed with bin
Plate 23 - Bollards
Plate 24 - Bollards - details
Plate 25 - STOP Sign
Plate 26 - NO ENTRY Sign
Plate 27 - Tree grating
Plate 28 - Kerb details
Plate 29 - Below grade utilities snapshot
Plate 30 - Manhole details
Plate 31 - Manhole details
Plate 32 - Horizontal grating details
Plate 33 - Precast ducts for utilities
1 - BRTS STATION

Note:
All dimensions are in metres.

Ahmedabad BRT Station

Pedestrian Crossing at Ahmedabad BRT Station
Refer Section 2.2.2

Note:
All dimensions are in metres.
5 - ON-STREET CAR PARKING

 Maneuvering width required for 30 parking

Note: All dimensions are in metres
6 - PARKING DETAILS - BICYCLE

Plan View

Front View

Side View

Detail A

1. Steel channels (C6 x 8.3) Bolted to sidewalk with anchor bolts (2 bolts per channel)

2. 2" x 2" x 2.5" Bent square steel tubing

See detail A
7 - PARKING DETAILS - BICYCLE

Bicycle Lane Symbol

Directional Arrow

Bicycle pavement marking

50 mm (2 in)
150 mm (6 in)
125 mm (5 in)

600 mm (24 in)
50 mm (2 in)
150 mm (6 in)
250 mm (10 in)
Details of Planting/Utility Strip

Image showing Planting Strip on Walton Road

Refer Section 2.4.3
Sectional View of Signal Pole

Dimensions are in mm unless otherwise specified.
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Source: Invicus Engg
Dimensions are in mm unless otherwise specified.
Diagonal Markings

Chevron Markings

Dimensions are in mm unless otherwise specified

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3.05 R.o.W DESIGN STANDARDS

15 - CENTRE LINE MARKING

Refer Section 2.5.4.3

Above Grade Street Fixtures

Beyond intersections

At intersections
2 - Lane

4 - Lane with median
At median openings

Sharp curves (<230 m radius)(No overtaking zone)
3.3 R-o-W DESIGN STANDARDS

18 - LANE MARKING

Refer Section 2.5.4.3

Dimensions are in mm unless otherwise specified.
Dimensions are in m unless otherwise specified.
21 - STREET LIGHT

Height = Width of Travel lane

1.5m

1 x height

Travel lane = 6m

Right of way - 9m

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<td>3</td>
<td>Collector</td>
<td>Staggered/Opposite</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>Sub-arterial</td>
<td>Central</td>
<td>30</td>
<td>12</td>
</tr>
<tr>
<td>5</td>
<td>Arterial</td>
<td>Central + opposite</td>
<td>30</td>
<td>12+6</td>
</tr>
</tbody>
</table>
Light pole embedded with a waste bin and space for flower & plants
Bollards should be visibly distinguishable from adjoining surface.

Bollards placed to restrict other vehicles entering bicycle track in Pune.
24 - BOLLARDS DETAILS

Classic Bollard

Light Bollard

Victorian Bollard
(source: www.streetfurniture.net)

Reflector Bollard
(source: www.nolandgrab.org)
Note:
All dimensions are in mm
Note: All dimensions are in mm.
27 - TREE GRATING

Note: All dimensions are in inches

Image showing a tree grating on a commercial corridor
Footpath

20 mm sand:cement
Molar bedding
Use M20 grade concrete

Cast at site plain
Use M15 grade concrete

Note:
All dimensions are in inches

Image of kerb embedded with horizontal storm water inlet
Note:
All dimensions are in metres
30 - MANHOLE DETAILS

Note:
All dimensions are in mm
31 - MANHOLE DETAILS

Inlet Cover Plan

10 mm Ø holes (1 min)

10 x 65 recess (see section of cover through recess)

Note: All dimensions are in mm

SECTION C-C
Frame and Cover section
Cross-section of Horizontal Grating

Plan of Horizontal Grating

Note: All dimensions are in mm

See image overleaf
33- PRECAST DUCTS FOR UTILITIES

Below grade utilities

Refer Section 2.9.4

Underground utility access grills
New York

Underground utility, Europe

150mm TYP

GL

3.0m

GL

1.5-2.0m

150 TYP

Power Cables

Water supply

OFC/ICT
Road composition comprises of layers of sub grade, granular sub base, wet mix macadam, dense bituminous macadam and bituminous concrete. The methodology and process of laying these layers are standardized by MoRTH. The table 4.1 gives general depths of the composition layers based on types of urban road. However, the numbers shown below vary based on traffic load conditions and the California Bearing Ratio (CBR), value of soil (refer to annexure vii for detailed information). Any new road should be laid layer by layer for longevity. Maintenance should be carried out once in 5 years thereafter, that requires laying of another course of BC. If the sub-grade is not laid properly, it results in rutting, hair cross and deformation occurs on the road surface.

<table>
<thead>
<tr>
<th>Serial Number</th>
<th>Road components</th>
<th>Arterial Road (depth in mm)</th>
<th>Sub-Arterial Road (depth in mm)</th>
<th>Sub-Arterial Road (depth in mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Earthwork Excavation (excluding drain works)</td>
<td>700-925</td>
<td>700-865</td>
<td>700</td>
</tr>
<tr>
<td>2</td>
<td>Sub grade</td>
<td>500</td>
<td>200-300</td>
<td>500</td>
</tr>
<tr>
<td>3</td>
<td>Granular Sub base</td>
<td>200-250</td>
<td>200</td>
<td>200-260</td>
</tr>
<tr>
<td>4</td>
<td>Wet mix macadam</td>
<td>200-250</td>
<td>150-200</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>Dense Bituminous macadam</td>
<td>120</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Bituminous concrete</td>
<td>40-50</td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.1>> Components for Arterial, Sub-arterial and Collector Roads

<table>
<thead>
<tr>
<th>Serial Number</th>
<th>Bituminous concrete</th>
<th>Local Road (depth in mm)</th>
<th>Sub-local Road (depth in mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Earthwork Excavation</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>2</td>
<td>Metalling followed by a tac coat</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>Bituminous macadam</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>Semi dense bituminous concrete</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

The above mentioned details are meant for new developments where roads are being laid fresh. For the existing roads either re-metalling or overlays are appropriate. The use of cobblestones and pavers for travel lane surfaces on low traffic residential roads, is highly desirable for ease of restoration and maintenance (refer table 2.13, page 94).
4.1 >>
Re-laying process for existing roads

4.2 >>
Process and Specifications for laying new road - Bituminous

---

a) The old road surface should be roughened with pick axes before spreading the new metal. All dirt, dust, animal dropping, vegetation, etc., should be removed from the surface. Normally, there will be a thin crust of hard metal on the existing road and scarification would not be possible. So criss-cross lines are to be made with pick axes for the full width of the road diagonally - i.e., at about 450 to the centre line. These may be at 30 to 40 cms intervals and about 40mm deep. These lines are the key to proper bonding between the existing and the new materials.

b) Sometimes, it becomes necessary to scarify the entire existing road and screen the metal removed. Chips from 20mm downwards are spread over the sub-grade so that a thick cushion is formed under the metal. It is then watered and the old metal is spread and managed in order to get the bigger metal to the top surface. New metal is now added and compacted. It may be observed that compaction is achieved very quickly as the base is wet and graded metal is used. Earth from the base fills up the interstices. Screenings may now spread over the surface and thoroughly watered and allowed for 24 hours before providing a final round of rolling. Traffic may be allowed on this surface only after two or more days.

An overlay is meant to restore or increase the load carrying capacity or life, which restores the riding quality of the pavement which might have suffered rutting and other deformations.

An overlay is meant to restore or increase the load carrying capacity or life, which restores the riding quality of the pavement which might have suffered rutting and other deformations. The overlay is not considered as a part of the periodic maintenance work, but it is an effort in the rehabilitation or strengthening of the road. Bituminous overlays on the existing black topped surfaces is the common practice in the country as these provide amenability to stage construction, is cheaper, and results in very little traffic dislocation. The alternatives available to make up for the additional thickness required are the following: (a) adding WBM over the existing bituminous surface and finishing; (b) making up the deficiency of thickness by ‘built up spray grout’ and finishing with bituminous surfacing; (c) providing an additional bituminous layer directly on the top of the existing surface and (d) providing cement concrete overlays (white topping).

---

a. Earth Work
Excavation of earth needs to be carried out as per drawing and technical specification Clause 305.1, including setting out, scrapping/scarifying for top existing road surface (bitumen, metal surface), excavation for foundation, construction of shoring and bracing, removal of stumps and other deleterious materials, multiple handling and disposing away entire excavated earth
away/debris from the site to designated areas by local authorities, including all lead and lifts, dressing of sides and bottom, and backfilling with approved material, dewatering if required as per direction of the engineer-in-charge. This excavation must also includes (arterial, sub-arterial and collector roads) for ‘H2’ type inlet, ‘BB’ type inlet, ‘DIL’ type inlet, storm manhole, sanitary sewer manhole, telecommunication ducts, telecommunication ditches, road and high tension cable ditch works.

**Note:** Type of inlets mentioned here are for reference, it varies from site to site. Reference – MoRTH No.300

---

**Section 4.1: Detail Earth-work excavation**

b. **Sub-grade**

Preparing sub base by compacting of original ground with maximum of 6 passes of 8 to 10 tonnes power roller including filling depression occurring during rolling, cost of all labour, machinery etc. complete as per specs.

---

Reference - MoRTH Specification No. 401

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c. **Granular sub-base**

Providing and laying of granular sub-base (GSB) of **200mm** thick using good quality graded materials from approved source and mixed in the specified proportion, filling to be carried out by breaking clods, removal of roots and other organic materials, stacking and mixing in the specified proportion, spreading after mixing to required camber, leveling, watering with all leads to obtain moisture levels of mix as per codes at the time of compaction, and compacting each layer to obtain the required modified proctor density. The rate should include the cost of earth, compaction by rollers and water, cost
of all labour, hire, fuel charges, all tools and plants, and all lead & lift and other incidental charges etc. complete as per drawing and technical specifications.

Section 4.3: Detail for granular sub-base

d. Wet-Mix Macadam:
Providing, laying, spreading and compacting to the required line camber level using graded stone aggregate wet mix macadam (wmm) of 200 mm thick as per specification including cost of all materials, laying uniform layer of base course, on a well prepared sub-base, and compacting with power roller to achieve the desired density, and with all lead metals sand and other materials, loading, unloading, stacking, spreading, etc., complete with all lead for the mix to the work spot as per specifications.

Reference - MORTH
Specification No. 406

Section 4.4: Detail for wet-mix macadam

e. Dense Bituminous Mix Macadam
Providing, laying and rolling with vibratory roller of built – up spray grout layer over prepared base consisting of a two layer composite construction of compacted crushed coarse aggregates, using motor grader for aggregates. Key stone chips spreader may be used with application of bituminous binder after each layer, and with key aggregates placed on top of the second layer to serve as a base conforming to the line, grades and cross – section specified, the compacted layer thickness being 120 mm complete as per specifications.

Reference - MORTH
Specification No. 406
f. Semi-dense Bituminous Concrete

Providing and laying semi dense bituminous concrete 25mm thick with 100-120 TPH batch type HMP, producing an average output of 75 tonnes per hour using crushed aggregates of specified grading, premixed with bituminous binder at 4.5 to 5% by weight of total mix and filler, transporting the hot mix to work site, laying with a hydro-static paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction.

4.3 >>
Process and Specifications for laying new road – Cement Concrete

For concrete roads, a layer of Dry Lean Concrete is to be provided over compacted earth on top of which M40 grade Cement Concrete is to be laid. A 150 micron thick Plastic sheet is to be laid over the quarry dust surface spread completely on the Road surface before laying concrete.

g. Ready Mix Concrete

Providing & laying M30 grade 300 mm thick Ready mix controlled reinforced cement concrete, conforming to grades as specified in (IS 456 - 2000) as per specifications using 20mm down size aggregates at all levels including necessary shuttering, scaffolding, pumping, compacting with vibrations, curing. The rate is to include for providing construction joints, providing expansion joint of 25mm thick. Bituminous filler board and sealing joint with sealing compound as specified,
laying to required size and slope, MS rod for expansion/construction joint dowels, including PVC pipe complete. Alternate panels shall be concreted, panels sizes has to be approved by consultants.

h. Reinforced Cement Concrete
Providing & Fabricating reinforcement for R.C.C. in all items. Work to include transporting, decoiling, cutting, straightening, bending and placing in position at all levels & binding, with approved gauge binding wire. The rate should include cost of binding wire, chairs, spacers which will not be measured separately for payment, providing & placing CM cover blocks of suitable size to ensure specified cover to main reinforcement etc., complete all as per design, specifications, with all lead & lift for all materials & labour as directed, at all heights & locations. Quantity of steel as per drawing and with authorised overlaps only shall be measured and paid for. Contractor must prepare bar bending schedule and fabrication shall be carried out as per bar bending schedules.

4.4 >> Specifications for other items

a. Plain Cement Concrete Kerb
Providing and laying of precast concrete kerbs 914 x 315 x 150mm high in M20 Grade P.C.C on M-15 Grade foundation using 20mm aggregates, 150mm thick foundation and side support concrete laid manually as per drawings upto the required profile as per drawings including excavation, backfilling, form work, curing, including cost of all materials, labour, hire charges of machinery, loading, unloading, lead, lift, transporting, etc.

Reference - MORTH
Specification No. 500.7

b. Construction of Manholes
Miscellaneous items of construction and finishing for the all types of inlets and manholes for storm system as per engineering drawings provided by the engineer in charge or consultant, and specifications excluding concrete and steel but including cost of all required materials, labour etc., completed as per the detailed drawings. Supply and
construction of manhole (on existing sewer or new sewer) up to a depth of 2000mm-4000mm with CBW (1:3) chamber of sizes mentioned below and 1400 mm length with circular shaft of brickwork (1:3), 275 mm thick RCC (M15) base slab placed over a layer of brick flat soiling including M20 grade doubly reinforced RCC cover slabs 200 mm thick over chamber and 150 mm thick over shaft; having an opening for the manhole, formation of chamber at the invert with PCC (1:2:4) finished with 1.5 mm thick net cement finish over 15 mm thick plaster in cement and mortar (1:3) on all internal faces, including supplying, fitting and fixing of safety chain (for pipe dia 800 mm and above) and 600 mm dia clear opening (HD20) 20 empty capacity RCC manhole cover with frame as per IS12592, packed around with PCC 1:2:4, including shuttering, reinforcement, dismantling road crust, excavation in any kind of soil, with shoring and dewatering as required, back filling with consolidation, disposal of spoils-surplus earth as directed by the engineer.

c. Construction of Chambers
Miscellaneous items of construction and finishing for the all-access chambers for the telecommunication network and high tension cable system as per engineering drawings and specifications, excluding concrete and steel but including cost of all required materials, labour etc., completed as per the detailed drawings.

d. Construction of cross drains
Providing and fixing MS grating (max weight : 15 kg/sft) for all cross drains as per drawings including red-oxide coating and related specification complete as per detailed design and drawings. Providing and fixing MS grating (max weight : 15 kg/sft) for MAJOR cross drain as per drawings including red-oxide coating and related specification etc., complete as per detailed design and drawings.
4.5 >> Material Specifications

a. Material details for Granular Sub-base

Scope
This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these specifications. The material shall be laid in one or more layers as sub-base or lower sub-base and upper sub-base (termed as sub-base hereinafter) as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the engineer.

Materials
The materials to be used for the work shall be natural sand, moorum, gravel, crushed stone, or combination thereof, depending upon the grading required. Materials like crushed slag, crushed concrete, brick metal and kankan may be allowed only with the specific approval of the engineer. The material shall be free from organic or other deleterious constituents and conform to one of the three grading given in Table 400-1 (see overleaf), while the grading in Table 400-1 is in respect to close-graded granular sub-base materials, one each for maximum particle size of 75 mm, 53 mm and 26.5 mm, the corresponding grading for the coarse graded materials for each of the three maximum particle sizes are given in Table 400-2. The grading to be adopted for a project is to be as specified in the Contract.

Physical requirements
The material shall have a 10 per cent fines value of 50 kN or more (for sample in soaked condition) when tested in compliance with BS:812 (Part 111). The water absorption value of the coarse aggregate shall be determined as per IS:2386 (Part 3); if this value is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS:383. For Grading II and III materials, the CBR shall be determined at the density and moisture content likely to be developed in equilibrium conditions which shall be taken as being the density relating to a uniform air voids content of 5 per cent.
b. **Material details for Dense Bituminous Macadam**

**Bitumen:**

The bitumen shall be paving bitumen of Penetration Grade complying with Indian Standard Specifications for "Paving Bitumen" IS: 73, and of the penetration indicated in Table 500-10 for dense bitumen macadam, or this bitumen as modified by one of the methods specified in Clause 521, or as otherwise specified in the tender contract. Guidance on the selection of an appropriate grade of bitumen is to be considered from the manual for construction and supervision of bituminous works.

**Coarse aggregates:**

The coarse aggregates should consist of crushed rock, crushed gravel or other hard material retained on the 2.36 mm sieve. They should be clean, hard, durable, of cubical shape, free from dust and of soft or friable matter, organic or other deleterious substances.

Where the contractor’s selected source of aggregates have poor affinity for bitumen, as a condition for the approval of that source, the bitumen shall be treated with an approved anti-stripping agent, as per the manufacturer’s recommendations, without additional payment. Before approval of the source, the aggregates must be tested for stripping. The aggregates must satisfy the physical requirements specified in Table 500-8 (see overleaf), for dense bituminous macadam. Where crushed gravel is proposed for use as aggregate, not less than 90% by weight of the crushed material retained on the 4.75 mm sieve, are to have at least two fractured faces.
Fine aggregates:
Fine aggregates shall consist of crushed or naturally occurring mineral material, or a combination of the two, passing the 2.36mm sieve and retained on the 75 micron sieve. They should be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter.

Table 4.3: Physical requirements for coarse aggregate for DBM

<table>
<thead>
<tr>
<th>Property</th>
<th>Text</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleanliness (dust)</td>
<td>Grain size analysis</td>
<td>Max 5% passing 0.075mm sieve</td>
</tr>
<tr>
<td>Particle shape</td>
<td>Flakiness and Elongation Index (Combined)</td>
<td></td>
</tr>
<tr>
<td>Strength*</td>
<td>Los Angeles Abrasion Value</td>
<td>Max 55%</td>
</tr>
<tr>
<td></td>
<td>Aggregate Impact Value</td>
<td>Max 27%</td>
</tr>
<tr>
<td>Durability</td>
<td>Soundness</td>
<td>Max 12%</td>
</tr>
<tr>
<td></td>
<td>Sodium Sulphate</td>
<td>Max 18%</td>
</tr>
<tr>
<td></td>
<td>Magnesium Sulphate</td>
<td>Max 5%</td>
</tr>
<tr>
<td>Water Absorption</td>
<td>Water absorption</td>
<td>Max 2%</td>
</tr>
<tr>
<td>Stopping</td>
<td>Coating and Stopping of Bitumen Aggregate Mixture</td>
<td>Minimum retained coating 95%</td>
</tr>
<tr>
<td>Water Sensitivity</td>
<td>Retained Tensile Strength</td>
<td>Min 80%</td>
</tr>
</tbody>
</table>

Notes:
1. IS:2380 Part 1
2. IS: 2380 Part 1
3. IS: 2380 Part 4
4. IS: 2380 Part 4
5. IS: 6241
6. IS: 2380 Part 4
7. IS: 6241
8. AASHTO T283**
** Aggregate may satisfy requirements of either of these two tests.
** The water sensitivity test is valid only if the minimum retained coating in the stopping test is less than 95%.

Image 4.10: Physical requirements for coarse aggregate for DBM

C Semi-Dense Bituminous Concrete (source IRC 95-1987 & MoRTH)
Semi-dense bituminous concrete should be used as a wearing course and should not be laid directly over WBM or any granular base. The item should consist of mineral aggregates and appropriate binder mixed in a hot-mix plant and laid with a paver on a previously prepared base in accordance with the specifications and conforming to the lines, grades and cross-sections.

Considering that these are high cost specifications, semi-dense bituminous concrete mixes should be properly designed so as to satisfy certain criteria needed to assure satisfactory performance and durability. The mix as designed and laid should satisfy the requirements given in Table 4.3 based on Marshall Method.

Table 4.3:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Number of compaction blows on each end of Marshall</td>
</tr>
<tr>
<td>2</td>
<td>Marshall stability in kg (Minimum)</td>
</tr>
<tr>
<td>3</td>
<td>Marshall flow (mm)</td>
</tr>
<tr>
<td>4</td>
<td>Percent voids in mix</td>
</tr>
<tr>
<td>5</td>
<td>Percent voids in mineral aggregate filled with bitumen</td>
</tr>
<tr>
<td>6</td>
<td>Binder content as percent by weight of total mix (to be decided on Marshall design method)</td>
</tr>
</tbody>
</table>
Notes:
1. It is suggested that higher stability values consistent with other requirements should be achieved as far as possible.
2. At bus stops, parking areas and roundabouts, near minimum flow values should be adopted.
3. The attempt should be to have well graded aggregate and the percent voids in the mix closer to the lower limit.

Materials
In order to satisfy the requirements spelt above, the SDBC mix should consist of coarse aggregate, fine aggregate and filler in suitable proportions and mixed with sufficient binder content. True and representative samples of the aggregates proposed to be used on the specific job should be tested in the design laboratory and proper blend of the aggregates should be worked out so that the gradation of the final composition will satisfy either of the three limits set forth in Table 4.4.

<table>
<thead>
<tr>
<th>Grading number</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve size</td>
<td></td>
<td>(Percent passing by weight)</td>
<td></td>
</tr>
<tr>
<td>22.4 mm</td>
<td></td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>13.2 mm</td>
<td>100</td>
<td>85–100</td>
<td>79–100</td>
</tr>
<tr>
<td>11.2 mm</td>
<td>88–100</td>
<td>70–92</td>
<td>68–90</td>
</tr>
<tr>
<td>5.6 mm</td>
<td>42–64</td>
<td>42–64</td>
<td>33–55</td>
</tr>
<tr>
<td>2.8 mm</td>
<td>22–38</td>
<td>22–38</td>
<td>22–38</td>
</tr>
<tr>
<td>710 um</td>
<td>11–24</td>
<td>11–24</td>
<td>6–22</td>
</tr>
<tr>
<td>355 um</td>
<td>7–18</td>
<td>7–18</td>
<td>4–14</td>
</tr>
<tr>
<td>180 um</td>
<td>5–13</td>
<td>5–13</td>
<td>2–9</td>
</tr>
<tr>
<td>90 um</td>
<td>3–9</td>
<td>3–9</td>
<td>0–5</td>
</tr>
</tbody>
</table>

Grading No.1 is suggested for compacted thickness of **25mm** and grading No.2 and 3 for compacted thickness of **25–40mm**.

The exact bitumen content required is to be arrived at as per Marshall procedure for the aggregategradation worked out in the laboratory and by using the same paving bitumen proposed to be used in the field.
The material should further satisfy the following physical requirements.

**Bitumen:**
The bitumen shall be paving bitumen of suitable penetration grade within the range of **S 35 to S 90 or A 35 to A 90** (30/40 to 80/100) as per IS:73 ‘Paving Bitumen’. The actual grade of bitumen to be used should be decided by the engineer-in-charge, appropriate to the region, traffic, rainfall and other environmental conditions.

**Coarse aggregate:**
The coarse aggregate should be crushed material retained on **2.8mm** sieve and crushed stone, crushed slag, crushed gravel (shingle) and consist of angular, clean, tough and durable fragments, free from disintegrated pieces and organic or deleterious matter and adherent coatings. The aggregate should be preferably hydrophobic and of low porosity. When hydrophilic aggregates are used, the bitumen is to be treated with anti-stripping agents of approved quality in suitable doses. The aggregate should satisfy the physical requirements as given in Table 4.5.

<table>
<thead>
<tr>
<th>Grading number</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.4 mm</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>13.2 mm</td>
<td>100</td>
<td>85–100</td>
<td>79–100</td>
</tr>
<tr>
<td>11.2 mm</td>
<td>88–100</td>
<td>70–92</td>
<td>68–90</td>
</tr>
<tr>
<td>5.6 mm</td>
<td>42–54</td>
<td>42–64</td>
<td>33–55</td>
</tr>
<tr>
<td>2.8 mm</td>
<td>22–38</td>
<td>22–38</td>
<td>22–38</td>
</tr>
<tr>
<td>710 um</td>
<td>11–24</td>
<td>11–24</td>
<td>6–22</td>
</tr>
<tr>
<td>355 um</td>
<td>7–18</td>
<td>7–18</td>
<td>4–14</td>
</tr>
<tr>
<td>180 um</td>
<td>5–13</td>
<td>5–13</td>
<td>2–9</td>
</tr>
<tr>
<td>90 um</td>
<td>3–9</td>
<td>3–9</td>
<td>0–5</td>
</tr>
</tbody>
</table>

**Fine aggregates:**
The fine aggregate should be the fraction passing **2.8mm** sieve and retained on **0.9mm** sieve, and should consist of crushed screenings, natural sand or a mixture of both. It should be clean, hard, durable, uncoated, dry and free from injurious, soft or flaky pieces and organic
or deleterious matter.

**Filler:**
The requirement of filler in semi-dense bituminous mixes should normally be met by the material passing 90 mm sieve in fine aggregate. In case the fine aggregate is deficient in material passing 90 mm sieve, extra filler shall be added. The filler shall be an inert material, the whole of which passes 710 mm sieve, at least 90 percent passes 180 mm sieve and not less than 70 percent passes 90 mm sieve. The filler should be stone dust, cement hydrate lime, flyash or other approved non-plastic mineral matter.

d. **Wet Mix Macadam Sub-Base/Base**

**Scope**
This work consists of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water, to a dense mass on a prepared subgrade/sub-base/base or existing pavement as the case may be, in accordance with the requirements of these specifications. The material is to be laid in one or more layers as necessary to the lines, grades and cross-sections shown on the approved drawings or as directed by the engineer.

The thickness of a single compacted wet mix macadam layer shall not be less than 75 mm. When vibrating or other approved types of compacting equipment is used, the compacted depth of a single layer of the sub-base course may be increased to 200 mm upon approval of the engineer.

**Aggregates -Physical requirements:**
Coarse aggregates shall be crushed stone. If crushed gravel/shingle is used, not less than 90 percent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates must conform to the physical requirements set forth in Table below.

![Image 4.31: Physical requirements for coarse aggregate for WMM (source: Table 400-10, MoRTH)](image)

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Method</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <em>Los Angeles Abrasion value or Aggregate Impact value</em></td>
<td>IS: 2386 (Part-4)</td>
<td>40 percent (Max)</td>
</tr>
<tr>
<td></td>
<td>IS: 2386 (Part-4) or IS: 5640</td>
<td>30 percent (Max)</td>
</tr>
<tr>
<td>2. Combined Flakiness and Elongation Indices (Total)</td>
<td>IS: 2386 (Part-4)</td>
<td>30 percent (Max)</td>
</tr>
</tbody>
</table>

* Aggregate may satisfy requirements of either of the two tests.
If the water absorption value of the coarse aggregate is greater than **2 per cent**, the soundness test shall be carried out on the material delivered to site as per IS: 2386 (Part-5).406.2.1.2.

**Grading requirements:** The aggregate shall conform to the grading given in Table below.

<table>
<thead>
<tr>
<th>IS Sieve Designation</th>
<th>Per cent by weight passing the IS sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>53.00 mm</td>
<td>100</td>
</tr>
<tr>
<td>45.00 mm</td>
<td>95-100</td>
</tr>
<tr>
<td>26.50 mm</td>
<td>---</td>
</tr>
<tr>
<td>22.40 mm</td>
<td>60-80</td>
</tr>
<tr>
<td>11.20 mm</td>
<td>40-60</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>25-40</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>15-30</td>
</tr>
<tr>
<td>600.00 micron</td>
<td>8-22</td>
</tr>
<tr>
<td>75.00 micron</td>
<td>0-8</td>
</tr>
</tbody>
</table>

Materials finer than **425 micron** should have Plasticity Index (PI) not exceeding **6.** The final gradation approved within these limits shall be well graded from coarse to fine and are not to vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa.

### 4.6 >>

**General**

Bituminous pavement courses shall be made using the materials described in the following specifications. The use of machinery and equipment mentioned in various clauses of these specifications is mandatory. Details of the machinery and equipment are available in the manual for construction and supervision of bituminous works. Equipment mandatory for any particular project shall be in accordance with the contract for that project.

**Materials**

**Binder:** The binder shall be an appropriate type of bituminous material complying with the relevant Indian Standard (IS), as defined in the appropriate clauses of these specifications, or as otherwise specified herein. The choice of binder shall be stipulated in the contract or by the engineer. Where penetration grades of bitumen are specified, they are referred to by a single-figure designation in accordance with IS:73. Thus bitumen grade 35 refers to a bitumen in the penetration range 30 to 40. Where modified binder is specified, the Clause 521 of these specifications shall apply.

**Coarse Aggregates**

The coarse aggregates must consist of crushed rock, crushed gravel or other hard material retained on the **2.36 mm** sieve. They should be clean, hard, durable, of cubical shape, free from dust and soft or friable.
matter, organic or other deleterious matter. Where the contractor’s selected source of aggregates has poor affinity for bitumen, as a condition for the approval of that source, the bitumen must be treated with approved anti-stripping agents, as per the manufacturer’s recommendations, without additional payment. Before approval of the source the aggregates shall be tested for stripping. The aggregates should satisfy the physical requirements set forth in the individual relevant clause for the material in question.

Where crushed gravel is proposed for use as aggregate, not less than 90% by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

**Fine Aggregates**

Fine aggregates should consist of crushed or naturally occurring material, or a combination of the two, passing 2.36 mm sieve and retained on the 75 micron sieve. They should be clean, hard, durable, dry and free from dust, soft or friable matter, organic or other deleterious matter.

**Source of material**

The source of all materials to be used on the project must be tested and be expressly approved by the Engineer. The engineer may from time to time withdraw approval of a specific source, or attach conditions to the existing approval, with adequate reason giving and recording. Any change in aggregate source for bituminous mixes, will require a new mix design, and laying trials, where the mix is based on a job mix design. Stockpiled from different sources, approved or otherwise, shall be kept separate, such that there is no contamination between one material and another. Each source submitted for approval shall contain sufficient material for at least 5 days work.

**Mixing**

Pre-mixed bituminous materials, including bituminous macadam, dense bituminous macadam, semi-dense bituminous concrete and bituminous concrete, shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. Appropriate mixing temperatures can be found in Table 500-5 of these specifications; the difference in temperature between the binder and aggregate should at no time exceed 14°C. In order to ensure uniform quality of the mix and better coating of aggregates, the hot mix plant shall be calibrated from time to time. If a continuous mixing-plant is to be used for mixing the bituminous bound macadam, the contractor must demonstrate by laboratory analysis, that the cold feed combined grading is within the grading limits specified for that bituminous bound material. In the case of a designed job mix, the bitumen and filler content is to be derived using this combined grading. Further details are available in the manual for
construction and supervision of bituminous works.

**Transporting**
Bituminous materials must be transported in clean insulated vehicles, and unless otherwise agreed by the engineer, shall be covered while in transit or awaiting tipping. Subject to the approval of the engineer, a thin coating of diesel or lubricating oil may be applied to the interior of the vehicle to prevent sticking and to facilitate discharge of the material.

**Laying**

**Weather and seasonal limitations:** laying shall be suspended while free-standing water is present on the surface to be covered, or during rain, fog and dust storms. After rain, the bituminous surface, prime or tack coat, shall be blown off with a high pressure air jet to remove excess moisture, or the surface left to dry before laying can start. Laying of bituminous mixtures shall not be carried out when the air temperature at the surface on which it is to be laid is below 10°C or when the wind speed at any temperature exceeds 40 km/h at 2m height unless specifically approved by the engineer.

**Cleaning of surface**
The surface on which the bituminous work is to be laid shall be cleaned of all loose and extraneous matter by means of a mechanical broom or any other approved equipment/method as specified in the contract. The use of a high pressure air jet from a compressor to remove dust or loose matter shall be available full time on the site, unless otherwise specified in the contract.

**Spreading**
Except in areas where a mechanical paver cannot gain access, bituminous materials shall be spread, leveled and tamped by an approved self-propelled paving machine. As soon as possible after arrival at site, the materials shall be supplied continuously to the paver and laid without delay. The rate of delivery of material to the paver shall be regulated to enable the paver to operate continuously. The travel rate of the paver, and its method of operations, shall be adjusted to ensure an even and uniform flow of bituminous material across the spread, free from dragging, tearing and segregation of the material. In areas with restricted space where a mechanical paver cannot be used, the material shall be spread, raked and leveled with suitable hand tools by experienced staff, and compacted to the approval of the engineer.

The minimum thickness of material laid in each paver pass shall be in accordance with the minimum values given in the relevant parts of these specifications. When laying binder course or wearing course approaching an expansion joint of a structure, machine laying shall stop 300mm short of the joint. The remainder of the pavement up to
the joint, and the corresponding area beyond it, shall be laid by hand, and the joint or joint cavity shall be kept clear of surfacing material. Bituminous material, with a temperature greater than 145°C, shall not be laid or, deposited on bridge deck waterproofing systems, unless precautions against heat damage have been approved by the Engineer.

Hand placing of pre-mixed bituminous materials is to be only be permitted in the following circumstances:
(i) For laying regulating courses of irregular shape and varying thickness.
(ii) In confined spaces where it is impracticable for a paver to operate.
(iii) For footways.
(iv) At the approaches to expansion joints at bridges, viaducts or other structures.
(v) For laying mastic asphalt in accordance with Clause 515.
(vi) For filling of potholes.
(vii) Where directed by the Engineer.

Manual spreading of pre-mixed wearing course material or the addition of such material by hand-spreading to the paved area, for adjustment of level, shall only be permitted in the following circumstances:
(i) At the edges of the layers of material and at gullies and manholes.
(ii) At the approaches to expansion joints at bridges, viaducts or other structures.
(iii) As directed by the engineer.

**Compaction of bituminous materials shall commence as soon as possible after laying**

**Cleanliness and overlaying**
Bituminous material shall be kept clean and uncontaminated. The only traffic permitted to run on bituminous material to be overlaid shall be that which is engaged in laying and compacting the next course, or, where a binder course is to be sealed or surface dressed, that which is engaged on such surface treatment. Should any bituminous material become contaminated the contractor shall make it good to the satisfaction of the engineer, in compliance with Clause 501.8.

Binder course material shall not remain uncovered by either the wearing course or surface treatment, whichever is specified in the contract, for more than three consecutive days after being laid. The engineer may extend this period, by the minimum amount of time necessary, because of weather conditions or for any other reason. If the surface of the base course is subjected to traffic, or not covered within three days, a tack coat shall be applied, as directed by the engineer.

**Compaction**
Bituminous materials shall be laid and compacted in layers which enable the specified thickness, surface level, regularity requirements
and compaction to be achieved. Compaction of bituminous materials shall commence as soon as possible after laying. Compaction shall be substantially completed before the temperature falls below the minimum rolling temperatures stated in the relevant part of these specifications. Rolling of the longitudinal joints shall be done immediately behind the paving operation. After this, rolling is to commence at the edges and progress towards the centre longitudinally except that on super elevated and unidirectional cambered portions, where it should progress from the lower to the upper edge parallel to the centre line of the pavement. Rolling should continue until all roller marks have been removed from the surface. All deficiencies in the surface after laying are made good by the attendants behind the paver, before initial rolling is commenced. The initial or breakdown rolling is to be done with 8-10 tonnes dead weight smooth-wheeled rollers. The intermediate rolling, is to be done with 8-10 tonnes dead weight or vibratory roller or with a pneumatic tyre roller of 12 to 15 tonnes weight having nine wheels, with a tyre pressure of at least 5.6 kg/sqcm.

The finish rolling should be done with 6 to 8 tonnes smooth wheeled tandem rollers. Where compaction is to be determined by density of cores the requirements to prove the performance of rollers shall apply in order to demonstrate that the specified density can be achieved. In such cases the contractor must nominate the plant, and the method by which he intends to achieve the specified level of compaction and finish at temperatures above the minimum specified rolling temperature. Laying trials shall then demonstrate the acceptability of the plant and method used.

Bituminous materials shall be rolled in a longitudinal direction, with the driven rolls nearest the paver. The roller shall first compact material adjacent to joints and then work from the lower to the upper side of the layer, overlapping on successive passes by at least one-third of the width of the rear roll or, in the case of a pneumatic -tyre roller, at least the nominal width of 300mm. In portions with super-elevated and unidirectional camber, after the edge has been rolled, the roller shall progress from the lower to the upper edge.

Rollers should move at a speed of not more than 5 km per hour. The roller shall not be permitted to stand on pavement which has not been fully compacted, and necessary precautions shall be taken to prevent dropping of oil, grease, petrol or other foreign matter on the pavement either when the rollers are operating or standing. The wheels of rollers shall be kept moist with water, and the spray system provided with the machine shall be in good working order, to prevent the mixture from adhering to the wheels. Only sufficient moisture to prevent adhesion between the wheels of rollers and the mixture should be used. Surplus water shall not be allowed to stand on the partially compacted pavement.
Joints
Where longitudinal joints are made in pre-mixed bituminous materials, the materials shall be fully compacted and the joint made flush in one of the following ways; only method (iii) shall be used for transverse joints:

(i) by heating the joints with an approved joint beater when the adjacent width is being laid, but without cutting back or coating with binder. The heater shall raise the temperature of the full depth of material, to within the specified range of minimum rolling temperature and maximum temperature at any stage for the material, for a width not less than 75 mm. The contractor shall have equipment available, for use in the event of a beater breakdown, to form joints by method (iii);

(ii) by using two or more pavers operating in echelon, where this is practicable, and in sufficient proximity for adjacent widths to be fully compacted by continuous rolling;

(iii) for a distance equal to the specified layer thickness, to vertical face, discarding all loosened material and coating the vertical face completely, with 80/100 penetration grade hot bitumen, or cold-applied bitumen, or polymer modified adhesive bitumen tape with a minimum thickness of 2 mm, before the adjacent width is laid. All joints shall be offset at least 300 mm from parallel joints in the layer beneath or as directed, and in a layout approved by the engineer. Joints in the wearing course shall coincide with either the lane edge or the lane marking, which ever is appropriate. Longitudinal joints shall not be situated in wheel track zones.

Scope
The work shall consist of constructing footpaths and/or separators at locations as specified in the drawings or as directed by the engineer. The lines, levels and dimensions shall be as per the drawings. The scope of the work shall include provision of all drainage arrangements as shown in the drawings or as directed.

Brief Material specifications
The footpaths and separators shall be constructed with any of the following types:

(i) Cast-in-situ cement concrete of Grade M20 as per Section 1700 of the Specifications.

(ii) Precast cement concrete blocks/tiles of Grade M20 as per Section 1700 of the specifications. The minimum thickness of the cement concrete block/tile shall be 25 mm and minimum size shall be 300 mm x 300 mm.

(iii) Natural stone slab cut and dressed from stone of good and sound quality, uniform in texture, free from defects and at least equal to a sample submitted by the contractor and approved by the engineer. The minimum thickness of the natural stone slab shall be 25 mm and
The use of cement in the joint - filling sand is not recommended as a general practice as the cemented sand is likely to crack into segments which are easily dislodged.

Minimum size shall be 300 mm x 300 mm.

Technical specifications for laying concrete paving blocks used for Footpaths

a. Base
1.a.1 The finished surface of the concrete base shall match the design profile of the concrete blocks within ±10 mm.
1.a.2 Compaction shall be done with vibratory roller. In restricted areas where normal rollers cannot operate, hand – held or plate vibrators should be employed.

b. Bedding Sand Layer
1.b.1 The bedding sand layer shall be from either a single source or blended to achieve the following grading
1.b.2 Single sized, gap – graded sands or those containing an excessive amount of fines will not be used. The sand particles should preferably by angular type. The joint – filling sand should pass a 2.35 mm sieve and be well graded. The following grading is recommended:
1.b.3 Average thickness of this laying course shall be 20 to 40 mm.
1.b.4 The sand should be slightly moist, and the moisture content shall be about 4 percent by weight.
1.b.5 It should contain not more than 3 percent by weight of clay and silt and the materials shall be free from deleterious salts or contaminates.
1.b.6 The finished surface of the bedding layer shall match exactly the design profile as indicated on the drawings.
1.b.7 Before placing the bedding layers, the surface of concrete should be clearly by sweeping.
1.b.8 Walking or driving on the finished surface of the bedding layers, the surface of concrete should be cleared by sweeping.

c. Concrete Paving Blocks
1.c.1 Laying of the blocks shall be done - precisely at the indicated level and profile and in a way that a good surface draining to the gulley chambers is assured.
1.c.2 Around gulley chambers and inspection pits, the pavement shall have a level of 5 mm higher than the above mentioned elements.
1.c.3 The blocks shall be laid to the pattern directed by the engineer. The blocks shall be laid as tight as possible to each other. The maximum joint width shall be limited to 4 mm.
1.c.4 Laying of broken blocks is not allowed except along connections or edges. The maximum length of a purpose broken block is 100 mm. Breaking of the blocks shall be done with a “block splitter” or a mechanical saw.
1.c.5 Fine angular sand as per specification shall be brushed into the joints, and thereafter compaction shall be done with a vibrating plate compactor on a clean surface. After compaction, again fine angular
sand shall be brushed into the joints.

4.7.1 >>
Plain Cement Concrete Kerb Specifications

Providing and laying of precast concrete kerbs 914 x 315 x 150mm high in M20 grade P.C.C on M-15 grade foundation using 20mm aggregates 150mm thick foundation and side support concrete laid manually as per drawings upto the required profile as per drawings including excavation, backfilling, form work, curing, including cost of all materials, labour, hire charges of machinery, loading, unloading, lead, lift, transporting etc.
Getting the drains right.
Vittal Mallya Road
Bangalore
CHAPTER 5

TENDER SURE

LIFE CYCLE COSTING
5.0 >> Life Cycle Costing of an Urban Road (UR) System

Life Cycle Costing of UR is a process to determine the sum of all recurring and one-time (non-recurring) costs over the full life span or a specified period of an UR system. It includes laying cost, material cost, operating costs, maintenance, overlay and upgrade costs, and remaining (residual or salvage) value at the end of useful life of the project.

Life Cycle Costing adds all the costs of alternatives over their life period and enables an evaluation on a common basis for the period of interest. This enables decisions on acquisition, maintenance, refurbishment or disposal to be made in the light of full cost implications.

The unit cost for all 34 road types detailed in TenderSURE is estimated here based on PWD Schedule of Rates, 2010. For items that are not present in the SR book the cost is assumed by cross referencing with local engineers and similar works that has been carried out locally. The LCC calculated here should be used as a reference only as the rate analysis is factored in. Actual quantity estimates based on ground conditions such as the type of material used, grading of aggregates, quality of cement, material price escalation, detailing, aesthetics, etc. demolition, site clearance and dismantling, traffic diversion costs will influence the final costing of the projects.

Three items were considered to obtain approximate cost of laying one km of an urban road. They are road material composition cost, street fixtures and below grade utilities.
### Table 5.1 (a) Schedule of rates extract for local road works

<table>
<thead>
<tr>
<th>Serial Number</th>
<th>Particulars</th>
<th>Cost (₹)</th>
<th>Unit</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Excavation in hard soil</td>
<td>300</td>
<td>cum</td>
<td>Item 19.2, Pg. no 126</td>
</tr>
<tr>
<td>2</td>
<td>Tack coat</td>
<td>200</td>
<td>cum</td>
<td>Item 21.9, Pg. no 149</td>
</tr>
<tr>
<td>3</td>
<td>Bituminous macadam</td>
<td>50</td>
<td>cum</td>
<td>Item 21.11.3, Pg. no 149</td>
</tr>
<tr>
<td>4</td>
<td>Semi Dense Bituminous concrete</td>
<td>25</td>
<td>cum</td>
<td>Item 21.20.2, Pg. no 151</td>
</tr>
</tbody>
</table>

Similarly, cost is calculated for higher order roads by considering all the elements.

### Table 5.2 (a) Schedule of rates extract for arterial, sub-arterial and collector road works

<table>
<thead>
<tr>
<th>Serial Number</th>
<th>Particulars</th>
<th>Cost (₹)</th>
<th>Unit</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Excavation in hard soil</td>
<td>72</td>
<td>cum</td>
<td>item 19.2, Pg. no 126</td>
</tr>
<tr>
<td>2</td>
<td>Tack coat</td>
<td>1,639</td>
<td>cum</td>
<td>item 20.2, Pg. no 140</td>
</tr>
<tr>
<td>3</td>
<td>Bituminous macadam</td>
<td>983</td>
<td>cum</td>
<td>item 20.18, Pg. no 143</td>
</tr>
<tr>
<td>4</td>
<td>Semi Dense Bituminous concrete</td>
<td>6,884</td>
<td>cum</td>
<td>item 21.17, Pg. no 150</td>
</tr>
<tr>
<td>5</td>
<td>Semi Dense Bituminous concrete</td>
<td>6,238</td>
<td>cum</td>
<td>item 21.20.2, Pg. no 151</td>
</tr>
<tr>
<td>6</td>
<td>Bituminous concrete</td>
<td>5,779</td>
<td>cum</td>
<td>item 21.22.2, Pg. no 152</td>
</tr>
<tr>
<td>7</td>
<td>UG Drain 1mx1m</td>
<td>2,135</td>
<td>running m</td>
<td>item 19.44, Pg. no 131</td>
</tr>
<tr>
<td>8</td>
<td>Footpath</td>
<td>415</td>
<td>Sq.m</td>
<td>item 20.21, Pg. no 144</td>
</tr>
<tr>
<td>9</td>
<td>UG Drain at edge of pavement</td>
<td>2,135</td>
<td>m</td>
<td>Item 19.44, Pg. no 131</td>
</tr>
</tbody>
</table>

The factors affecting LCC are initial cost of construction, operation and maintenance, periodic overlay and design life of urban road. LCC is calculated for two scenarios, proposed life over 20yrs and current.

It is assumed here that when roads are built according to the integrated city plan, with well-designed right-of-ways considering various elements such as above ground fixtures and underground utilities, the post-construction operations and maintenance cost over the life of the roads. The current road construction practices require frequent maintenance cycles, among other reasons, due to imperfect methodology and excessive cutting and digging by various public and private agencies. The life-cycle cost in current practice increases significantly over the 20 year design life (see table overleaf).
### LIFE CYCLE COSTING

<table>
<thead>
<tr>
<th>Road Type</th>
<th>R-o-W width (M)</th>
<th>Tender SURE costs over 20 years</th>
<th>Current Costs over 20 years - conservative</th>
<th>Current Costs over 20 years - realistic</th>
<th>Cost difference Current/TenderSURE - conservative</th>
<th>Cost difference Current/TenderSURE - realistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>10</td>
<td>27,846,528</td>
<td>30,978,000</td>
<td>41,304,000</td>
<td>111%</td>
<td>148%</td>
</tr>
<tr>
<td>Collector</td>
<td>21</td>
<td>102,418,536</td>
<td>128,785,050</td>
<td>171,733,400</td>
<td>126%</td>
<td>168%</td>
</tr>
<tr>
<td>Sub-arterial</td>
<td>30</td>
<td>133,717,157</td>
<td>176,840,100</td>
<td>235,786,800</td>
<td>132%</td>
<td>176%</td>
</tr>
<tr>
<td>Arterial</td>
<td>48</td>
<td>217,307,735</td>
<td>252,460,100</td>
<td>309,946,800</td>
<td>107%</td>
<td>143%</td>
</tr>
</tbody>
</table>

Table 6.3>> LCC cost difference between TenderSURE and current road construction practices

Calculations for LCC of bituminous pavement road types as per Tender SURE specifications are shown in the table below. The costs are also calculated for roads as per current practices. As the preparatory work in Tender SURE roads would be according to best practices, regular O&M costs would not be high and considered at 3% whereas current roads this goes up to 5%. Even with conservative estimates of maintenance and periodic relay, 20-year LCC of roads built with current practices result in higher cumulative expenditures. In reality, the cost goes higher as relying costs need to be calculated considering the factors such as utility shifting and upgrades etc.

### Tender SURE COST

<table>
<thead>
<tr>
<th>Road Type</th>
<th>R-o-W width (M)</th>
<th>Total</th>
<th>O &amp; M Cost-annual (3% of initial cost) (INR)</th>
<th>Relay Cost - 25% of initial cost every 10yrs (INR)</th>
<th>Life Cycle Cost over 20 yrs (INR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>10</td>
<td>13,260,252</td>
<td>7,956,131</td>
<td>6,630,126</td>
<td>27,846,528</td>
</tr>
<tr>
<td>Collector</td>
<td>21</td>
<td>48,770,731</td>
<td>29,262,439</td>
<td>24,385,366</td>
<td>102,418,536</td>
</tr>
<tr>
<td>Sub-arterial</td>
<td>30</td>
<td>63,674,837</td>
<td>38,204,902</td>
<td>31,837,418</td>
<td>133,717,157</td>
</tr>
<tr>
<td>Arterial</td>
<td>48</td>
<td>103,479,974</td>
<td>62,087,924</td>
<td>51,739,937</td>
<td>217,307,735</td>
</tr>
</tbody>
</table>

### Current COST Conservative

<table>
<thead>
<tr>
<th>Road Type</th>
<th>R-o-W width (M)</th>
<th>Total</th>
<th>O &amp; M Cost-annual (5% of initial cost) (INR)</th>
<th>Relay Cost - 50% of initial cost every 4 yrs (INR)</th>
<th>Life Cycle Cost over 20 yrs (INR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>10</td>
<td>6,884,000</td>
<td>6,884,000</td>
<td>17,210,000</td>
<td>30,978,000</td>
</tr>
<tr>
<td>Collector</td>
<td>21</td>
<td>28,618,900</td>
<td>28,618,900</td>
<td>71,547,250</td>
<td>128,785,050</td>
</tr>
<tr>
<td>Sub-arterial</td>
<td>30</td>
<td>39,297,800</td>
<td>39,297,800</td>
<td>98,244,500</td>
<td>176,840,100</td>
</tr>
<tr>
<td>Arterial</td>
<td>48</td>
<td>51,657,800</td>
<td>51,657,800</td>
<td>129,144,500</td>
<td>232,450,100</td>
</tr>
</tbody>
</table>
### Current COST Realistic

<table>
<thead>
<tr>
<th>Road Type</th>
<th>R-o-W width (M)</th>
<th>Total</th>
<th>O &amp; M Cost-annual (5% of initial cost) (INR)</th>
<th>Relay Cost - 100% of initial cost every 4 yrs (INR)</th>
<th>Life Cycle Cost over 20 yrs (INR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>10</td>
<td>6,884,000</td>
<td>6,884,000</td>
<td>27,536,000</td>
<td>41,304,000</td>
</tr>
<tr>
<td>Collector</td>
<td>21</td>
<td>28,618,900</td>
<td>28,618,900</td>
<td>114,475,600</td>
<td>171,713,400</td>
</tr>
<tr>
<td>Sub-arterial</td>
<td>30</td>
<td>39,297,800</td>
<td>39,297,800</td>
<td>157,191,200</td>
<td>235,786,800</td>
</tr>
<tr>
<td>Arterial</td>
<td>48</td>
<td>51,657,800</td>
<td>51,657,800</td>
<td>206,631,200</td>
<td>309,946,800</td>
</tr>
</tbody>
</table>

Table 5.4 (contd.): Detailed LCC cost estimates for bituminous roads as per TenderSURE and current road construction practices

LCC calculations for roads with cement concrete pavement as per Tender SURE specifications are shown in the table below. As relaying is not involved in the CC roads, the 20-year LCC costs compared to bituminous roads are significantly less.

Comparative analysis with current practices cannot be done as CC roads are constructed only for narrow alleys and access roads.

### Tender SURE COST

<table>
<thead>
<tr>
<th>Road Type</th>
<th>R-o-W width (M)</th>
<th>Total</th>
<th>O &amp; M Cost-annual (2% of initial cost) (INR)</th>
<th>Life Cycle Cost over 20 yrs (INR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>10</td>
<td>14,099,490</td>
<td>5,639,796</td>
<td>19,739,286</td>
</tr>
<tr>
<td>Collector</td>
<td>21</td>
<td>50,322,144</td>
<td>20,120,858</td>
<td>70,423,002</td>
</tr>
<tr>
<td>Sub-arterial</td>
<td>30</td>
<td>55,545,056</td>
<td>26,218,022</td>
<td>91,763,078</td>
</tr>
<tr>
<td>Arterial</td>
<td>48</td>
<td>107,616,172</td>
<td>43,046,469</td>
<td>150,662,641</td>
</tr>
</tbody>
</table>

Table 5.5: Detailed LCC cost estimates for cement concrete roads as per TenderSURE
Annexures
i. Mini - Circle Junction Design

1) Provision of small diameter island of a diameter of about one-third that of a hypothetical circle inscribed within the outer carriageway boundaries, but normally not less than 8m. For new layout, space for larger diameter (15m to 25m) may be reserved if such a provision becomes necessary in future.

2) An increase in number of lane at the Give-Way line.

3) A minimum stopping distance of 26m between the give way line and the point of conflict with a vehicle from the left (shown as X in the figure 1).

4) A width between traffic islands and the circle (shown as Y in the figure 1) Which is not less than the total lane width at the entry preceding it i.e. dimension shown as Z in figure 1.

5) An entry taper (about 1 in 6) that is about twice sharp as the exit taper (1 in 12).

6) A deflection island (shown as B in figure 1) intends to ensure that straight-through movements do not occur.

7) To maintain junction capacity, a single lane approach should be tapered to give at least three lanes at the junction and a 2-lane approach tapered to at least four lanes at the junction. At the exit, the merge should normally be from four lanes to two lanes and two lanes to one lane.
ii. Rotary Junction Design

The main of providing the rotary is to eliminate the necessity of stopping even for crossing streams of vehicles and to reduce the area of conflict.

Figure 2 >>> Elements of rotary

Various design factors to be considered in a traffic rotary are speed, shape of central island, weaving angle, weaving distance, width of rotary road way, radius of entrance and exit curves, channelizing islands, lighting and signs.

**Design speed** – The design speed for rotaries in urban areas is 30 kmph adopted.

**Shape of Central Island** – The shape of Central Island depends on the number and the layout of the intersecting roads. The various shapes considered to suit condition are circular, turbine, elliptical and tangent shapes. When two equally important roads cross at roughly right angle, a circular shape is suitable.

**Weaving angle** – The angle between the path of a vehicle entering the rotary and that of another vehicle leaving the rotary at adjacent road, thus crossing the path of former is termed as the weaving angle, for smooth flow of traffic the weaving angle should be small but not less than 150 as the diameter of central island required will be too large.

**Weaving distance** – The weaving operation including merging and diverging can take place between the two channelizing island of adjacent intersecting legs and this length of the rotary roadway is
known as weaving length, the recommended value of weaving length are 30 to 60m for the design speed of 30 kmph.

**Width of carriageway at the entry and exit** – The carriageway width at the entrance and exit of a rotary is governed by the amount of traffic entering and leaving the rotary. It is recommended that the minimum width of the carriageway be at least 5m with necessary widening to account for the curvature of the road, Table A below gives the value of the width of carriageway at entry inclusive of widening needed on account of curvature.

<table>
<thead>
<tr>
<th>Carriageway width of the approach road</th>
<th>Radius at entry (m)</th>
<th>Width of carriageway at entry and exit (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7m (2 lanes)</td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td>10.5m (3 lanes)</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>14m (4 lanes)</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>21m (6 lanes)</td>
<td>13-25</td>
<td></td>
</tr>
<tr>
<td>7m (2 lanes)</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>10.5m (3 lanes)</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>14m (4 lanes)</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>21m (6 lanes)</td>
<td>15-25</td>
<td></td>
</tr>
</tbody>
</table>

**Width of rotary carriageway** – The width of rotary carriageway is further split into two parts, one is the width of the weaving section and the other is the width of the non-weaving section, the weaving section width should be one traffic lane wider than the entry width and the non-weaving section width should be equal to the widest single entry into the rotary and should generally be less than the width of the weaving section.

Weaving width can be found out with the following formula

\[ W = \text{average of } e_1 \text{ and } e_1 + 3.5m, \text{ where } W- \text{ width weaving section, } e_1- \text{ width at entry, } e_2- \text{ width of non-weaving section} \]

**Radius of curve at entry and exit** – For the design speed of 30kmph the recommended radius of curve at entry is 15 to 25 m. The radius of curve at the exit should be larger than that of the central island and at the entry so as to encourage the driver to pick up speed and clear away from the rotary expeditiously. For this reason the
radius of exit curve may be kept about 1.5 to 2 times the radius of entry curves

**Radius of Central Island** – Theoretically, the radius of central should be equal to the radius at entry. In practice, value of 1.33 times the radius of entry curve is suggested as a general guideline for adoption.

**Capacity of Rotary** – The practical capacity could be calculated from the following formula

\[ Q_p = 280 \frac{w}{w-e} (1 - \frac{p}{3}) (1 + \frac{w}{l}) \]

- \( Q_p \) = practical capacity of the weaving section of the rotary in passenger car unit (PCU) per hour.
- \( W \) = width of weaving section in meters
- \( e \) = Average entry width in meters (\( e/w \) to be within the range of 0.4 to 1.0)
- \( l \) = length in meters of the weaving section between the ends of channelizing islands (\( w/l \) to be within the range of 0.12 and 0.4)
- \( p \) = proportion of weaving traffic i.e. ratio of sum of crossing streams to the total traffic on the weaving section.
  The range of \( p \) being 0.4 to 1.0

**Traffic signage** – The important traffic signages used at the rotary intersection are KEEP LEFT, NO RIGHT TURN, STOP, ROTARY AHEAD, PEDESTRIAN CROSSING, etc. the details and location all those sign boards is shown in the typical layout.
### ii. Design criteria for separate cycle lane

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Justification for separate cycle tracks</td>
<td>Where the peak cycle traffic is 400 or more on routes with vehicular traffic of 100 - 200 veh/hr, where the motor vehicle traffic is more than 200 veh/hr, a separate cycle track are justified even if the cycle traffic is only 50 per hour</td>
</tr>
<tr>
<td>2. Capacity (per day)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 lanes</td>
</tr>
<tr>
<td></td>
<td>one way traffic</td>
</tr>
<tr>
<td></td>
<td>two way traffic</td>
</tr>
</tbody>
</table>
| 3. Horizontal Curves (radius) | (i) Minimum 10m,  
(ii) Where the gradient is steeper than 1 in 40, minimum radius shall be 15m. |
| 4. Vertical Curves | Minimum radius - submit curve - 200m and valley curve - 100m |
| 5. Gradients (gradient of 1 in 20 and 1 in 30 may be allowed for short lengths of 20m and 50m respectively) | Gradient | Maximum Length |
| | 1 in 30 | 90 |
| | 1 in 35 | 125 |
| | 1 in 40 | 160 |
| | 1 in 45 | 200 |
| | 1 in 50 | 250 |
| | 1 in 55 | 300 |
| | 1 in 60 | 300 |
| | 1 in 65 | 425 |
| | 1 in 70 | 500 |
| 6. Sight distance | Clear view should not be less than 25m. In gradient of 1 in 40 or steeper, clear view shall not be less than 60m. |
| 7. Lane width | 1 m per lane |
| 8. Width of pavement | Minimum of 2m (for 2 lanes) |
| 9. Clearance | (i) Vertical : 2.25 minimum and desirable 2.5m  
(ii) Horizontal : 0.25m |

**Table 3A:** Design criteria commonly adopted for cycle track

Other general considerations for the design of separate cycle tracks are:

1. **Preferably** Cycle track should be provided on both sides of the road.
2. They should be separated from the main carriageway be a verger or a berm, which should be preferably 0.5 to 1 m wide.
3. **Cycle** tracks should be constructed and maintained with care and should have good riding qualities. Black – topped and concreted surface provide smooth riding qualities, whereas water bound macadam and earthen tracks are not inviting for cyclists to ride upon.
4. The tracks should be clear of obstructions such as hedges, ditches, tree roots, kerbs etc. by at least 0.5m.
5. The design speed for cycles is about 32 km/hr.
iv. Patching and Repairing of Existing roads

(source: MoRTH, section 3004)

Filling Pot-holes and Patch Repairs

**Scope:** This work shall include repair of pot-holes and patching of all types of bituminous surfaces with a bituminous mix either produced at plant site or at the site itself with manual method of mixing and placed at site in the pot holes or in patches after trimming the pot-hole or depression to proper shape and depth, side painting with tack coat and compacting the layer to the levels specified in the drawing.

**Materials:** The materials used for the pot-hole and patch repair of bituminous surface shall be as per the Contract and shall be of the same type as used for the existing bituminous surface, A mix superior to the one on existing surface can also be considered appropriate for repair work. An emulsified bitumen mix compatible with the existing layer shall also be considered appropriate. The grading of aggregates and bitumen content of the mix used for such patch repair shall be in accordance with Clause 501.

**Preparation of the area for pot-hole and patch repair:** Each pot-hole and patch repair area shall be inspected and all loose material removed. The area shall be cut/trimmed either with jack hammer or hand tools like chisels, pick-axes etc., such that the area is in the shape of a rectangle or square. The edges shall be cut vertically upto the level where the lower layer is stable without any loose material. The area shall be thoroughly cleaned with compressed air or any appropriate method approved by the engineer to remove all dust and loose particles. The area shall be tacked or primed with cutback or emulsion depending upon whether the lower layer is bituminous or granular in nature. The sides, however, are to be painted with hoi lack coat material using a brush. The prime coat and tack coat shall conform to Clauses 502 and 503 of these Specifications, respectively.

**Backfilling operation:** The mix to be filled shall be either a hot mix or a cold storable mix (using bituminous emulsion). Mixing shall be done in a plant of suitable capacity. It shall be placed in thicknesses not more than 100 mm (loose). It shall be compacted in layers with roller/plate compactor/hand roller/rammer. While placing the final layer, the mix shall be spread slightly proud of the surface so that after rolling, the surface shall be flush with the adjoining surface. If the area is large, the spreading and levelling shall be done using hand shovel and wooden straight edge. During the process of compaction with roller or other means, the surface level shall be checked using a 3 m straight edge.

**Measurements for payment:** Filling of pot-holes and patch repair shall be measured in sq.m.
Rate: The Contract unit rate for filling of pot-holes and patch repair shall be in full compensation for:
(i) Furnishing all materials required;
(ii) Works involved in trimming, tacking, palming with cutback or emulsion;
(iii) All labor, tools, equipments and incidentals to complete the work in accordance with the Specifications.

---

**Work Inspection Guide (WING)**

**General Information**

Work Number __________________________

Locality __________________________

Name of Road/ Street/ Mauza/ Cross __________________________

From (door number/ site number) __________________________ To (door number/ site number) __________________________

Road length _______ mts Road width _______ mts

**Inspection Of (Tick the work being inspected)**

<table>
<thead>
<tr>
<th>Road</th>
<th>Drain</th>
<th>Footpath</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet Road with black top</td>
<td>Side</td>
<td>Earth</td>
</tr>
<tr>
<td>Inlet road without black top</td>
<td>Culvert</td>
<td>Snow slab</td>
</tr>
<tr>
<td>Cement concrete road</td>
<td>Shoulder</td>
<td>Interlocked pavers</td>
</tr>
<tr>
<td>Mud road</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Work Details (Information from ward engineers)**

Name of the work __________________________

Work code __________________________

Work order number __________________________

Name of contractor __________________________ Telephone Number __________

AEE in charge __________________________ Telephone Number __________

<table>
<thead>
<tr>
<th>Details</th>
<th>As per contract</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work start date</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date of completion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of work</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Work Evaluation (as per tender and technical sanction)**

As per contract specifications Yes [ ] No [ ]

Signature/Stamp of inspecting association
Roads
Pot hole: Road cut patching
1. Area cut into geometric shape
2. Area gauged out neatly
3. Loose material removed
4. Bitumen coated evenly on all surfaces and vertical edges
5. Aggregate compacted and level with surrounding surface

Jet setting
1. Mix layer thickness correct and uniform (\( \text{mm} \))
   - Additional 30% for compaction
   - Thickness specified in contract (\( \text{mm} \))
2. Camber achieved (1 in 50)

Rolling
- Number of passes (______)
- Overlap (30%)
- Sequence (edge to centre)
- No ridges after final pass

Asphalt
1. Patched and road cut patched
2. Surface cleaned of loose material
3. Tar or bitumen applied uniformly (spray [ ] rest [ ])
4. Mix layer thickness correct (______ mm)
   - Additional 30% for compaction
5. Thickness specified in contract (20 [ ] 25 [ ] 30 [ ] mm)
6. Camber achieved (1 in 50)

Rolling
- Number of passes (______)
- Overlap (50%)  
- Sequence (edge to centre)
- No ridges after final pass

Footpaths
1. Mud footpath
   - Clear vegetation
   - Compact earth

2. Stone slab footpath
   - Re-lay stone slab
   - Surface even/level
   - Replace broken stone slabs
   - Missing kerb-stones replaced/re-fixed

Cross section of road

Drains
Side/Shoulder
1. Discarded and cleared of debris
2. Broken slabs replaced

Cover
1. Discarded and cleared of debris
2. Broken slabs replaced
3. Cover slabs free of gaps
4. Surface flush with the adjoining roads

Has work been completed according to specifications? (Yes [ ] No [ ])
SECTION I: Metalling (Base Course)

Laying Water Bound Macadam

1. Shoulder
   a. Shoulders compacted down
   b. Kerb stone firmly bedded (optional)

2. Standard Thickness of metalling layers after compaction
   WBM grade I: 100mm
   WBM grade II: 75mm
   WBM grade III: 75mm

3. Aggregate Spread
   a. Measure thickness during execution at edges BEFORE Compaction
   b. Layer thickness 33% more than specified compacted thickness

4. Rolling
   a. If dual Camber is required, the rolling should start along either edge and shift in toward the center after each lap
   b. If single camber is required rolling should start from lower edge and proceed toward higher level after each lap
   c. Rolling runs should overlap by 50% for uniform compaction
   d. Each completed compaction across the width of the road is called a pass. There should be 4-6 such "passes" of compaction
   e. Walk on freshly compacted metal to test quality. It must NOT feel like walking on dry leaves

SECTION II: Asphaltic

A. Preparation before overlaying or re-surfacing

1. Drainage
   a. Side drains and shoulder drains must be desilted before asphalting
   b. Debris to be removed within 24 hours.

2. Potholes & Ruts
   a. Affected area gouged out to a rectangle/square shape (with sides vertical), down to a depth where base is stable and free of loose material
   b. All loose material and dust removed
   c. (Only if exposed base is non-bituminous aggregate) Prime coat of Cut-back bitumen or bituminous emulsion applied
   d. Tack coat of bitumen applied:
      * Either hot, or Cut-back grade, or emulsion
      * All surfaces (including the vertical edges) fully and
uniformly coated

e. **Pre-mix bituminous material** prepared and filled into the cavity and compacted
   * Hot mix with well-graded aggregate of specified size and at 145 to 155 °C OR
   * Cold mix of graded aggregate and bituminous emulsion OR
   * Hot or cold mix with open-graded aggregate of specified size
   AND
   Hot or cold mix with open-graded aggregate of specified size
   AND

f. **Seal coat** applied
   * Material placed in layers (50 to 100 mm thick) and each layer well compacted, till the final layer is at the same level as the adjoining area.

3. **Surface cracks** (upto 3mm width)
   a. Surface clean and dust-free
   b. "Fog Seal" applied Bituminous emulsion applied (by hand spray or pressure distributor)
      * Left to cure for one hour before allowing traffic+A87 OR
      * "Seal Coat (Type A)" applied:
      * Hot bitumen sprayed (Coverage to be uniform)
      * Aggregate spread and rolled (8-IOT roller) OR
      * "Seal Coat (Type B)" applied
      * Hot mix of bitumen and aggregate (2:36-0.18 mm)
        prepared
      * Mix laid (6 mm thick)
      * Rolled (8-IOT roller)

4. **Depression filling & Profile correction** (Not necessary if max fault is less than 40 mm deep as it can be taken care of during resurfacing/overlaying)
   a. Surface is free of dust
   b. Tack coat applied
      * Applied by spray
      * Coverage is uniform
   c. Bituminous pre-mix spread and rolled in successive layers of compacted thickness 50 to 75 mm each, till depression is totally leveled out and also correct camber (2% or 1 in 50) is achieved

5. **Rectification of incorrectly filled road cuttings or trenches**
   i) The section below is not part of any specification, but given as expert advice (If filled material is firm and has got compacted)
   a. Material dug out to depth of 0.3m
b. Cavity refilled with sand (or crusher stone dust) and compacted to a thickness of 100mm

c. A layer of graded crushed hard aggregate (50 to 10 mm) size laid to a loose thickness of 100 mm, and compacted to 75 mm thickness

d. *Prime coat (Cut-back bitumen) applied

e. *Tack coat (Applied by spray and of uniform coverage)

f. **BM** layer of compacted thickness 75 mm laid (as per Section B)

g. **MSS** layer of compacted thickness 20 mm laid (as per Section C)

ii) If filled material is loose

   a. Material dug out to depth of 0.5m
   b. Cavity refilled with sand (or crusher stone dust) laid in two layers and compacted to a final thickness of 180 mm
   c. Three layers of graded stone aggregate (50 to 10 mm) size laid, each layer compacted to a thickness of 75 mm before spreading the next layer
   d. Prime coat (Cut-back bitumen) applied
   e. Tack coat applied by spray and uniformly
   f. **BM** layer of compacted thickness 75 mm laid (as per Section)
   g. **MSS** layer of compacted thickness 20 mm laid (as per Section)

B. Laying of Bituminous Macadam

1. Preparatory
   a. Complete procedures under B, ‘Preparations’
   b. Dust and loose soil cleared

2. Bitumen coating
   a. Prime coat applied (Only if the existing base is non-bituminous/ granular)
      *Bituminous material of low viscosity (viz. Cut-back bitumen or emulsion) sprayed
      *Allowed to cure for 12 hours
   b. Tack coat applied
      * Applied by spray and uniformly

3. Aggregate mix laying
   a. Aggregate size as specified
   b. Bitumen temp (145-155 deg C)
   c. Spread thickness (25 to 30 % more than specified compacted thickness)
4. Rolling
   a. Roller weight (8 to 10 t)
      Rolling sequence
      *(In case of dual camber: Along edge, shifting
towards center after each run, with 50%
overlap. Repeat from the other edge)*
      OR
      *(In case of single camber: Along the lower edge
shifting towards higher edge after each run, with
50% overlap)*
   b. No. of passes (4 to 6 complete passes)
   c. No rolling marks to be visible during final run
   d. Rolling completed before mix temperature falls below
   100°C

5. Usage restriction
   a. Road not to be opened for traffic unless cooled down to
      ambient temperature and a surfacing course (BC or MSS or
      PC or at least Seal coat) has been applied

C. Laying of Pre-mix Carpet (PC) or Mixed Seal Surfacing
(MSS) (4.1 and 4.2 required only if PC/MSS is being laid on
old existing black top surface and not on freshly constructed
BM / DBM surface )

1. Surface preparation
   a. Complete procedures as per section B

2. Bitumen (Tack) coat
   a. Applied by spray and with uniform coverage
   b. Bitumen/Aggregate layer
   c. Aggregate sizes (22.4-11.2 mm & 13.2-5.6 mm for PC ;
      Various for MSS)
   d. Bitumen temp (145-155°C )
   e. Bitumen uniformly coated
   f. Spread thickness (27 mm) compacted to 20 mm

3. Rolling
   a. As per C.4
   b. Rolling must be started before mix temperature comes
down to 120°C and completed before it falls below 100°C
   c. Final layer thickness should be average 20 mm(Check
      within a few hours of completion

4. Seal Coat
   (Only required on PC layer and is to be applied before cooling down)
   (Type A)
   a. Bitumen sprayed to seal off all voids on the surface
   b. Aggregate (11.2 to 2.6 mm) spread immediately and rolled
      (Type B)
   c. Coarse sand (2.36 to 0.18) pre-mixed with bitumen spread
and rolled immediately

5. Surface Finish Checks
   a. When water is poured, make sure it flows either along the slope of the road or across the width of the road
   b. When water is poured on the surface of the road, absorption of a very small proportion of about 5% is acceptable.
   c. Longitudinal undulations causing uncomfortable ride in a small car or scooter is not acceptable
   d. Camber (At least 2%, or 1 in 50)

SECTION III: Bituminous Concrete

1. Complete all procedures under asphalting

2. Tack Coat application
   Applied by spray [not perforated can]

3. Aggregate Mix Laying
   a. Aggregate size as specified (Checked by sieves)
   b. Bitumen mix temp (145-155°C)
   c. Spread thickness (25% more than specified compacted thickness)

4. Rolling
   As per section II-C

5. Surface Finish Checks
   a. When water is poured, make sure it flows either along the slope of the road or across the width of the road
   b. When water is poured on the surface of the road, absorption of a very small proportion, of about 5% is acceptable.
   c. Longitudinal undulations causing uncomfortable ride in a small car or scooter is not acceptable
   d. Camber (At least 2%, or 1 in 50)
### vi. Material Testing Specifications

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Type of Construction</th>
<th>Test</th>
<th>Frequency (min)</th>
</tr>
</thead>
</table>
| 1      | Granular             | (i) Gradation  
       |                     | (ii) Atterberg limits  
       |                     | (iii) Moisture content prior to compaction  
       |                     | (iv) Density of compacted layer  
       |                     | (v) Deleterious constituents  
       |                     | (vi) C.B.R.  | One test per 200 m³  
       |                     |                  | One test per 200 m³  
       |                     |                  | One test per 250 m³  
       |                     |                  | As required  
       |                     |                  | As required  |
| 2      | Lime/Cement Stabilised Soil Sub-base  
       |                     | (i) Quality of lime/cement  
       |                     | (ii) Lime/Cement content  
       |                     | (iii) Degree of pulverization  
       |                     | (iv) CBR or Unconfined Compressive Strength test on a set of 3 specimens  
       |                     | (v) Moisture content prior to compaction  
       |                     | (vi) Density of compacted layer  
       |                     | (vii) Deleterious constituents  | One test per each consignment subject to a minimum of one test per 3 tonnes  
       |                     |                  | Regularly, through procedural checks  
       |                     |                  | Periodically as considered necessary  
       |                     |                  | As required  
       |                     |                  | One test per 250 sq. m.  
       |                     |                  | One test per 500 m³  
       |                     |                  | As required  |
| 3      | Water Bound Macadam  
       |                     | (i) Aggregate Impact Value  
       |                     | (ii) Grading  
       |                     | (iii) Flakiness Index and Elongation Index  
       |                     | (iv) Atterberg limits of binding material  
       |                     | (v) Density of compacted layer  
       |                     | (vi) Portion of aggregate passing 425 micron sieve  | One test per 200 m³ of aggregate  
       |                     |                  | One test per 100 m³  
       |                     |                  | One test per 200 m³ of aggregate  
       |                     |                  | One test per 25 m³ of binding material  
       |                     |                  | One test per 100 cubic metre of aggregate  |
| 4      | Wet Mix Macadam  
       |                     | (i) Aggregate Impact Value  
       |                     | (ii) Grading  
       |                     | (iii) Flakiness and Elongation Index  
       |                     | (iv) Atterberg limits of portion of aggregate passing 425 micron sieve  
       |                     | (v) Density of compacted layer  | One test per 200 m³ of aggregate  
       |                     |                  | One test per 100 m³ of aggregate  
       |                     |                  | One test per 200 m³ of aggregate  
       |                     |                  | One test per 100 m³ of aggregate  
       |                     |                  | One test per 500 m²  |

AA. Control tests and their minimum frequency for subbases and bases (excluding bitumen bound bases)  
(Source: MoRTH - table 900-3)
<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Type of Construction</th>
<th>Test</th>
<th>Frequency (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prime Coat/Tack Coat</td>
<td>(i) Quality of binder</td>
<td>Two samples per lot to be subjected to all or some tests as directed by the Engineer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) Binder temperature for application</td>
<td>At regular close intervals Two tests per day.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) Rate of spread of binder</td>
<td>Two samples per lot. Dressing to be subjected to all or some tests as directed by the Engineer.</td>
</tr>
<tr>
<td>2</td>
<td>Seal Coat/Surface Dressing</td>
<td>(iv) Quality of binder</td>
<td>One test per 50 m³ of aggregate.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(v) Aggregate Impact Value</td>
<td>One test per 50 m³ of aggregate. Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(vi) Flakiness Index and Elongation Index of aggregates</td>
<td>One test per 25 m³ of aggregate. Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(vii) Water absorption of aggregates</td>
<td>One test per 50 m³ of work. As required.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(viii) Grading of aggregates</td>
<td>At regular close intervals One test per 500 m³ of work.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ix) Stone polishing value</td>
<td>Two samples per lot to be subjected to all or some tests as directed by the Engineer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(x) Temperature of binder at application</td>
<td>One test per 50 m³ of aggregate. -do. Same as mentioned under Serial No. 2.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(xi) Binder content</td>
<td>As required. At regular close intervals Two tests per day.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(xii) Rate of spread of materials</td>
<td>Regular control through checks on materials and layer thickness.</td>
</tr>
<tr>
<td>3</td>
<td>Open-graded Premix Carpet/Mix Seal Surfacing</td>
<td>(i) Quality of binder</td>
<td>Two samples per lot to be subjected to all or some tests as directed by the Engineer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) Aggregate Impact Value</td>
<td>One test per 50 m³ of aggregate. -do.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) Flakiness Index and Elongation Index of aggregates</td>
<td>Same as mentioned under Serial No. 2. Two tests per day per plant both on the individual constituents and mixed aggregates from the dryer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iv) Water absorption of aggregates</td>
<td>Same as in Serial No. 2 Periodic, subject to minimum of two tests per day per plant.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(v) Grading of aggregates</td>
<td>At regular close intervals. Regular control through checks of layer thickness.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(vi) Binder content</td>
<td>Two samples per lot to be subjected to all or some tests as directed by the Engineer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(vii) Control of temperature of binder and aggregate for mixing and of the mix at the time of laying and rolling</td>
<td>One test per 200 m³ of aggregate. -do. Same as mentioned under Serial No. 2.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(viii) Rate of spread of mixed material</td>
<td>Same as in Serial No. 2 One test per 100 m³ of aggregate.</td>
</tr>
<tr>
<td>4</td>
<td>Bituminous Macadam</td>
<td>(i) Quality of binder</td>
<td>Two samples per lot to be subjected to all or some tests as directed by the Engineer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) Aggregate Impact Value</td>
<td>One test per 50 m³ of aggregate. -do.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) Flakiness Index and Elongation Index of aggregates</td>
<td>Same as mentioned under Serial No. 2. Two tests per day per plant both on the individual constituents and mixed aggregates from the dryer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iv) Water absorption of aggregates</td>
<td>Same as in Serial No. 2 Periodic, subject to minimum of two tests per day per plant.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(v) Grading of aggregates</td>
<td>At regular close intervals. Regular control through checks of layer thickness.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(vi) Binder content</td>
<td>Two samples per lot to be subjected to all or some tests as directed by the Engineer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(vii) Control of temperature of binder and aggregate for mixing and of the mix at the time of laying and rolling</td>
<td>One test per 200 m³ of aggregate. -do. Same as mentioned under Serial No. 2.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(viii) Rate of spread of mixed material</td>
<td>Same as in Serial No. 2 One test per 100 m³ of aggregate.</td>
</tr>
<tr>
<td>5</td>
<td>Bituminous Penetration Macadam/ Built-up Spray-GROUT</td>
<td>(i) Quality of binder</td>
<td>Two samples per lot to be subjected to all or some tests as directed by the Engineer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) Aggregate Impact Value</td>
<td>One test per 200 m³ of aggregate. -do.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) Flakiness Index and Elongation Index of aggregates</td>
<td>Same as mentioned under Serial No. 2. Two tests per day per plant both on the individual constituents and mixed aggregates from the dryer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iv) Water absorption of aggregates</td>
<td>Same as in Serial No. 2 Periodic, subject to minimum of two tests per day per plant.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(v) Aggregate grading</td>
<td>At regular close intervals. Regular control through checks of layer thickness.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(vi) Temperature of binder at application</td>
<td>Two samples per lot to be subjected to all or some tests as directed by the Engineer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(vii) Rate of spread of binder</td>
<td>One test per 500 m³ of area.</td>
</tr>
</tbody>
</table>

68. Control tests and their minimum frequency for subbases and bases (excluding bitumen bound bases) (source: MoRTH - table 900-3)
### ANNEXURE 6  
**MATERIAL TESTING SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Type of Construction</th>
<th>Test</th>
<th>Frequency (min)</th>
</tr>
</thead>
</table>
| 6      | Dense Bituminous Macadam/Semi Dense Bituminous Concrete/Bituminous Concrete | (i) Quality of binder  
(ii) Aggregate Impact Value  
(iii) Flakiness Index and Elongation Index of aggregates  
(iv) Stripping Value  
(v) Water absorption of aggregates  
(vi) Sand equivalent test  
(vii) Stone Polishing Value  
(viii) Mix grading  
(ix) Stability of Mix  
(x) Water sensitivity of mix (Retention of Marshall Stability)  
(xi) Swell test on the mix  
(xii) Control of temperature of binder in boiler, aggregate in the dryer and mix at the time of laying and rolling  
(xiii) Control of binder content and gradation in the mix  
(xiv) Rate of spread of mixed material  
(xv) Density of compacted layer | Two samples per lot to be subjected to all or some tests as directed by the Engineer  
One test per 50 m³ of aggregate  
- do  
As in Serial No. 2  
As in Serial No. 2  
As required  
As required for Semi Dense Bituminous Concrete / Bituminous Concrete  
One set of tests on individual constituents and mixed aggregate from the dryer for each 400 tonnes of mix subject to a minimum of two tests per plant per day  
For each 400 tonnes of mix produced, a set of 3 Marshall specimens to be prepared and tested for stability, flow value, density and void content subject to a minimum of two sets being tested per plant per day  
As required for Bituminous Concrete  
- do  
At regular close intervals  
One test for each 400 tonnes of mix subject to a minimum of two tests per day per plant  
Regular control and through checks on the weight of mixed material and layer thickness  
One test per 250 m² area |
<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Type of Construction</th>
<th>Test</th>
<th>IS codes</th>
<th>Frequency (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cement</td>
<td>Physical and chemical tests</td>
<td>IS : 269, IS : 455, IS : 1459, IS : 8112, IS : 12269</td>
<td>Once for each source of supply and occasionally when called for in case of long/improper storage. Besides, the Contractor also will submit daily data on cement released by the Manufacturer</td>
</tr>
</tbody>
</table>
| 2     | Coarse and Fine aggregates | (i) Gradation                             | IS : 2386 (Pt 1) | One use test for every day's work of each fraction of coarse aggregate and fine aggregate, initially; may be relaxed later at the discretion of the Engineer.  
(ii) Deleterious constituents  
(iii) Water absorption     |
| 3     | Coarse aggregates         | (i) Los Angeles Abrasion value or Aggregate impact test  
(ii) Soundness  
(iii) Alkali aggregate reactivity | IS : 2386 (Pt 4), IS : 2356 (Pt 5), IS : 2386 (Pt 7) | Regularly as required subject to a minimum of one test a day for coarse aggregate & two tests a day for fine aggregate. This data shall be used for correcting the water demand of the mix on daily basis.  
Once for each source of supply and subsequently on monthly basis.  
Before approving the aggregates and every month subsequently do- |
| 4     | Water                     | Chemical Tests                            | IS : 456         | Once for approval of source of supply, subsequently only in case of doubt,  
2 cubes and 2 beams per 150 in² or part thereof (one for 7-day and other for 28-day strength) or minimum 6 cubes and 6 beams per day's work whichever is more.  
As per the requirement of the Engineer; only in case of doubt.  
One test per each dumper load at both Batching plant site and paving site initially when work starts. Subsequently sampling may be done from alternate dumpers.  
From the level data of concrete pavement surface and sub-base at grid points of 5/6.25 m x 3.5 m  
3 cores per trial length.  
String line or steel forms shall be checked for level at an interval of 5.0 m or 6.25 m. The level tolerance allowed shall be ± 2mm. These shall be got approved 1-2 hours before the commencement of the concrete activity. |
| 5     | Concrete                  | (i) Strength of concrete                  | IS : 516         |                                                                                                                                               |
|       |                           | (ii) Core strength on hardened concrete  
(iii) Workability of fresh concrete- 
Slump Test  
(iv) Thickness determination  
(v) Thickness measurement for trial length  
(vi) Verification of level of string line in the case of slip form paving and steel forms in the case of fixed form paving | IS : 516, IS : 1199 |                                                                                                                                               |

6C. Frequency of quality control tests for paving quality concrete  
(source: MoRTH - table 900-6)
Design Approach & Criteria

Carriage of the road can mostly be design by the following three layer structure
1. Bituminous surface layer(s)
2. Granular Base
3. Granular Sub base

This structure rests on sub-grade which in turn rests on natural ground.

Design of Flexible Pavement

The following sub sections describe the various variables and parameters involved in design of flexible pavement of road as per IRC 37 - 2001.

Traffic- CV/Day Annual traffic census 24 X 7

For structural design, commercial vehicles are considered. Thus vehicle of gross weight more than 8 tonnes load are considered in design. This is arrived at from classified volume count.

Wheel loads

Urban traffic is heterogeneous. There is a wide spectrum of axle loads plying on these roads. For design purpose it is simplified in terms of cumulative number of standard axe (8160 kg) to be carried by the pavement during the design life. This is expressed in terms of million standard axles or msa.

Climate

Temperature is an important factor affecting the performance of flexible pavement (Hot or Cold). Most of our country comes under hot climate. In urban scenario, the traffic is heterogeneous. There is sizable bicycle traffic. There is sizable pedestrian traffic. The demand for road can be estimated by a classified volume count of traffic. This survey should be conducted for seven days throughout – 24 x 7 surveys. All vehicle categories including non motorised traffic like bicycles, animal driven carts etc. There should be a separate pedestrian survey. An Origin – Destination (OD) survey to estimate preference for a particular route may also be carried out. Locations attracting heavy traffic demand such as Government offices, commercial centres, hospitals, educational institutes, religious and other places of interest may be marked and traffic generated should be estimated.
A detailed socio economic study is required for understanding and future trends. Planning must provide for future requirements. It is usually found that the future projections are overtaken by faster developments, people start development faster than estimated years the grade of bitumen to be used in surface layers. Planning must provide for future requirements. Considerations for different climate are given in annexure 6 of IRC 37 – 2001.

**Terrain Plain or Hilly**

The terrain is dependent on natural gradient available. When natural gradient is up to 10 percent, it is known as plain terrain. When natural gradient is between 10 to 25 percent, terrain is known as rolling. When natural gradient is between 25 to 60 percent, terrain is known as hilly. And when natural gradient is more than 60 percent, terrain is known as steep terrain.

**Pavement Thickness**

Pavement Thickness Composition can be decided by using following chart presented in figure 10A.

Design Traffic

Computation of design Traffic In terms of cumulative number of standard axle to be carried by the pavement during design life.

\[
n = \frac{(365 \times (1 + r)^r - 1)}{r} \times A \times D \times F
\]
ANNEXURE 7  FLEXIBLE PAVEMENT DESIGN

Where,
N = The cumulative number of standard axles to be catered for in design in terms of million standard axles - msa.
A = Initial traffic in the year of completion of construction duly modified as shown below. D = Lane distribution factor
F = Vehicle damage factor, VDF
n = Design life in years
r = Annual growth rate of commercial vehicles

\[ A = P \left(1 + r\right) \]

Where,
P = Number of commercial vehicle as per last count
X = Number of years between the year of last count and the year of completion of construction
D = Lane distribution factor

It is the distribution of commercial traffic over the carriageway. It should be considered by deciding the lane of the road. Following values should be taken for lane distribution factor.

<table>
<thead>
<tr>
<th>Description</th>
<th>Lane Distribution Factor (D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Lane Road</td>
<td>1.00</td>
</tr>
<tr>
<td>Two Lane Single Carriageway</td>
<td>0.75</td>
</tr>
<tr>
<td>Two Lane Double Carriageway</td>
<td>0.40</td>
</tr>
<tr>
<td>Four Lane Single Carriageway</td>
<td>0.40</td>
</tr>
<tr>
<td>Four Lane Double Carriageway</td>
<td>0.45</td>
</tr>
</tbody>
</table>

F = Vehicle damage factor (VDF).

It is a multiplier to convert the number of CV of different axle load and axle configuration to the number of standard axle load repetition. VDF depends on vehicle configuration, axle load, terrain, type of road. Where sufficient information of axle load is not available then the VDF value considered are presented in table 10.2.

<table>
<thead>
<tr>
<th>Initial Traffic volume in terms of Commercial</th>
<th>Terrain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles per Day</td>
<td></td>
</tr>
<tr>
<td>0-150</td>
<td>1.5</td>
</tr>
<tr>
<td>150-1500</td>
<td>3.5</td>
</tr>
<tr>
<td>More than 1500</td>
<td>4.5</td>
</tr>
</tbody>
</table>
In view of the concept of cumulative axle loads, it is now possible to design a flexible pavement for a definite period.

**Design Period**

A design period of 15-20 years should be adopted for arterials sub-arterial and 10-15 years should be adopted for local and Collector Street. A higher design should be taken for small towns and lower period for large cities. For high volume streets and busy intersections, peak hour volumes should be used to determine the width of road.

For Arterial & Sub arterial 15-20 years
For collector & local road 10-15 years
Expressway and Urban Roads - 20 Years
N H & SH – 15 Years
Other Roads – 10 – 15 Years

Traffic Growth: From the data’s available for the last five or ten years traffic census traffic growth can be determined. In absence of adequate data, an average value of 7.5 % per annum growth rate may be adopted.

**CBR Value**

California Bearing Ratio (CBR) Value as per IS 2720 (Part-XVI):

- CBR is an indirect measure of the stability of sub-grade i.e. the capacity to resist deformations under wheel loads.
- CBR value is determined by conducting the CBR test on specimen in laboratory as per the procedure laid down in IS 2720 Part:- XVI
- It is basically a penetration test.
- The CBR test is carried out in standard CBR apparatus & the standard test procedure prescribed in accordance with IS 2720(part-XVI) as per the requirement.
- The material is statically compacted in three layers at MDD & OMC determined by a standard proctor test as per IS 2720 – part:7 for light compaction or IS-2720- part:8 for heavy compaction as per the requirement.
- The sample is subjected to 4 days soaking.
- There after a plunger of 50 mm dia. is allowed to penetrate in the material at the rate of 1.25 mm/min.
- The required loads required causing 2.5 mm & 5.0 mm penetrations are recorded.
- These loads are then expressed as percentages of standard/loads, which are the loads for corresponding penetrations in standard crushed stone aggregates.
- Higher of two values is adopted as CBR value.

As per the IS requirements three samples shall have to be tested for CBR and the average CBR value of three samples is taken as final CBR provided the CBR value of all three samples are within the permissible limit of variation.
### Annexure 7: Flexible Pavement Design

#### Table 2.7: Recommended Design for Traffic range 1-10 msa 1

<table>
<thead>
<tr>
<th>msa for given CBR Value</th>
<th>Total Thickness (mm)</th>
<th>Bituminous Surfacing</th>
<th>Binder Course (mm)</th>
<th>Base Course</th>
<th>Sub base Course</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Wearing Course</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBR 3%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>550</td>
<td>20 PC</td>
<td>225</td>
<td>435</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>610</td>
<td>20 PC</td>
<td>225</td>
<td>335</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>645</td>
<td>20 PC</td>
<td>230</td>
<td>335</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>650</td>
<td>20 PC</td>
<td>230</td>
<td>335</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>670</td>
<td>40 BC</td>
<td>250</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBR 2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>660</td>
<td>20 PC</td>
<td>225</td>
<td>433</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>715</td>
<td>20 PC</td>
<td>225</td>
<td>440</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>750</td>
<td>20 PC</td>
<td>230</td>
<td>440</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>755</td>
<td>25 SDBC</td>
<td>230</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>850</td>
<td>40 BC</td>
<td>250</td>
<td>460</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBR 4%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>460</td>
<td>20 PC</td>
<td>225</td>
<td>255</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>540</td>
<td>20 PC</td>
<td>225</td>
<td>265</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>560</td>
<td>20 PC</td>
<td>230</td>
<td>280</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>620</td>
<td>25 SDBC</td>
<td>230</td>
<td>285</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>700</td>
<td>40 BC</td>
<td>250</td>
<td>330</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBR 5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>430</td>
<td>20 PC</td>
<td>225</td>
<td>205</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>450</td>
<td>20 PC</td>
<td>225</td>
<td>215</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>530</td>
<td>20 PC</td>
<td>230</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>560</td>
<td>25 SDBC</td>
<td>230</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>660</td>
<td>40 BC</td>
<td>230</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBR 6%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>390</td>
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<td>225</td>
<td>165</td>
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<td>2</td>
<td>450</td>
<td>20 PC</td>
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<td>175</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>490</td>
<td>20 PC</td>
<td>230</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>535</td>
<td>25 SDBC</td>
<td>230</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>615</td>
<td>40 BC</td>
<td>250</td>
<td></td>
<td></td>
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<tr>
<td>CBR 7%</td>
<td></td>
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</tr>
<tr>
<td>1</td>
<td>375</td>
<td>20 PC</td>
<td>225</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>425</td>
<td>20 PC</td>
<td>225</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>460</td>
<td>20 PC</td>
<td>250</td>
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</tr>
<tr>
<td>4</td>
<td>505</td>
<td>25 SDBC</td>
<td>250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>580</td>
<td>40 BC</td>
<td>250</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CBR 8%</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

*Note: The CBR values and corresponding pavement designs are illustrative and may vary based on specific traffic and soil conditions.*
### ANNEXURE 7
### FLEXIBLE PAVEMENT DESIGN

<table>
<thead>
<tr>
<th>msa for given CBR Value</th>
<th>Total Thickness (mm)</th>
<th>PAVEMENT COMPOSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Bituminous Surfacing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wearing Course (mm)</td>
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<tr>
<td></td>
<td></td>
<td>Binder Course (mm)</td>
</tr>
<tr>
<td>1</td>
<td>375</td>
<td>20 PC</td>
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<td>2</td>
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<td>3</td>
<td>450</td>
<td>20 PC</td>
</tr>
<tr>
<td>5</td>
<td>475</td>
<td>25 SDBC</td>
</tr>
<tr>
<td>10</td>
<td>550</td>
<td>40 BC</td>
</tr>
</tbody>
</table>

CBR 9% & 10%

| 1                        | 375                  | 20 PC                | 225        | 150            |
| 2                        | 425                  | 20 PC                | 225        | 150            |
| 3                        | 450                  | 20 PC                | 250        | 150            |
| 5                        | 475                  | 25 SDBC              | 250        | 150            |
| 10                       | 540                  | 40 BC                | 250        | 200            |

Source: IRC 37; 1998

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**Figure 10B**: Pavement thickness design chart for traffic 10-150 msa
<table>
<thead>
<tr>
<th>msa for given CBR Value</th>
<th>Total Thickness (mm)</th>
<th>Bituminous Surfacing</th>
<th>PAVEMENT COMPOSITION</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>BC (mm)</td>
<td>DBM (mm)</td>
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<tr>
<td>CBR 2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>850</td>
<td>40</td>
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<tr>
<td>20</td>
<td>880</td>
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<td>150</td>
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<tr>
<td>CBR 3%</td>
<td></td>
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<tr>
<td>10</td>
<td>760</td>
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<td>CBR 4%</td>
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<tr>
<td>150</td>
<td>820</td>
<td>50</td>
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<tr>
<td>CBR 5%</td>
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</tr>
<tr>
<td>10</td>
<td>660</td>
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<td>Base = 250</td>
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<td>Base = 250</td>
<td>Sub base = 200</td>
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References
REFERENCES

- Better streets better cities – a (draft) manual for street design in urban India, ITDP – EPC, 2010
- National Urban Transport Policy, 2006, MoUD, GoI
- Design guideline for allocation of On-street parking, 2004, City of Yarra
- Standard Paving Detail, City of Jacksonville Standard
- Design & Safety of pedestrian facilities, 2009, Dr. PurnimaParida, CRRI, New Delhi
- Pedestrian Design Guidelines, 2009, UTITPEC, Delhi Development Authority, New Delhi
- Policy paper for pedestrian movement in the Bangalore Metropolitan Region, 2008, Draft Report, DULT, Bangalore
- Roads and sidewalk standards, 2000, city of Port Alberni, Engineering Department
- Reference guide for urban road design, 2009, SuhasKulhalli, praja.in
- The Karnataka Transparency in Public Procurements Act, 1999, GoK
- Guidelines for construction and maintenance of City Roads, 2009, Bruhat Bengaluru Mahanagara Palike
- Schedule of Rates, 2010-2011, PWD, Bangalore Circle, Bangalore
- Role of Transportation in society, 2006, Tom V. Mathew and K V Krishna Rao
- R. Ewings, Washington Institute of Transport. Published in APA Planners Press and American Society of Civil Engineers, 2009
- Ahmedabad BRTS, 2005, working paper-4, Centre for Environmental Planning & Technology University, Ahmedabad
- A Policy on the accommodation of utilities within freeway R-o-w, 2005, AASHTO
- Concrete Pavement Construction Basics, 2006, Centre for Transportation Research and Education, Iowa State University
- India Transport at a Glance, 2005, The South Asia Energy and Infrastructure group of World Bank
- National Policy on Urban Street Vendors, 2006, GoI
- Technical Specifications of Hyderabad Growth Corridor, 2007-2008, Hyderabad Growth Corridor Limited
REFERENCES

- Brigade Road Improvements, 2010, Invicus Engineering Co. Pvt. Ltd
- Road Standard drawings, 2009, City of Yarra
- Facelift of VittalMallya Road, 2009, Prestige Group and Invicus Engineering Co. Pvt. Ltd
- Signal pole and utility coordination drawings, Invicus Engineering Co. Pvt Ltd
- Roads and sidewalk standards, 2000, City of Port Alberni
- Construction of four lane roads in Gulbarga City Corporation Limit, Karnataka Road Development Corporation Limited, Bangalore

- MoRTH, 2000, Specifications for Road and Bridge Works
- MoRTH, 2002, Pocketbook for Highway Engineers
- IRC: 98 (under revision), Guidelines on Accommodation of Utility Services on Roads in Urban Areas
- IRC: 99 – 1988, Tentative guidelines on the provision of Speed Breakers for control of Vehicular Speeds on Minor Roads
- IRC: 95 – 1987, Specification for Semi-Dense Bituminous Concrete
- IRC: 94-1986, Specification for Dense Bituminous Macadam
- IRC: 93-1985, Guidelines on Design and Installation of Road Traffic Signals
- IRC: 92-1985, Guidelines for the Design of Interchanges in Urban Areas
- IRC: 69-1977, Space standards for Road in Urban Areas
- IRC: 37-2001, Guidelines for the design of Flexible Pavements
- IRC: 35-1997, Code of practice for Road Markings
- IRC: 29-1988, Specification for Bituminous Concrete for Road Pavement
- IRC: 27-1967, Tentative specification for Bituminous Macadam
- IRC: 103-1988, Guidelines for Pedestrian Facilities
- IRC: 19-1977, Standard specification and code of practice for Water Bound Macadam
- IRC: SP 41, 1944, Guidelines for the design of At-grade intersections in Rural and Urban Areas
MoRT&H, 2000, Specifications for Road and Bridge Works
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IRC: 19-1977, Standard specification and code of practice for Water
Bound Macadam
IRC: SF 41, 1944, Guidelines for the design of At-grade intersections
in Rural and Urban Areas

www.arc.govt.nz
www.bangaloretrafficpolice.gov.in
www.bbmp.gov.in
www.bmtcinfo.com
www.eproc.karnataka.gov.in
www.ijanaagraha.org
www.lta.gov.sg
www.trafficcalming.org
www.chennainicityconnect.com
samarthyam.org
Glossary
Aggregate
Stone and gravel of various sizes which compose the major portion of the surfacing material. The sand or pebbles added to cement in making concrete.

Aggregate Base Course
The layer of material laid immediately beneath the pavement. It may be composed of crushed stone, crushed or uncrushed sand and gravel, or combinations of these materials. To provide the service intended it must be uniform in strength to support the pavement.

Alignment
The vertical and horizontal location of a road.

Arbitrator
A private, neutral person chosen to arbitrate a disagreement, as opposed to a court of law. An arbitrator could be used to settle any non-criminal dispute, and many business contracts make provisions for an arbitrator in the event of a disagreement. Generally, resolving an disagreement through an arbitrator is substantially less expensive than resolving it through a court of law.

Arbitration
A process in which a disagreement between two or more parties is resolved by impartial individuals, called arbitrators, in order to avoid costly and lengthy litigation.

Auxiliary Lane
Auxiliary lanes are added at the intersection, usually to accommodate turning motor vehicle

Average Daily Traffic or ADT
A measurement of the number of vehicle which use a highway over a period of a year divided by 365 to obtain the average for a 24-hour period.

Backfill
Material used to replace, or the act of replacing, material removed during construction. Also, may denote material placed, or the act of placing material adjacent to structures.

Base
A course of fairly rigid material, sometimes cement- or asphalt-treated, that is placed on the sub--base to provide a stable platform for the concrete pavement slab.

Bid
Bid means the documents in their entirety comprised in the bid submitted by the Bidder in response to the Tender Notice in accordance with the provisions thereof.

Bicycle Lanes
Portions of a roadway set aside for bicycle use, with the lanes distinguished from the motor vehicle portion of the roadway by painted stripes, curbs, or parking blocks.

Bitumen
A natural asphalt or substance found in a natural state or a residue by-product from petroleum refinement.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bituminous</td>
<td>Containing Bitumen</td>
</tr>
<tr>
<td>Borrow Pit</td>
<td>The source of approved material required for the construction of embankments, or other portions of earthwork requirements.</td>
</tr>
<tr>
<td>BRT</td>
<td>Bus rapid transit (BRT) is a term applied to a variety of public transportation systems using buses to provide faster, more efficient service than an ordinary bus line.</td>
</tr>
<tr>
<td>Capacity</td>
<td>Maximum number of vehicles which has a reasonable expectation of passing over a given section of a lane or a roadway in one direction during a given time period under prevailing roadway and traffic conditions.</td>
</tr>
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<td>Cement</td>
<td>A powdered product made by grinding clinkers of limestone, clay, and other materials, and which reacts with water to form a rock like substance used to bond aggregates together in concrete.</td>
</tr>
<tr>
<td>Chevron marking</td>
<td>A Chevron is an inverted V-shaped or V-shaped pattern used as warning sign to guide motorists on the approach to islands/oclusions within the travel lane.</td>
</tr>
<tr>
<td>Chicane</td>
<td>A chicane is an artificial feature creating extra turns in a roadway, used in motor racing and on city streets to slow cars.</td>
</tr>
<tr>
<td>Concrete</td>
<td>Concrete is a building material made of sand and gravel bonded together with portland cement into a hard, compact substance.</td>
</tr>
<tr>
<td>Corridor</td>
<td>An area of variable width between two points. In highway work, corridors are defined areas where the needs for Improvements are studied.</td>
</tr>
<tr>
<td>Cross fall</td>
<td>The transverse sloping of a travel lane toward the verge or gutter on either side</td>
</tr>
<tr>
<td>Cul-de-sac</td>
<td>Local street open at one end only, which allows vehicles to turn around.</td>
</tr>
<tr>
<td>Culvert</td>
<td>Any structure, not classified as a bridge, which provides an opening under the roadway.</td>
</tr>
<tr>
<td>Cutting</td>
<td>A trenchlike excavation, especially through a road section.</td>
</tr>
<tr>
<td>Dead End</td>
<td>A local street open at one end only and with no special provisions for turning around.</td>
</tr>
<tr>
<td>Design Capacity</td>
<td>Maximum number of vehicles which can pass over a lane or roadway during one hour without operating conditions falling below a preselected design level.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Design Life</td>
<td>Initially figured to be a 20-year period for pavement.</td>
</tr>
<tr>
<td>Design Phase</td>
<td>The development of a project from the conclusion of the corridor location work to the completion of final plans.</td>
</tr>
<tr>
<td>Design Speed</td>
<td>A speed determined for design and correlation of the physical features of a highway which influence vehicle operation.</td>
</tr>
<tr>
<td>Design Standards</td>
<td>Specifications for such design features as curvature, grades, roadway width, drainage facilities, etc.</td>
</tr>
<tr>
<td>Destination</td>
<td>The zone in which a trip ends.</td>
</tr>
<tr>
<td>Divided Highway</td>
<td>A roadway with separated roadways for traffic in opposite directions.</td>
</tr>
<tr>
<td>Earth Excavation</td>
<td>On a construction project that requires new or relocated roadway, the earth which must be moved from one place to another is called earth excavation.</td>
</tr>
<tr>
<td>Egress</td>
<td>The exit points on a controlled access roadway.</td>
</tr>
<tr>
<td>Emulsified Asphalt</td>
<td>An emulsified asphalt is a common construction material used to prime, seal or resurface a highway. It consists of an asphalt that is chemically mixed with water in an emulsion.</td>
</tr>
<tr>
<td>Excavation</td>
<td>The act of taking out materials, the materials taken out, or the cavity remaining after materials have been removed.</td>
</tr>
<tr>
<td>Expressway</td>
<td>A divided arterial road for through traffic with full or partial control of access and generally with grade separations at major intersections.</td>
</tr>
<tr>
<td>Filling</td>
<td>Something that is put in to fill something else.</td>
</tr>
<tr>
<td>Fly ash</td>
<td>A byproduct of coal furnaces. When mixed with soil and water, it acts as a binder. Self-cementing Class C fly ash can be used for treating sub-grades.</td>
</tr>
<tr>
<td>Forecasting</td>
<td>Procedure for estimating future land use, population and traffic patterns.</td>
</tr>
<tr>
<td>Functional Classification</td>
<td>Identification of a road by the function it serves.</td>
</tr>
<tr>
<td>Grade Separation</td>
<td>A crossing of two arterial roads, or a arterial road and a railroad, at different levels. The bridge that spans highways or Rail road tracks (as in an overpass) is a grade separation structure.</td>
</tr>
<tr>
<td>Guard Rail</td>
<td>A steel rail with two corrugations at the shoulder edge of a highway, usually in front of roadside hazards. Also cable guard rail.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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<tr>
<td>-------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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<tr>
<td>Highway, Street or Road</td>
<td>A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.</td>
</tr>
<tr>
<td>Horizontal Curve</td>
<td>Bend from a straight line or course along a roadway.</td>
</tr>
<tr>
<td>Ingress</td>
<td>The entrance points on a roadway which have access control.</td>
</tr>
<tr>
<td>Interchange</td>
<td>A system of interconnecting roadways providing for the free movement of traffic between two or more roadways on different levels.</td>
</tr>
<tr>
<td>Intermodal Transfer</td>
<td>Change from one type of carrier to another.</td>
</tr>
<tr>
<td>Internal Trip</td>
<td>A trip with both origin and destination within the survey area.</td>
</tr>
<tr>
<td>Land Use</td>
<td>The functions for which various land areas are used or are planned to be used, such as: agriculture, housing, education, cultural recreations, religious, industrial and commercial uses.</td>
</tr>
<tr>
<td>Level of Service</td>
<td>The term used to indicate the quality of service provided by a facility under a given set of operating conditions. These conditions include speed, travel time, traffic interruptions, freedom to maneuver, safety, driving comfort and convenience, and operating costs.</td>
</tr>
<tr>
<td>Lime</td>
<td>Either quicklime or hydrated lime, either high calcium or dolomitic. Through chemical reactions with soil, lime reduces soil plasticity and increases compressive strength. It is sometimes used to stabilize wet soils.</td>
</tr>
<tr>
<td>Maintenance</td>
<td>The preserving and keeping of each type of roadway, roadside, structure, and facility as nearly as possible in its original condition as constructed, or as later improved.</td>
</tr>
<tr>
<td>Maintenance and Operating Costs</td>
<td>Cost of keeping the road in operating condition.</td>
</tr>
<tr>
<td>Median</td>
<td>The portion of a divided highway separating the traveled ways for traffic in opposite directions.</td>
</tr>
<tr>
<td>Modal Split</td>
<td>The division of person trips between mass and private transportation.</td>
</tr>
<tr>
<td>Mode of Travel</td>
<td>Means of travel such as auto driver, vehicle passenger, mass transit passenger, or pedestrian.</td>
</tr>
<tr>
<td>Mulch</td>
<td>A protective covering spread on the ground to reduce evaporation, maintain even soil temperature, and prevent erosion.</td>
</tr>
<tr>
<td>Neighborhood</td>
<td>A primary informal group consisting of all persons who live in local proximity.</td>
</tr>
</tbody>
</table>
**Node**  A specific point on a study system network where two or more links intersect and where a choice of travel routing is possible.

**Noise**  Unwanted sound.

**Noise Level**  The degree of undesired sound which affects the auditory senses.

**Operating Speed**  The highest overall speed at which a driver can travel on a given roadway under favorable weather conditions and under prevailing traffic conditions without at any time exceeding the safe speed as determined by the design speed on a section-by-section basis.

**Origin**  The zone in which a trip begins.

**Origin-Destination Studies**  Trip data is obtained from vehicle drivers as to where they started, where they are going, and the purpose of their trip. This data helps the Department to forecast traffic patterns.

**Over-All Speed**  Total distance divided by total time, including all delays.

**Overpass**  A grade separation where the highway passes over a highway or railroad.

**Parking Lane**  An auxiliary lane primarily for the parking of vehicles.

**Pavement**  The part of a roadway having a constructed surface for the facilitation of vehicular movement.

**Pavement Marking**  The lane lines or symbols painted on pavement surfaces. Marking can be done with several different types of materials.

**Pavement/Pothole Patching**  When the pavement begins to deteriorate due to the influences of the environment and traffic, holes, ruts and cracks are usually localized at existing pavement joints. The repair of this type of failure consists of sawing out, removing and replacing the material with new Portland cement concrete or bituminous concrete.

**PCU's**  Passenger Car Equivalent is essentially the impact that a mode of transport has on traffic variables (such as headway, speed, density) compared to a single car.

**Peak Hour**  That one-hour period during which the maximum amount of travel occurs. Generally, there is a morning peak and an afternoon peak and traffic assignments may be made for each period, if desired.

**Pedestrian**  Any person afoot.
<table>
<thead>
<tr>
<th>Term</th>
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<tbody>
<tr>
<td>Pedestrian Crossings</td>
<td>Designated crossings where pedestrians may safely cross a busy highway or roadway.</td>
</tr>
<tr>
<td>Population Estimate</td>
<td>Estimating current population on the basis of demographic and economic data.</td>
</tr>
<tr>
<td>Population Forecast</td>
<td>Estimating future population on the basis of demographic and economic data.</td>
</tr>
<tr>
<td>Portland cement</td>
<td>Hydrates with moisture in the soil and hardens. Portland cement performs best with well graded, sandy, and gravelly materials with 10 to 35 percent fines. More cement is usually needed for soils with little or no fines and with clay soils.</td>
</tr>
<tr>
<td>Public, Mass or Rapid Transit</td>
<td>(a) Vehicles used to convey people from one place to another. (b) The system or company which owns such vehicles.</td>
</tr>
<tr>
<td>Raised Island</td>
<td>That portion of the roadway which is raised above the travel-way by means of a curb to separate traffic.</td>
</tr>
<tr>
<td>Ramp</td>
<td>A connecting roadway between two intersecting highways at a highway separation.</td>
</tr>
<tr>
<td>Right-of-Way</td>
<td>Land acquired by purchase, gift or eminent domain in order to build and maintain a public road.</td>
</tr>
<tr>
<td>Roadside Development</td>
<td>Those items necessary to complete the highway which provide for the preservation of landscape materials and features; the rehabilitation and protection against erosion of all areas disturbed by construction through seeding, sodding, mulching and the placing of other ground covers, trees and shrubs, and such suitable planting and other improvements as may increase the effectiveness and enhance the appearance of the highway.</td>
</tr>
<tr>
<td>Scheduling</td>
<td>The process of developing a plan of operations to carry out the program. The process first involves breaking down projects into activities, setting starting and ending times for those activities, determining the resources required to perform the work, then adjusting the times as necessary to balance the resource requirements.</td>
</tr>
<tr>
<td>Service lane</td>
<td>A local road that runs parallel to an expressway or interstate highway and that provides access to the property bordering it. Also called frontage road.</td>
</tr>
<tr>
<td>Shoulder</td>
<td>The portion of the roadway adjacent to the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of the base and surface courses.</td>
</tr>
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</table>
GLOSSARY

**Sight Distance**  
The line of sight available to the driver to see another car for passing sight distance or to see a fixed object for stopping sight distance.

**Social Costs**  
Cost that is not included in the usual calculations concerning engineering, construction and right-of-way costs.

**Socio-Economic Factors**  
These are used to assess the effect of the highway on the human environment. Some include: population trends and growth, economic activity, transportation facilities, wildlife, scenic and wildlife, scenic and recreational facilities, historical resources, aesthetics, social service facilities, land use, and national defense.

**Soil Erosion**  
The wearing away of soil by the action of water, wind, or glacial ice.

**Specifications**  
The standard specifications, supplemental specifications, special provisions, and all written or printed agreements and instructions pertaining to the method and manner of performing the work or to the quantities and qualities of the materials to be furnished under the contract.

**Speed-change Lane**  
An auxiliary lane including tapered areas, primarily for the acceleration or deceleration of vehicles entering or leaving the through traffic lanes.

**Sub-base**  
A course of material that is placed on the subgrade to provide drainage and stability. Three kinds of sub-bases may be used, based on the need to balance drain ability and stability:

>> **Granular subbase is the most drainable subbase. It is a mixture of granular material that is uniformly shaped and minimally compacted. It does not provide sig-nificant structural support; no construction traffic is allowed on a granular subbase.**

>> **Modified subbase is moderately drainable. It contains a greater percentage of crushed particles and a denser gradation than granular subbase, providing more sta-bility.**

>> **Special backfill provides more stability and support but is the least drainable. It is generally a uniform mixture of crushed concrete or crushed limestone, or a mixture of gravel, sand, and soil, with or without crushed stone. Special backfill or modified subbase is often used under pavement in urban areas to support construction traffic.**

**Sub-grade**  
Earth that has been graded to the desired elevation. (In villages and municipal paving projects with low traffic volumes, concrete is often placed directly on the prepared earth subgrade.)

**Surfacing**  
Material used to construct the roadway. There are four types: Asphalt, Bituminous, Concrete, Gravel.
**Tender**
A formal offer made for supply of goods or services in response to an invitation for tender published in a Tender Bulletin. There are three types of tender, they are as follows:

- **Open tender** – which is open to all bidders
- **Restricted tender** – which is open only for the pre-qualified bidders
- **Short term tender** – duration of the tenders can be reduced based on the requirements

**Tender Document**
The set of papers detailing the requirement of goods Procurement Process and services, calendar of events, schedule of works, technical specifications, procurement criteria and such other particulars as may be prescribed for evaluation and comparison of tenders.

**Topography**
Representation on maps or charts depicting natural and man-made features of an area or region.

**Topographical Survey**
To gather survey data about the natural and man-made features of the land, as well as its elevations.

**Traffic**
All types of conveyances, together with their load, whether singly or as a whole, as well as pedestrians, while using any roadway for the purpose of transportation or travel.

**Traffic Assignment**
A method of distributing trips on a road network or on a theoretical network to illustrate how various sets of physical conditions and travel characteristics would affect the traffic flow pattern, for instance, speed, distances, etc.

**Traffic Control Device**
Any sign, signal, marking or installation placed or erected under public authority, for the purpose of regulating, warning, informing or guiding traffic.

**Traffic Count**
A count of total vehicular traffic passing a given point on a roadway during a specified time period. This might be a manual or machine count.

**Traffic Demands**
The number of vehicles desiring to use a particular route.

**Traffic Flow**
The movement of vehicles on a roadway system or on a single route.

**Traffic Forecasting**
Estimating future traffic patterns on the basis of known transportation variables.

**Traffic Island**
An island provided in a roadway to separate or direct streams of traffic; includes both divisional and channelizing islands.
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<td>Travel lane</td>
<td>A strip delineated on a street or highway to accommodate a single line of vehicles.</td>
</tr>
<tr>
<td>Traffic Marking</td>
<td>A traffic control device consisting of line, patterns, or colors on the pavement, curbs, or other objects within or adjacent to the roadway, or words or symbols on the pavement.</td>
</tr>
<tr>
<td>Traffic Sign</td>
<td>A traffic control device mounted on a fixed or portable support which conveys a specific message by means of words or symbols, and is officially erected for the purpose of regulating, warning, or guiding traffic.</td>
</tr>
<tr>
<td>Traffic Signal</td>
<td>A power-operated traffic control device by which traffic is regulated, warned, or alternately directed to take specific actions.</td>
</tr>
<tr>
<td>Traffic Volume</td>
<td>The amount of traffic on a particular route.</td>
</tr>
<tr>
<td>Travel Time</td>
<td>The time of travel, including stops and delays, except those off the traveled way.</td>
</tr>
<tr>
<td>Traffic Islands</td>
<td>The traffic is separated to flow through definite paths by raising a portion of the road in the middle usually called an island.</td>
</tr>
<tr>
<td>Trench less cabling</td>
<td>Trenchless cabling or plowing technology, also known as cable plow or mole plow technology, which cuts across the road without digging the road and cables are buried.</td>
</tr>
<tr>
<td>Trip</td>
<td>A one-direction movement of a vehicle which begins at the origin at the start time, ends at the destination at the arrival time, and conducted for a specific purpose.</td>
</tr>
<tr>
<td>Trip Generation</td>
<td>Commonly used to describe the number of trips starting or ending in a particular area in relation to the land use or socio-economic characteristics of that area.</td>
</tr>
<tr>
<td>Turning Radius</td>
<td>At intersection turning radius are important for vehicle’s maneuvering or making turns, if there is no sufficient turning radius, sometimes a big vehicle can occupy more space blocking the intersection, hence the turning radius for the speed 15 to 30km per hour should be minimum of 15mtr to 27mtr respectively for arterial and sub arterial road, for local road (residential road) were only car, two wheelers and small vehicle are plying the radius can be minimum of 7mtr.</td>
</tr>
</tbody>
</table>