

Smart Parking: Underground Parking Station for Traffic Congested Localities in Metro Cities.

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Abstract: Every Metro city in our country is facing severe difficulty of adequate parking space. This is due to the number of vehicle ownership with the increased living standard has increased. As a result these vehicles are found parked on the streets, narrowing them for regular traffic. These narrowed streets won't serve the purpose in the disaster situation which will delay the rescue. The present study focusses on Nashik city marching towards being a Metro City for the study. In consideration we have focused on the localities like Ganjamal and Old CIDCO. The traffic and parking scenario of these two localities during the peak hours and during night hours. To conclude with the study we have identified two Municipal open spaces, which will serve their purpose on the surface and be utilized for the underground smart parking stations with their detailed design. The detailed design with the suggestions for implementation of Pay & Park to the municipal authorities.

Key Words: Metro City, Traffic Congestion, Disaster, Smart Parking, etc.

1. INTRODUCTION

The nation today is facing a new challenge: Adequate Parking Space. The day by day increasing population with the increasing number of vehicles is the basic challenge.. With families getting smaller and the total number of motor vehicles exceeding the total number of heads per family, the parking scenario is miserably falling short of the current requirements in the country. The situation can be understood on any given working day; approximately 40% of the roads in urban India are taken up for just parking the cars. The problem has been further exacerbated by the fact that nowadays even people from low income group are able to own a car. Our country is unable to manage the increasing number of cars per family.

Lack of proper spaces for parking, and the growing number of small vehicles especially motorcycles and light vehicles have created mess in the city. To improve all these, there is a need to create ample parking spaces.^[4]

Traffic jam is an issue here as it kills precious time. It troubles the students and patients' with emergency to a great extent. It is necessary to provide appropriate parking system that will reduce the vehicle rush due to the well planned parking.^[6] In this paper we have tried to provide a solution for parking of vehicles and can be implemented in residential as well as commercial areas according to need and situation. To provide easy access during emergencies like fire, accidents, disaster...etc.^[6]

2. LITERATURE REVIEW

Sonar, (2017)^[8] To make use of underground space, it is beneficial to the city and the decedent.

Duvanovaa et.al^[2] (2016) Based on the developed space-planning solutions of the two-level open parking Dike, calculated the economic and social efficiency of the project.

Geng et.al^[3] (2012) In "smart parking" system, communication includes drivers sending their parking requests, providing driver information and confirming reservation to the system.

Yan-ling et.al² (2017)^[4] To change original “Closed-off Management”, all parking lots should be announced and seek operators through open tender, and every parking management company with qualification has the right to participate and compete. The role of government is a rule maker and supervisor to ensure parking.

Patel et.al², (2017)^[7] The improvement in parking situations has a direct impact not only on the improvement in traffic conditions and road safety in the area considered, but also on the local economy.

Sharma et.al², (2017)^[9] In Kota, special authority called as Traffic and Transportation authority is working at city level Kota. This provides the solutions which are short term and long term basis. We have worked on long-term plan and at the same time have taken care of discomforts or problems.

Meliak et.al², (2015)^[6] Research was carried out on the demand for parking and also on traffic and the health issues related to it. Different payment methods together with dynamic pricing were explored rigorously too.

Duvanovaa et.al², (2016)^[2] Distance from the entrance and exit to a residential or public building is not regulated when placing diked car parking away.

3 PAPER THEORY

Problem Statement

Rapid motorization and inadequate space to support it are one of the most important factors influencing the mobility and accessibility in a city. Tremendous pressure on parking spaces has led to serious concerns like traffic congestion, accidents, environmental hazards etc. The present assignment focuses on the common problems and challenges faced by the parking sector in a country like India.

The number of parking spaces available in Indian cities are considerably less compared to the number of cars travelling in the city every day and it is also to be kept in the vision at which the new the registration of the light vehicles is taking place which is likely to create a barrier in the meeting of the balance in demand and supply of parking lots. One of the suitable solutions is to replace public transport with private vehicles.

Objectives

1. To provide adequate parking spaces.
2. To provide full width of road for traffic
3. To avoid traffic congestions
4. To provide easy access during emergencies like fire, accidents, disaster...etc. [6]

The chief research questions are

- I. What are the common parking problems faced by highly populated Indian cities?
- II. What are the proposed solutions to the identified problems of parking in these cities?

Steps followed to solve the problem

1. Collection of data.
2. To identify the obstacles and remedial measures.
3. To study the existing methods of parking and their effectiveness.
4. To identify the necessity of effective vehicle parking.
5. Adopting the best suitable method and implementation.
6. To design a structure for the parking system.

4 DEVELOPMENT OF IDEA

Smart and optimistic public parking system for residential and commercial areas

While providing a smart park system we thought of using the open spaces which are reserved for different recreational purposes in municipal areas. These recreational areas will be utilized for the intended purpose in addition to the use as parking places which will be located below the recreational zones. ^[1]

We are working on SMART PARKING SYSTEM. We have adopted combination of two systems i.e. a typical traditional underground parking with semi-automatic parking system and the development of underground parking areas below the existing open spaces: important for achieving a prosperous urban environment. This can be effectively implemented in congested cities, by preserving the public parks, gardens, playgrounds etc.

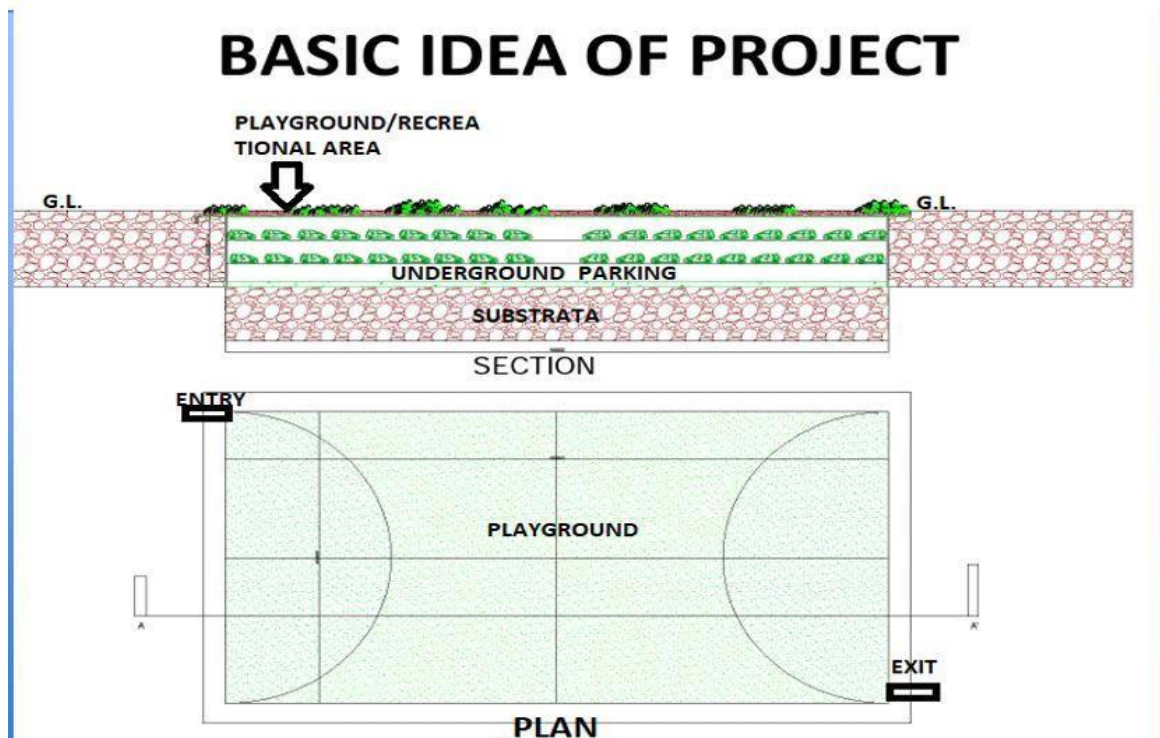


Fig 1. Basic idea of project



Fig. 2 : Underground parking



Fig. 3 : Recreation of underground parking (Jio Garden)

Case study

We visited Soham Architectural Engineering Services to study review the idea, Underground parking solution for commercial as well as residential area (Commercial Building). Location of Project- F.P. No. 157, S. No. 631/A/2 & C.T.S. No. 306/A, Khadkali Signal, Nashik.

This project includes two basement public parking with commercial complex of six storey. Below are the details of project are

Area Under Parking Reservation - Site No 141, As Per DP		Parking Statement			
Lower ground floor =	1573.33 m ²	Required for	Car	Scooter	Cycle
Beasment 1 =	1542.69 m ²	Comm.(1668 m ²)	34	68	68
Beasment 2 =	1542.69 m ²	Resi. (Below 40)	00	00	00
Total =	4658.71 m ²	Resi. (40 - 80m ²)	00	00	00
Parking Area Available for Building =		TOTAL -	34	68	68
= 4658.71 - 4470.00 = 188.71 m ²		+ 5% visitors parking	02	04	04
		TOTAL Required -	36	72	72
		Proposed -	36	72	72

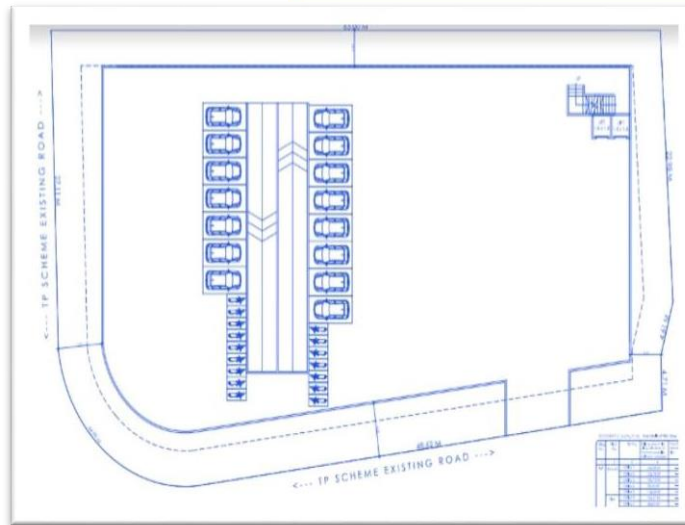


Fig. 4. Basement plan of project

5 IMPLEMENTATION

Project for Nashik city

Over half of population, nowadays lives in city. The forecast states that by 2030 there will be a rise by 60%. Cities have a big mobility and pollution problem that lowers live quality. 35% of the population travel during rush hours looking for free parking spots that are hard to find. That’s why parking is very important to regulate vehicle flow and reduce atmospheric pollution..

1. Cities must turn into gentle, smart and efficient places and evolve to become Smart Cities. Regarding mobility it should imply:
2. Improve infrastructures and public transport flow.

3. Availability of dynamic systems to guide the traffic towards its final destination, the parking.
4. Promote the use of autonomous, connected, electric, smart and non-polluting vehicles to reduce traffic, noise and pollution.
5. Get a more effective and ecological parking that allows the driver to find the free parking space quickly, safely and with the minimal energetic consumption.

Problems in Nashik

1. Problem of saturated parking spaces
2. The problem of unregulated tariff structure and the price is not proportional to demand
3. Preference of on-street parking over off-street parking : On-street parking makes the problem of traffic jam. So to avoid traffic flow problem of the street to give the priority to the off-street parking.^[4]
4. Problem of parking in residential apartments: Due to less provision of parking area in residential area the parking problem occurs. Ultimately residents or guest park their vehicles in ground or on street.^[2]
5. Problem of parking on special occasions: In Nashik after every twelve years the great occasion named as KUMBHAMELA. On this occasion devotees come from various states of India in huge quantity. So for this occasion the parking spaces are required in high quantity.^[4]
6. Environmental problems due to parking: Parking lots have a variety of negative effects on the environment. Cars themselves produce greenhouse gases that contribute to global warming when on the road, but even parking them on pavement can compound the problem. Fortunately, there are ways to reduce the pollutants caused by parking lot issues. The need for more parking spaces suggests an increase of traffic and congestion, which increases gas emissions that damage air quality. Too many parking lots and garages can also contribute to area blight that continues a cycle of environmental damage. More paved parking areas reduce green space that allows trees and plants to thrive, absorbing carbon dioxide and releasing clean oxygen into the air.
7. Limited parking supply: This is the first thing that comes to mind when pondering parking problems and solutions. Essentially, it gets property managers/developers, businesses and central/local governments to build more parking facilities. It has the advantage of economies of scale. The top disadvantage is that it increases overheads and encourages driving as opposed to public transport.^[6]
8. Lack of Established minimum parking requirements: By raising the requirements for parking spaces the demand for parking can be reduced. The use of zoning is usual in this context. This method is easy to implement but can add to the costs of providing parking to developers and public authorities.
9. Increasing on-street parking: Town planners can design more on-street parking while local governments can have fewer parking restrictions and encourage parallel parking. This is easy and cost-effective but there are limits on how many extra parking spaces can be created.
10. Excess demand: This amounts to having in reserve extra parking facilities when the usual nearby parking spaces have been all taken up. This can happen during popular events. It has the advantage of flexibility and one disadvantage is how remote the secondary parking area is. Maximising parking spaces in existing facilities. This can involve utilising unused spaces such as in corners and on the edges of the parking

areas and having specially sized spaces for smaller vehicles. This is relatively inexpensive but there is a ceiling on how much can be added.

11. Costly of parking: This is merely scratching the surface of parking problems and solutions and people involved in this field can choose from these and other methods.

Obstacles

In Residential zone and Commercial zone



Fig. 5: Parking problem in residential zone



Fig.6: Parking problems in commercial

Table: 1 Difficulties in different zones.

Residential zone	Commercial zone
No place for playground	No place for movement in front of shops and market.
No place for movement of vehicles (cars as well as bikes)	There is traffic jam in market areas due to road side parking.
Insufficient width of road due to side parking	Unattractive appearance of the city.
May cause disturbance to the emergencies like accidents, fire....etc.	Loss of revenue.

6. DESIGN ASPECTS

Design of Parking

The Parking lot's design will be heavily influenced by the purpose it serves. It should range from efficient circulation to structural matters, crime prevention and health & safety aspects.

The underground parking would be the best alternative to resolve the deficient parking in the developing cities. It's suitable for large-scale parking as well as freeing up ground-level space and can help to transform spaces: as well as concealing cars, covering underground parking with a deck creates, for instance, an opportunity for landscaping – hidden from sight, it can generate a pleasing new view for surrounding buildings and a

valuable communal space. Room is created for other active uses, from restaurants and cafes to shops, which can be located at street level.

While designing an underground parking, several key aspects have to be kept in mind, like regulations to recommendations. It has to be thought of that providing the appropriate level of parking; should be user friendly, with suitable and appropriate design across layout, sufficient lighting and clear demarcation for pedestrian safety.

Planning

Planning for parking facilities is a complex activity that requires the collaboration of many professionals for a successful outcome. Planning for the integration of parking in the urban environment must first start with the consideration of site. Transit Villages, Smart Growth and New Urbanist planning strategies are becoming popular and are being built in greater frequency around the country. They each address the movement and storage of cars in various ways that combine residential use with many other building types and other forms of transportation.

The aspects those are to be considered while designing the underground parking are – Layout, required parking area(2.75m x 5.8m), Boundaries and Perimeters, Parking lot size, Space efficiency, Parking space angles (at 45 to 60 degrees), Access, Determine parking slot size, Consider accessibility requirements, Other uses for extra space and General space requirements.

Table: 2		
S.No.	Type of Vehicle	Minimum Size/ area of parking space
(1)	(2)	(3)
(a)	Motor vehicle	2.5 m X 5 m
(b)	Scooter, Motor Cycle.	1.0 m. x 2.0 m.
(c)	Bicycle	0.50 m x 1.4 m.
(d)	Transport vehicle	3.75 m. X 7.5 m.
Note:	In the case of parking spaces for motor vehicle, upto 50 percent of the prescribed space may be of the size of 2.3 m. X 4.5 m.	

Structural Design:

Multi storey car parks are essentially elementary building structures, albeit with certain specific performance criteria that must be met. The overall structural form will be heavily influenced by the design geometry adopted. Underground car parks will, to a large extent, be determined by the structure above (for example a multi storey building or a public garden).

The structural frame can be reinforced concrete (precast units or cast in-situ), steel or a composite structure (steel beams and columns, supporting concrete floor slabs). Ribbed or coffered slabs are often used. Lightweight-aggregate concrete can reduce overall loadings significantly, and has better fire performance – but smaller span: depth ratios and additional shear reinforcement are needed.

Concrete must be designed to be durable against chemical corrosion attack. Non-slip finishes in particular to ramps are also prudent, to prevent skidding. Heated structures are also possible, although their effectiveness can be questionable.

Vehicular loading of buildings is covered in Section 6 of BS EN 1991-1-1. Parapet loading (impact resistance) for car parks is covered in Annex B of the same Eurocode. Wind loads and vibration also need to be taken into account. Structural resistance to explosions (over and above fire resistance) should also be considered. Underground car parks will need extensive retaining wall design, incorporating tanking and land drainage.

Lift plays important role in vertical movement of public whom are parked there vehicle. The general size shall be taken as 1.9m X 1.9m.

Slab is the structural member which is based on design aspect. The size general is taken between 150mm to 300mm.

Retaining wall is the important structure in underground structure. It resists earth pressure and also water entry in the structure. The thickness of retaining wall is based on the design.

Access ramps Changes in elevation should be accounted for in your asphalt parking lot specifications, and proper safety measures should be taken to ensure that everyone who needs to access the lot can do so without risking harm. Ramps leading from the pedestrian access to the lot to the shared handicapped access aisles are crucial, for instance. Similarly, ramps that allow access from the pavement to the elevated sidewalks should be built into the perimeter curb design.

Ventilation As people are supposed to use parking, proper ventilation is must. The preferred option is always natural ventilation where possible. But for convenience we adopted a combination of both natural as well as mechanical ventilation system. by providing louvered natural ventilation is provided. Also air-conditioning system is provided.

6.3.5 Flood risk while underground car parks aren't subject to the same cycles of wetting and drying as the exposed concrete decks of multi-storey car parks, there are distinct challenges to consider relating to the ingress of water from the surrounding ground. Clearly, an area at high risk of flooding may not be suitable for underground parking. In any other environment, close attention needs to be paid to using appropriate waterproofing systems.

6.3.7 Lighting should be even, to eliminate shadows. White (or light-coloured) walls, floors and ceilings can reduce the quantity of luminaires needed. Anti-vandal cabling. Siting of lighting columns to avoid being used as climbing aids.

7 RESULTS AND REPORTS

Design of underground multi-level car parking system

1. Reason for selecting site:

- Due to traffic jam, since there are more shops, banks and hospitals around the bus stop
- Easily accessible to all area from the parking

2. Methodology plan analysis designing detailing

- Type of car parking: “Conventional underground parking with smart solutions”
- Number of storey: G -2
- Spherical ramp is provided for car movement between the floors
- FOUR Lift and two Stair case is also provided.

3. Plan

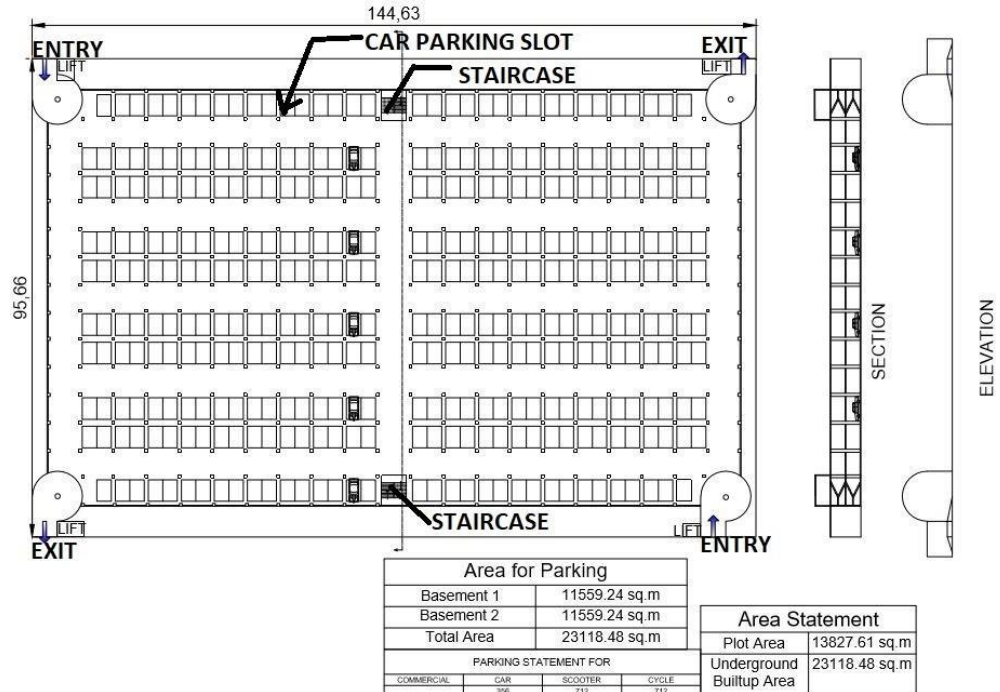


Fig. 7: Underground parking plan.

4. Plan details

- All floors are same in plan (144.63 x 95.66m²)
- Ramp of diameter = 9m
- Staircase and Lift is provided for emergency.
- Height of each floor = 3m
- Retaining wall thickness = 200mm

5 Slab:

The most common type of structural element used to cover floors and roofs of buildings is a reinforced concrete slab. The slabs are classified into the following types.

They are

- One-way slab (l/b ratio greater than 2)
- Two-way slab (l/b ratio lesser than 2)
- Flat slabs
- Grid slabs

6 Detailing of slab

- Slab thickness = 150mm

7 Underground car parking ventilation system

When cars enter, exit and drive through your enclosed parking garage, they release toxic and non-toxic gases. For ventilation we adopted combination natural and artificial ventilation. As peoples are supposed to use parking, proper ventilation is must. The preferred option is always natural ventilation where possible. But for convenience we adopted a combination of both natural as well as mechanical ventilation system. by providing louvered natural ventilation is provided. Also air-conditioning system is provided.

8 Staircase

Staircase is nothing but number of steps arranged in series for the purpose of giving access to different floors in a building. Staircases are usually designed similar to slabs. The only difference between slabs and staircase is that the staircase is inclined and is subjected to inclined loading. Sometimes a landing is provided either to turn the direction of the staircase or to relax while climbing up the stairs. The various types of staircases available are as follows. 1. Straight staircase. 2. Dog legged staircase.

9 Drainage provisions

To prevent damages to the underlying soil, the pavement itself prevents moisture from trickling through. Part of what makes asphalt so effective is precautions taken to provide proper water drainage. Avoid standing water on your asphalt through inlets and catch basins — along with other drainage methods — as part of your parking lot pavement design. The construction of these drainage provisions should be handled as early as possible. Parking area surfaces are usually designed to prevent accumulating water at the pavement edges, with a slope of two percent at minimum.

10 Ramp

An inclined plane, also known as a ramp, is a flat supporting surface tilted at an angle, with one end higher than the other, used as an aid for raising or lowering a load. Moving an object up an inclined plane requires less force than lifting it straight up, at a cost of an increase in the distance moved. The mechanical advantage of an inclined plane, the factor by which the force is reduced, is equal to the ratio of the length of the sloped surface to the height it spans. Due to conservation of energy, the same amount of mechanical energy (work) is required to lift a given object by a given vertical distance, disregarding losses from friction, but the inclined plane allows the same work to be done with a smaller force exerted over a greater distance. The mechanical advantage of an inclined plane depends on its slope, its gradient or steepness. The smaller the slope, the larger the mechanical advantage, and the smaller the force needed to raise a given weight

11. Retaining wall

Retaining wall is the important structure in underground structure. It resists earth pressure and also water entry in the structure. The thickness of retaining wall is based on the design.

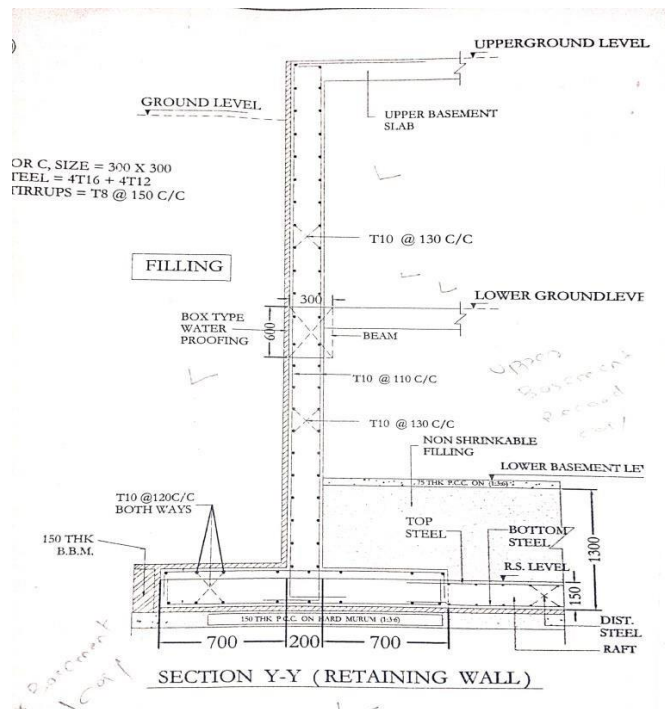


Fig. 8: RCC Details of the designed retaining structure.

8 APPLICATIONS

Residential parking

People can use common areas as parking these will help to use common plots optimistically. These provides open spaces place for playground. Also congested colonies becomes more comfortable due to parking vehicles in parking zones, so there is sufficient place for movement of vehicles (cars as well as bikes) these provides sufficient width of road due on road side, May helpful the emergencies like accidents, fire.... etc.

Commercial parking

Users find the best spot available, saving time, resources and effort. The parking lot fills up efficiently and space can be utilized properly by commercial and corporate entities

Optimistic use of gardens

The recreational zones are the true beauty of city. These areas are preserve by such underground parking system. These will provide beauty to city as well as these balances city environment.

Subsidizing off-street parking

This has the advantage of making parking cheaper and bringing it into policy but it amounts to a public subsidy for driving instead of encouraging utilisation of public transport.

Advantages of Underground Parking:

- Use of recreational areas- these is one of the most impactful advantage of such parking system over other types. These fulfils the purpose of providing open spaces, gardens and beautify city.
- Reduced traffic – Traffic flow increases as fewer cars are required to drive around in search of an open parking space.
- Reduced pollution – Searching for parking burns around one million barrels of oil a day. An optimal parking solution will significantly decrease driving time, thus lowering the amount of daily vehicle emissions and ultimately reducing the global environmental footprint.
- New Revenue Streams – Many new revenue streams are possible with smart parking technology. For example, lot owners can enable tiered payment options.
- Increased Safety – Parking lot employees and security guards contain real-time lot data that can help prevent parking violations and suspicious activity. License plate recognition cameras can gather pertinent footage. Also, decreased spot-searching traffic on the streets can reduce accidents caused by the distraction of searching for parking.
- Your vehicle is likely to be secure.
- The parking likely won't inconvenience your neighbours
- It's less likely to be hit or marred than being parked on the street
- Provides facilities like washing, electric vehicles are easier to plug in for charging. etc
- Enhanced User Experience – A smart parking solution will integrate the entire user experience into a unified action. Driver's payment, spot identification, location search and time notifications all seamlessly become part of the destination arrival process.^[5]
- Dependent on parking space location. Also, reward programs can be integrated into existing models to encourage repeat users.^[5]
- Integrated Payments and POS – Returning users can replace daily, manual cash payments with account invoicing and application payments from their phone. This could also enable customer loyalty programs and valuable user feedback.
- Decreased Management Costs – More automation and less manual activity saves on labour cost and resource exhaustion.

Disadvantages of Underground Parking

- It seems costly.
- People consent plays important role as they are users.
- Acquisition of land is tedious work and takes so much time.
- Maintenance require at certain intervals.

9 CONCLUSION

Parking Space is a very important resource for the efficient operation of lives of the people. The demand for parking spaces is rising considerably and it is very important to realize that our resources are limited and we cannot conveniently plan parking spaces as per the demand. Increase in the number parking space should be the last idea worth considering. The problem discussed here in the article is not inaccessible but is interlinked. Efforts are taken to improve the scenario. Working more in the already existing policies and increasing our technical soundness would be appreciable attempts. Foreign countries have come up with sound and efficient ideas like parking meters and mobile parking apps has made the search easy for the people and if the ideas

like setting price according to demand and occupancy control are implemented, technical material comfort will work as a fairy point for the public and for the entire city.

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