

Transport Safety in an Industrial Complex

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Abstract

Transport Facilities inside an industrial site/warehouse involves movement of pedestrians, slow moving vehicles, passenger vehicles, office bus, work related vehicles, freight vehicles and emergency vehicles. The development of road network and traffic management outside the industrial complex is function of the public body like PWD/NHAI and Traffic Police. Whereas, development of road network within industrial complex is the responsibility of the Employer. The provision of transportation within the industrial complex is generally ignored and maximum space allocation is being given to production area. The plying of traffic is generally self-organised and not enforced to follows traffic rules within the complex boundaries. Therefore, there are greater chances of people getting injured due to interaction between vehicle and vulnerable road users.

The design of road network and traffic management plays an important role to ensures overall safety of the transport network area. The complex circulation begins with entry to complex and ends with exit gate of complex. The transportation with in complex involves leading to parking complex, loading & unloading area, personnel travel, etc. A detailed assessment needs to be carried for road network requirement based on traffic volumes, peak hours of different category of traffic, intersection of different streams of traffic i.e. pedestrian and vehicular, Day/night visibility, public utilities, etc. Better planning, traffic management and awareness, can avoid most of accidents within complex. This paper presents some key elements to enhance transport safety in an industrial complex. Keywords are Transport, Safety, Industrial Complex, Driveways, Parking, Signs, Markings, ITS, Intersection, Access Gate, Road Surface, Lighting, ITS, Drainage, Traffic Calming & Landscape.

1. Introduction

Transport Safety risks do occur in every complex and these can be mitigated by meticulous planning and implementation. It is required to develop a comprehensive road network to provide safe & efficient traffic circulation plan within the complex. The major components affect the traffic movement in an industrial complex are entry and exit from work place, traffic movement within the complex, loading & unloading location and its process, officials & visitors' vehicles, parking of officials and freight vehicles, Vehicles-Vehicle conflict areas (i.e. Intersections), pedestrian paths, pedestrian-vehicles conflicts, visibility, delineation, lighting, guidance to drivers through signs and pavement markings, speed restrictions, etc.

The key aspects to be considered and designed to provide optimum efficiency in traffic operations with maximum safety at a reasonable cost is shown in fig 1.

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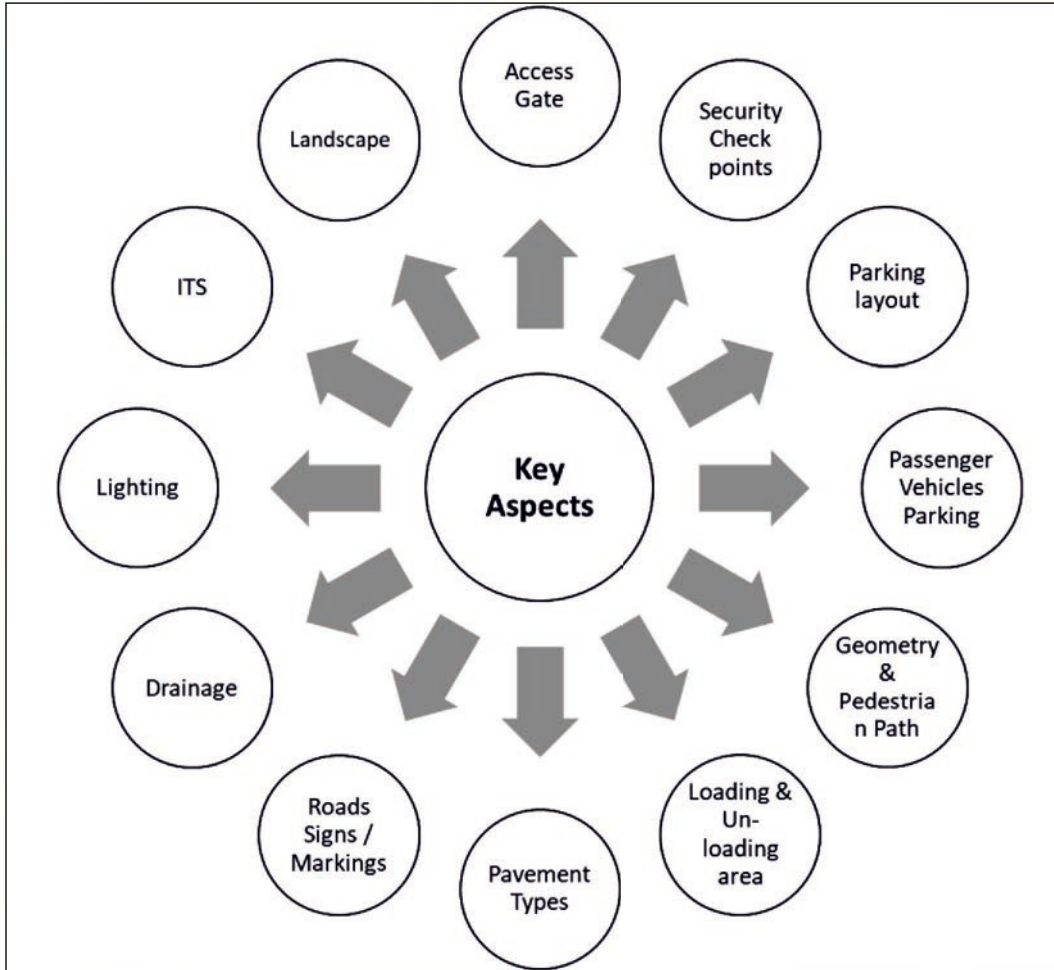


Fig 1: Key Aspects

2. Causes of Crashes

The collision of one road user with the other road user or with the fixed object lying within the roadway or running off from the roadway is termed as road crash. These crashes may cause damage to property, vehicles, injury to users or even its death.

The smooth and congestion free traffic flow within a campus is required to ensure safety of the road users (vehicles and pedestrians). The key design elements like road geometrics, parking layout, pedestrian infrastructure, operational safety, truck operations at parking spot plays an important role in mitigating the risks involved.

3. Traffic Within Complex

Traffic studies play a major role in assessing the road network requirement in an industrial complex. The carriageway width, pavement type and its composition are determined based on volume of traffic and loads carried by freight traffic. Therefore, detailed traffic studies shall be conducted/estimated for classified traffic volume counts at entry/exit, mode share of traffic within complex, and Internal OD (traffic distribution within the site).

4. Access (Entry/Exit) Gate Location

The access gate location in terms of inbound and outbound traffic with respect to the external road network is an important aspect considering the right turns (median opening location) and U-turns on external road network. There are two types of traffic which access an industrial complex as follows:

- i. Freight Traffic carrying raw material inside the industry and finished products from the Industry
- ii. Passengers traffic carrying officials/ workers and visitors' traffic

The access for both kind of traffic can be planned single or dual depending upon volume of traffic of different modes. The freight traffic having large trucks and trailers are expected to create delays at the turning points leading to congestion on the through traffic flow. The access gates should be planned considering the access location of adjoining industry, median openings, external road alignment, required U-turn / right geometry and existing junction locations.

It is mandatory to take access permission from road owning authority as per Indian Roads Congress guidelines specified in IRC 12. Various safety factors (shown below in the image) should be considered while planning an industrial campus.

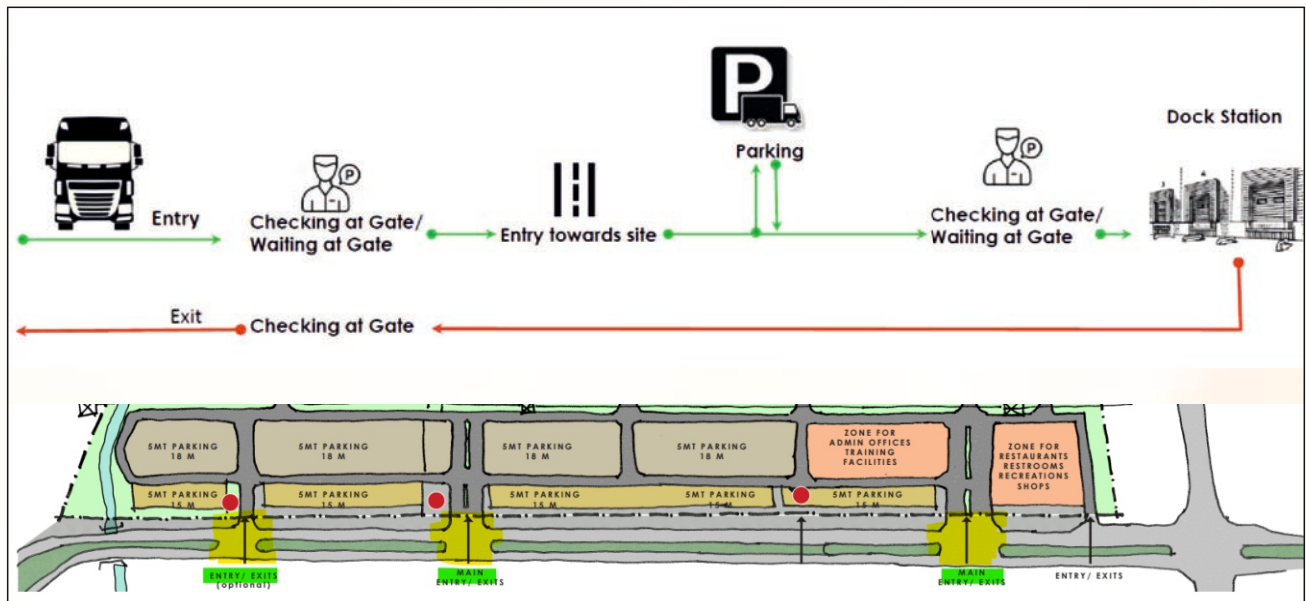


Fig 2 : Entry/Exit Layout

5. Security Check Points

Security Check is an important and integral part of an industrial complex. The security check may be entry location only or at both entry/exit location. The location of checkpoint shall be decided based on security check duration for which a vehicle need to stop. Accordingly, provide sufficient throat length (holding length) based on security check duration. Efforts should be made to avoid queue spill over on the external/internal road network. The spill over may cause congestion and safety concerns for vehicles and pedestrian movements. Detailed evaluation for the holding lengths can be analysed through micro simulation tools.

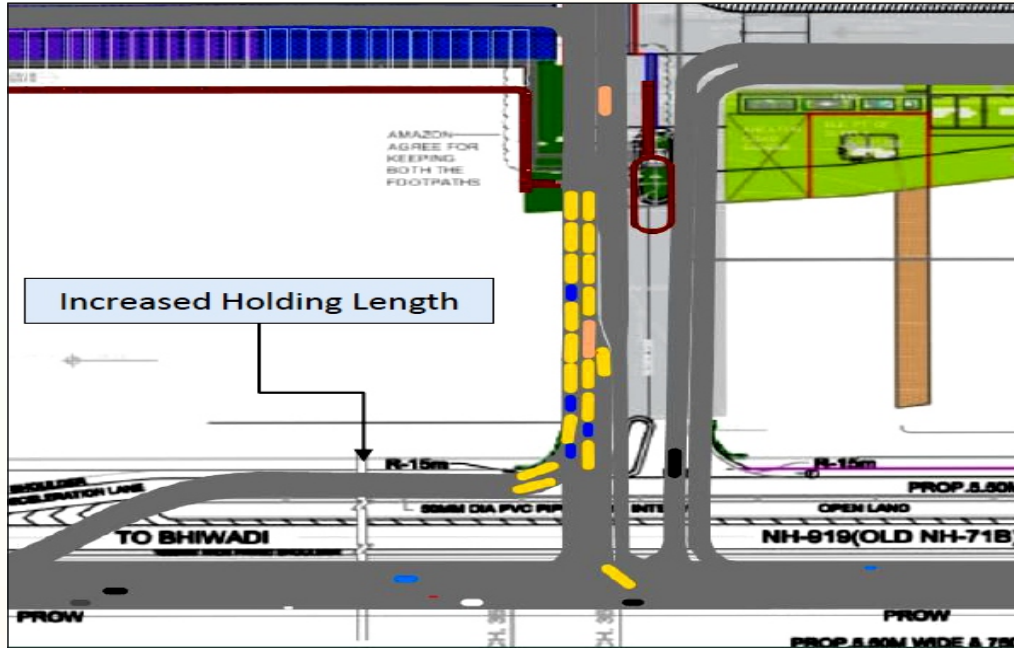


Fig 3 : Security Check Points

6. Freight Parking and its Layout

Parking location, its size and layout depend upon the parking load. It is suggested to provide separate parking locations for freight vehicles and passengers vehicles. The parking layout can be further sub divided for larger vehicles and smaller vehicles, longer duration and short duration parking of vehicles. The layout inside the parking shall be planned considering the pedestrian movement (driver movement after getting down from vehicle) and traffic flow direction. To achieve the maximum parking area efficiency in Industrial sites, angular parking having trucks and trailers are provided. Here "link and place" is an important concept to be considered. The "links" being the driveway for the vehicle movement and "place" being the area for pedestrian, street furniture, canteen, pantry, kitchenettes etc. A safe passage to be kept either between the parking or along the main driveway for the pedestrian movement. It is required to provide 1.5- 2m pedestrian walkway for the two people to cross each other. The pedestrian walkway provided in between two bays of truck parking is shown in Fig 4. It is required to install wheel stoppers to make sure vehicles do not drive into a pedestrian area and hit the pedestrian. The parking bays can be planned as per the truck sizing composition as per the requirements for efficient use of area.

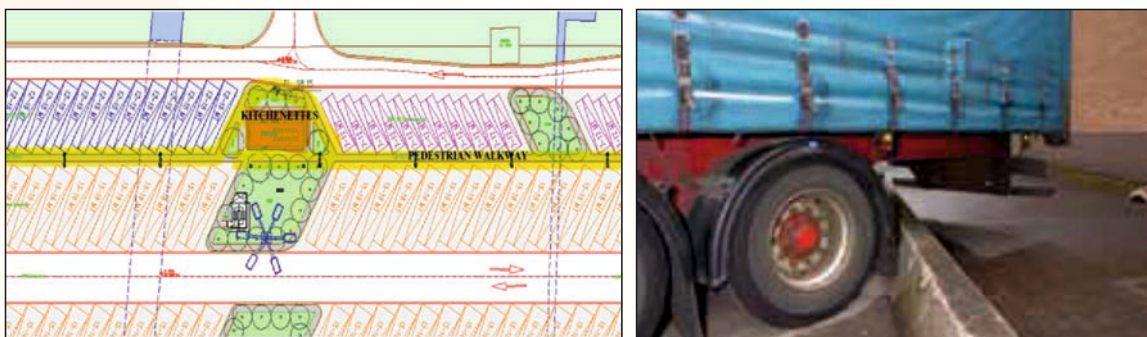


Fig 4 : Angular Parking Layout with wheel stopper and pedestrian path

Coupling and uncoupling of truck trailers may be undertaken in parking area. Accidents occur during coupling and drivers or other people being run over, hit or crushed by moving vehicles or trailers - often while trying to get back into a cab to apply brakes. Therefore, parking area should be designed with gentle gradient taking due care for drainage.

7. Passenger Vehicles Parking

Passenger Vehicles Parking is required for personalised vehicle (Parked for 9-10 hrs), visitors' vehicles (parked for 1-2 hrs) and public transport (8-9 hrs for company owned buses and 30 minutes for others). As mentioned in freight parking, parking provision shall be planned separately for various categories of vehicles. Provision of bus parking, boarding - alighting area and private vehicle parking should be planned within the industrial complex. The entry of passenger vehicles and freight vehicles shall be planned independent so that congestion free smooth traffic movement can be achieved. However, exit can be planned independent or combined depending upon the volume of traffic and security checks. The image shows, bus area near the main administrative block in a warehouse.

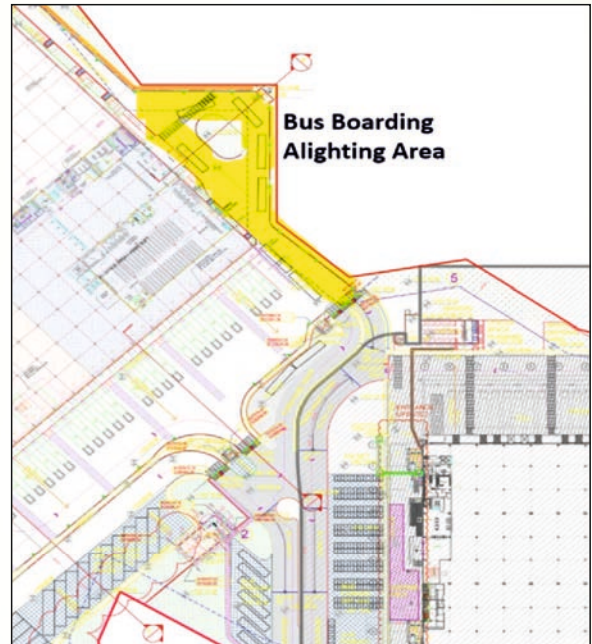


Fig 5 : Passenger es Boarding/ Alighting

8. Driveway Geometry and Pedestrian Paths

It is required to plan an extensive network of vehicle driveway to fulfil the transport requirement of all functions, begin with supply of raw material to dispatch of finished goods. Pedestrian paths are required for smooth movement of industry officials to various units of the industrial complex.

Driveways can be designed for one way traffic movement or two way traffic movement depending upon the traffic volume, their model split and availability of space for driveways within the complex. The traffic movements in an industrial complex can be broadly classified as follows:

- i. Trucks from Entry to Parking to Raw Material to Yard/Store to Exit
- ii. Trucks from Entry to Parking to Finish Product Yard/Store Material to Exit
- iii. Movement of Raw Material from Yard/Store to manufacturing units to Finish Product Store
- iv. Movement of Passengers vehicles from Entry to Parking to Exit
- v. Movement of Passengers vehicles from Parking to administrative blocks and manufacturing units to Parking Lot
- vi. Requirement for movement of emergency vehicle such as fire tenders, ambulances, etc.

The design of driveways/pathways shall be undertaken for efficient, congestion free and safe movement of above cited traffic movements. The minimum width of driveway for motorised traffic

shall be 5.5m in case of one way driveway and 7m in case of two-way. The driveways shall be designed for 30 km/hr. The intersections shall be designed with sufficient visibility. In workplaces where one-way systems are not practical, it may be appropriate to use cul-de-sac (Fig 6) or other arrangements to allow vehicles to turn and drive forwards for most of the time. Turning arrangements should ideally be a roundabout or a 'banjo' type, although 'hammerhead' and 'stub' arrangements may be acceptable.

The pedestrian pathways shall be minimum 2m wide as per IRC 103. The pedestrian paths can be standalone or can be provided parallel to driveways. Where vehicles and pedestrians share a traffic route, they must be safely separated. Where pedestrian and vehicle routes cross, well-marked and signposted crossing points should be provided (Fig 7). Use dropped kerbs where the walkway is raised above the driving surface. Provide barriers, rails or deterrent paving to direct pedestrians to designated crossing points.

A suitable barriers or guard rails shall be provided to enhance safety such as :

- i. at the entrances and exits to buildings
- ii. at the corners of buildings
- iii. to prevent pedestrians from walking straight onto roads

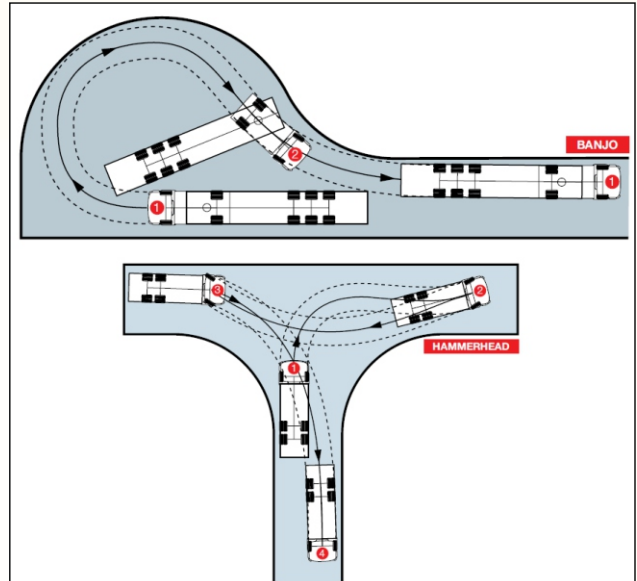


Fig 6 : Cul-De-Sac / Hammer Head

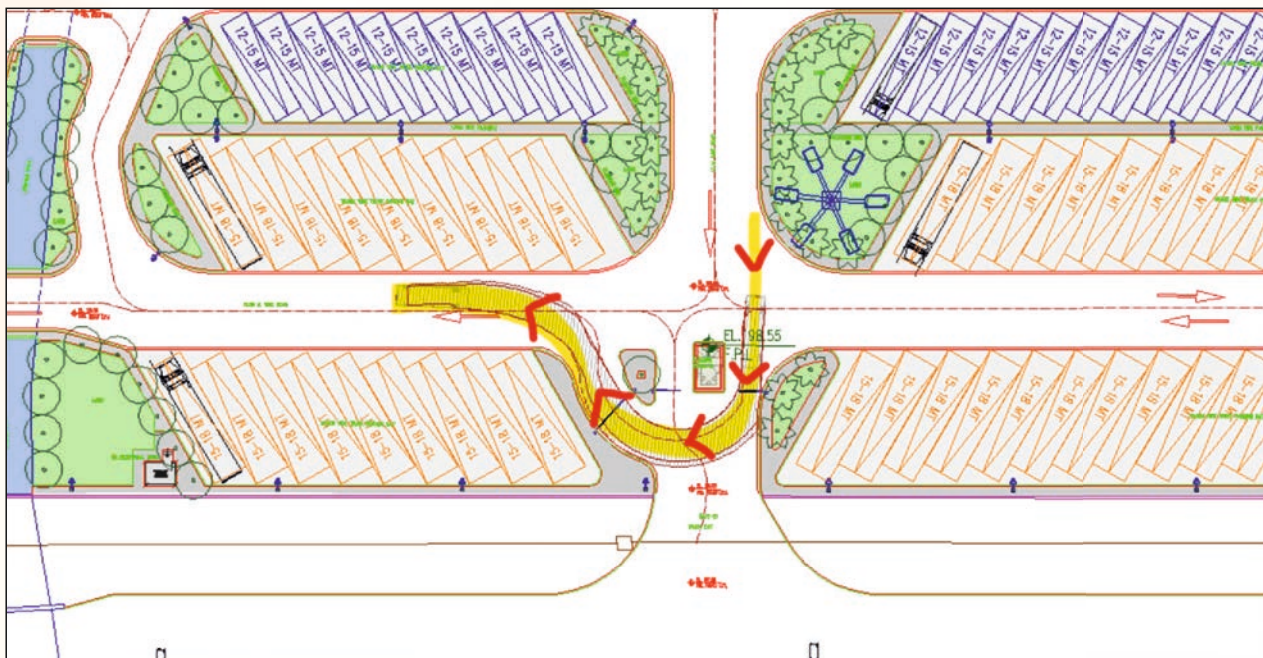


Fig 7 : Pedestrian and Vehicle Route Crossing

9. Loading/Un-loading Area

Loading and unloading is an important activities i.e. unloading of raw material, transfer of raw material to assembly line, transfer of finished product from assembly line to store and finally loading of finished product. Heavy loads, moving or overturning vehicles and working at height can lead to fatal or serious injuries. The loading/unloading area is highly accident prone as workers are hit by objects falling from vehicles, getting hit during reversing, etc. It is required to design loading and unloading areas as follows:

- i. Loading/Unloading area shall be clear of passing traffic, pedestrians and other people who are not involved in loading or unloading
- ii. Loading/Unloading area clear of overhead pipework or electricity cables so that there is no chance of fouling them, or of electricity jumping to 'earth' through machinery, loads or people
- iii. Loading/Unloading area shall be levelled/flat to maintain stability vehicles and their trailers
- iv. Loading/Unloading area shall be free from potholes or debris, which could make vehicles unstable

10. Road Surface/Pavement Type

The design and type of pavement in driveway, parking, loading/unloading area, pedestrian pathways, etc. is an important aspect. The various types of surfaces are bituminous, concrete, paver blocks, PCC boomed Surface, stone blocks (smooth/uneven), chequered tiles, etc. The road surface shall be designed for expected vehicle loading. The riding surface, shall be strong, non-slippery, potholes, etc. The road surface should provide a level of skid resistance that should facilitate the braking and steering manoeuvres reasonably for a particular site



Fig 8: Concrete Broomed Surface/
Concrete Tiles



Fig 9 : Paver Blocks



Fig 10 : Uneven Stone Surface



Fig 11 : Porous Paving

11. Road Signs

Road Signs speak language of the road and required for guidance of motorists on the driveway. Road Signs installed at appropriate locations on the driveway to controls the motorists' driving behaviours inside the complex. Therefore, road signs are essential to be placed to enhance safety on driveaway. The Road signs shall be of High Intensity Prismatic Grade Sheeting Type III/IV as per IRC 67 and in the language mostly spoken/understood by road users. The various types of sign provided are Regulatory Sign, Warning Signs, Object Markers, Conventional Road Guide Signs General Service Signs Sizes, etc.



Fig 12: Traffic Signs

12. Road Markings

Road markings are also language of road and interact with road users for information and guidance. The co-ordination of pavement markings with road signs is essential to convey definite message to road user and enhance overall safety on the road. The markings shall be retro reflective by using glass beads to enhance night visibility. The various type of markings provided are Centre line, Edge lines, Chevron lines, Stop lines, Zebra markings, direction arrows, Kerb paintings, etc. Road studs can be fixed to enhance the night visibility further. Traffic blinkers and signals are devices that control vehicular and pedestrian traffic by assigning the right-of-way to various movements for certain pre-timed or traffic-actuated intervals of time. Careful consideration should be given in planned development to intersection and access locations, pedestrian needs.

13. Drainage and Ground Water Recharge

Drainage is a process of removing and controlling excess surface and sub-soil water on the roadway. It includes interception and diversion of water from the road surface and sub grade. Surface water from the carriageway and shoulder should be effectively drained off without allowing it to percolate into road subgrade. Surface water from the adjoining land should be prevented from entering/flooding the roadway. The longitudinal side drain provided along driveway/pathways and should have sufficient capacity and longitudinal slope to carry away all the surface water collected. Inadequate Longitudinal and cross drainage causes softening of the road sub-grade and renders it too weak to take load of moving traffic. Road side drains are therefore necessary all along driveway. Similarly drainage of Parking area, loading/unloading are shall be designed to remove the storm water at the earliest. It is required to design outfalls of the drains effectively and integrate drains constructed in the industrial complex with public drains or lead to ground water recharge system constructed in the complex. It is

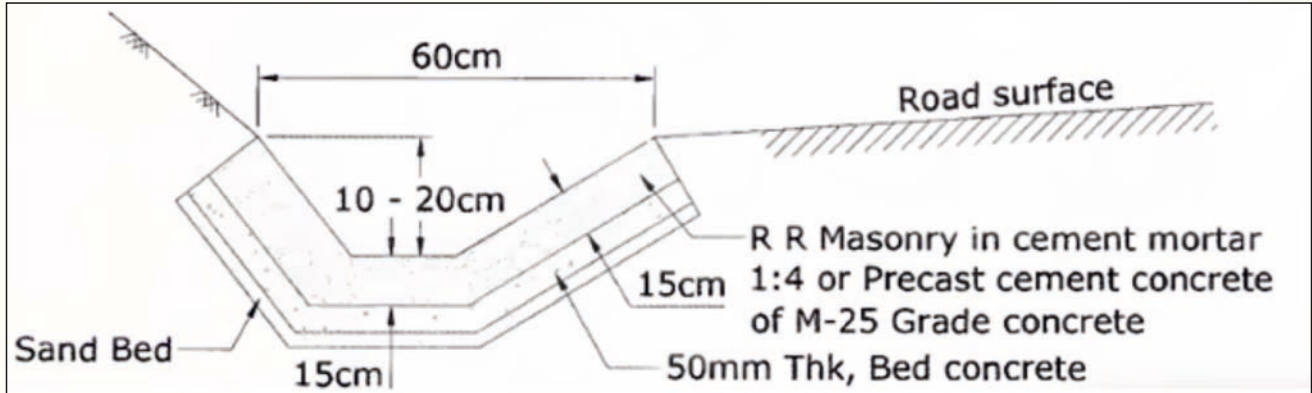


Fig 13: Open Drain

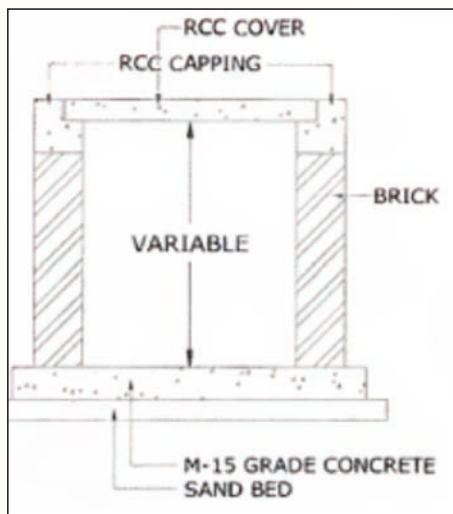


Fig 14: Covered Drain

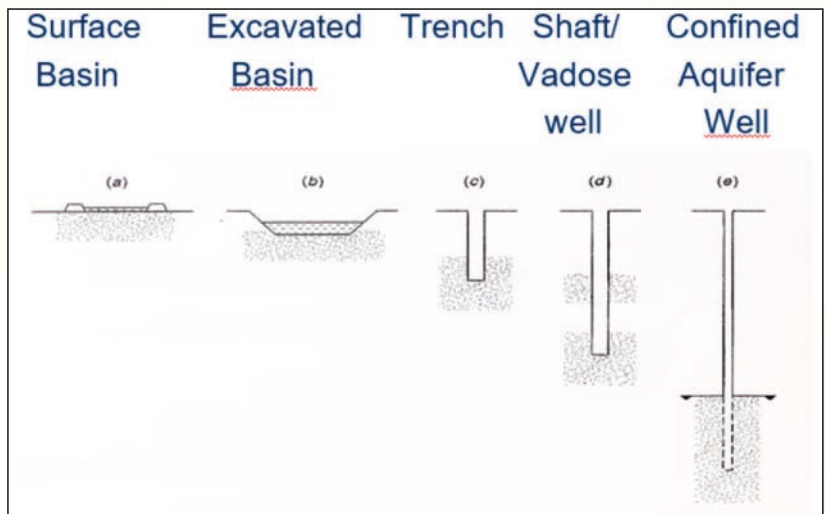


Fig 15: Ground Water Recharge

required to maintain free flow of the major drains within complex or at entry/exit of complex and adequate cross drainage structures shall be provided. On the basis of the shape of drain, the road side drain may be rectangular, trapezoidal, triangular or semi-circular. The type of drain may be angular drain, saucer drain or kerb and channel drain.

14. Lighting

Lighting of the complex including driveway is required to ensure security of complex and safe movement of traffic on driveway, parking, loading/unloading area, pedestrian pathways, etc. The minimum illumination of lux as per statutory or activity specific shall be provided. On driveway, parking, loading/unloading area, pedestrian pathways a minimum of 40 lux shall be provided. It is proposed consider three Phase distribution of lighting system so that even if one phase goes out, lights will be in operation and provision of Electro Mechanical timers for auto switching on/off. The lighting can be provided Single/Double Bracket Street Light Poles or High Mast Light Poles. The Solar Lighting system can also be provided.

15. Intelligent Transport System

Intelligent Transport Systems (ITS) refers to efforts that apply information, communication and sensor technologies to vehicles and transportation infrastructure in order to provide real time information for road users and transportation system operators to make better decisions. ITS is widely used for traffic management at entry/exit, parking management, incident detection and warning System, emergency response system, speed management, automatic traffic control for vehicles and pedestrians. Install PTZ CCTV Pan Tilt Zoom CCTV Camera, capable to remote



Fig 16: Boom Barrier



Fig 17: Parking Display

directional and zoom control with video surveillance system. Install automatic boom barrier at entry/exit, loading/unloading and parking incident detection system (VIDS) to detect wrong direction traffic movement and unusual road traffic at the Entry/exit or parking. Provide Electronic Display Variable Messages Sign (VMS) to inform on traffic congestion/any delay Incident at entry and parking.

Parking Guidance Systems (PMS) is a convenience solution to facilitate commuters of vacant space with the help of signages and sensor combination. These system reduce the vehicle travel, simplify the operations, ease of information, reduce duplication of trips and enhance safety by reducing traffic volume on driveways and within parking complex. .

16. Traffic Calming Measures

The basic principle of Traffic Calming remains universal, that is to lower the vehicle speeds in order to reduce accidents, pollution and enhance liveability of surrounding areas. Although, the driveways have been designed for 30 km/hr but drivers tend to speed up and higher speeds reduce the time available to avoid collisions and makes the impacts in collisions more severe. Therefore, speed calming measures are required at entry/exit from complex, security check points, intersections of driveways and with pathways, etc. Traffic calming measures can be active or passive as shown in Fig 18. Measures such as road narrowing, roundabouts and road humps, reduce the negative effects of motor vehicle use, and alter driver behaviour and improve conditions for pedestrians.

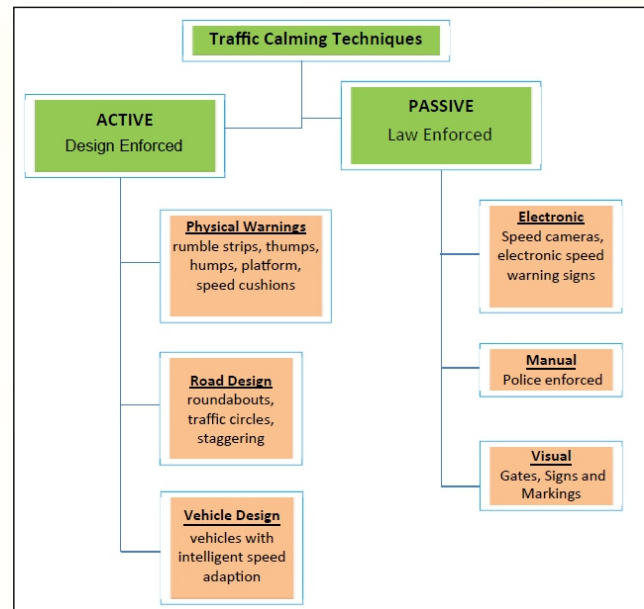


Fig 18 : Traffic Calming Techniques

17. Landscaping

The landscape of industrial complex, driveways, pathways, parking, etc. shall be developed. A concept shall be evolved so as to maintain visual characteristics and uniformity in terms of landscape along drive ways and pathways. In the land available for plantations, different schemes may be worked out in tune with the local variations in the design. To achieve this, the entire complex shall be divided into homogenous landscape sections based on similarity in terms of land area availability, soil conditions, and climate (temperature and rainfall). The focus shall be on planting native tree / shrubs species with ecological importance contributing towards higher GHG sequestration, soil-water conservation, nitrogen fixation etc. During selection process priority shall also be given to RET (rare, endangered and threatened) tree/ shrub species to promote conservation and enhance ecosystem values.



Fig 19: Landscape along Driveway

18. Miscellaneous

The employer should circulate the operational guidelines applicable for all the users of the campus. Proper induction training to all the employees and drivers should be performed. Visitors shall be briefed about the traffic and safety norms applicable in the complex.

Drivers should be provided with rest rooms, cooking area, canteen and sitouts. The cooking area and rest areas should be included in planning to discourage the activities to happen in open parking zones under the trucks.

19. Conclusions

A detailed study and design of transport network in industrial complex shall be undertaken to finalise the driveways, intersections, entry / exit, parking, road surface, signs, markings, ITS and landscape for an efficient and safe transport system.

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