"Parking Lot Design"

A PROJECT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

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By

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To

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT SOLAN – 173234

HIMACHAL PRADESH INDIA

June, 2016

CERTIFICATE

This is to certify that the work which is being presented in the project title **“PARKING LOT DESIGN FOR JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY”,** in partial fulfillment of the requirements for the award of the degree of Bachelor of technology and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by ADITYA KHANNA(121609) and KAUSTUBH CHAUHAN(121610) during the period from July 2015 to June 2016 under the supervision of **Mr. SAURABH RAWAT ,**Assistant Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of my knowledge.

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ACKNOWLEDGEMENT

It has been a wonderful & intellectually stimulating experience working on **“PARKING LOT DESIGN FOR JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY,SOLAN”** which gives us the full knowledge & innovative ideas in the field of Parking Lot Design.

We gratefully acknowledge the Management and Administration of Jaypee University of Information Technology for providing us the opportunity and hence the environment to initiate and partially complete our project till now.

For providing wuth the finest suggestions for the project, we are greatly thankful to our project guide **MR. SAURABH RAWAT** . He provided us the way to get the job done, by providing the concept behind the complexities so that we can make better use of existing knowledge & build up higher skills to meet the industry needs. Their methodology of making the system strong from inside has taught us that output is not the end of project. Last but not the least; we would also like to thank our Lab Assistants, especially Mr. Itesh for the help & support.

ADITYA KHANNA (121609)

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ABSTRACT

The project report presents a study on proper design of parking lot in the field nearby guard's hostel and traffic survey in the Jaypee University of Information Technology, Solan.

Initially, to understand the condition of the field, the site visit was done. The traffic survey (Average Daily Traffic Survey & Spot Speed Survey) for the period 18th November 2015 to 24th November 2015 was carried out to understand the traffic behavior in the University. Basic soil characteristics and parameters are studied by carrying out some experiments and tests on soil sample sand results are used in the rigid pavement design. The CBR test could not be done because the soil is mainly sandy in nature. In this report, an attempt has been made to design the parking lot in Auto Cad and rigid pavement as per IRC 15-2002 and IRC 58-2002 guidelines. Design of drainage system is done for parking lot and also the maintenance and facilities criteria has also been taken and at the last the cost estimation of the project is done.

Keywords: Parking lot, Average Daily Traffic Survey, Spot Speed Survey, Rigid pavement design, drainage design, cost estimation.

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LIST OF SYMBOLS

Symbol	Description
G.F.A.	Gross floor area
G.L.A.	Gross leasable area
AADT	Annual average daily traffic
VMT	Vehicles miles travelled
MADW	Monthly average day of week
K	Modulus od subgrade reaction
E	Modulus of elasticity of cement concrete
M	Poisson’s ratio of concrete
H	Slab thickness
L_c	Length of contraction joint
S_c	Allowable stress in tension in cement
W	Unit weight of the concrete
F	Coefficient of sub-grade friction
P_f	Load transfer capacity in friction
P_s	Load transfer capacity in shear
P_b	Load transfer capacity in bear
F_s	Permissible stress in shear
F_f	Permissible stress in bending
F_b	Permissible stress in bearing
L_d	Length of dowel bar
D	Diameter of bar
q_u	Allowable soil bearing capacity
Γ	Specific density of water
ϕ	Internal friction angle
N_q	Terzaghi’ s bearing capacity factor
N_c	Terzaghi’ s bearing capacity factor
N_γ	Terzaghi’ s bearing capacity factor
C	Cohesion value of sand
δ'	Joint interval
C_x	warping coefficient
C_y	warping coefficient
S_s	Allowable working tensile stress in steel
S_b	Allowable bond stress
L_t	Length of tie bar

CHAPTER 1

INTRODUCTION

1.1 GENERAL

A parking lot also known as a car lot, is a cleared area that is intended for parking vehicles. Usually, the term refers to a dedicated area that has been provided with a durable or semi-durable surface. In most countries where cars are the dominant mode of transportation, parking lots are a feature of every city and suburban area. Shopping malls, sports stadiums, mega churches and similar venues often feature parking lots of immense area..The parking lot is the first - and the last part of a building complex to be viewed by the user. It is the gateway through which all customers, visitors, and employees pass. This first impression is very important to the overall feeling and atmosphere conveyed to the user.

Developers want their new facilities to be attractive, well designed, and functional. Though many hours are spent on producing aesthetically pleasing building designs, the same design consideration for the parking area is often overlooked. Pavements in parking areas that are initially under-designed can experience excessive maintenance problems and a shortened service life. When properly designed and constructed, parking areas can be an attractive part of the facility that is also safe, and most important, usable to the maximum degree. In addition, parking areas should be designed for low maintenance costs and easy modification for changes in use patterns.

1.2 GENERAL PLANNING

In developing the parking area plan, several important details should be considered. First and foremost in the mind of the developer may be providing the maximum parking capacity in the available space while ensuring convenience and safe.

Fig. 1.2(a) 30^o parking provides less space

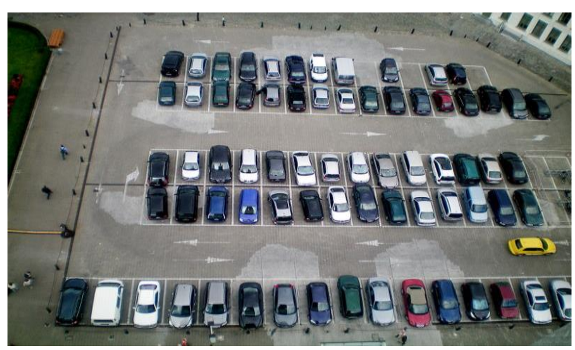

Fig. 1.2(b) 90^o parking provides more space

(Source: http://www.parking-net.com)

Rules have been developed for optimizing parking area space. Among them are the following :

1. Use rectangular areas where possible.

2. Make the long sides of the parking areas parallel.

3. Design so that parking stalls are located along the lots perimeter.

4. Use traffic lanes that serve two rows of stalls.

Table for recommended parking requirements –

Table 1.2 Recommended Parking Requirements

Land Use	Spaces/Unit
Residential	
Single-Family	2.0/Dwelling
Multifamily	
Efficiency	1.0/Dwelling
1-2 Bedroom	1.5/Dwelling
Larger	2.0/Dwelling
Hospital	1.2/Bed
Auditorium/Theatre/Stadium	0.3/Seat
Restaurant	0.3/Seat
Industrial	0.6/Employee
Church	0.3/Seat
College/ University	0.5/Student
Retail	4.0/1000 G.F.A.
Office	3.3/1000 G.F.A.
Shopping Center	5.5/1000 G.L.A.
Hotels/Motels	1.0/Room
	0.5/Employee
Senior High Schools	0.2/Student
	1.0/Staff
Other Schools	1.0/Classroom

G. F. A., sq. feet of gross floor area
G. L. A., sq. feet of gross leasable area

Special attention should be given to the flow of traffic in and out of the lot as well as circulating routes inside the lot. Keep entrances far away from busy street intersections and from lines of vehicles stopped at a signal or stop sign. Be sure that the entering vehicles can move into the lot on an internal aisle, thereby avoiding entering congestion caused by involvement with turning vehicles. A pedestrian traffic-flow study is important to provide information about both safety and convenience.

1.3 PARKING ANGLES

The most popular angles for parking stalls are 30° 60°, 45°, and 90°. The most common angle for parking is the 60° angle because of the ease of operation it provides. This angle permits reasonable traffic lane widths and eases entry and exit of the parking stall.

Where lot size restricts the dimensions available for aisles and stalls, a 45° angle may be used. The smaller change of direction required to enter and back-out of the stall space permits use of narrower aisles. The 45° angle reduces the total number of parking spaces for a given area but is the only acceptable angle for a herringbone parking lot pattern.

The 90° parking angle provides the most parking spaces for a given area. The high degree of difficulty for entering and leaving these parking stalls makes this type of parking more suited to all-day parking, such as employee parking. This angle is generally not preferred for in and out lots such as those of fast food restaurants and banks.

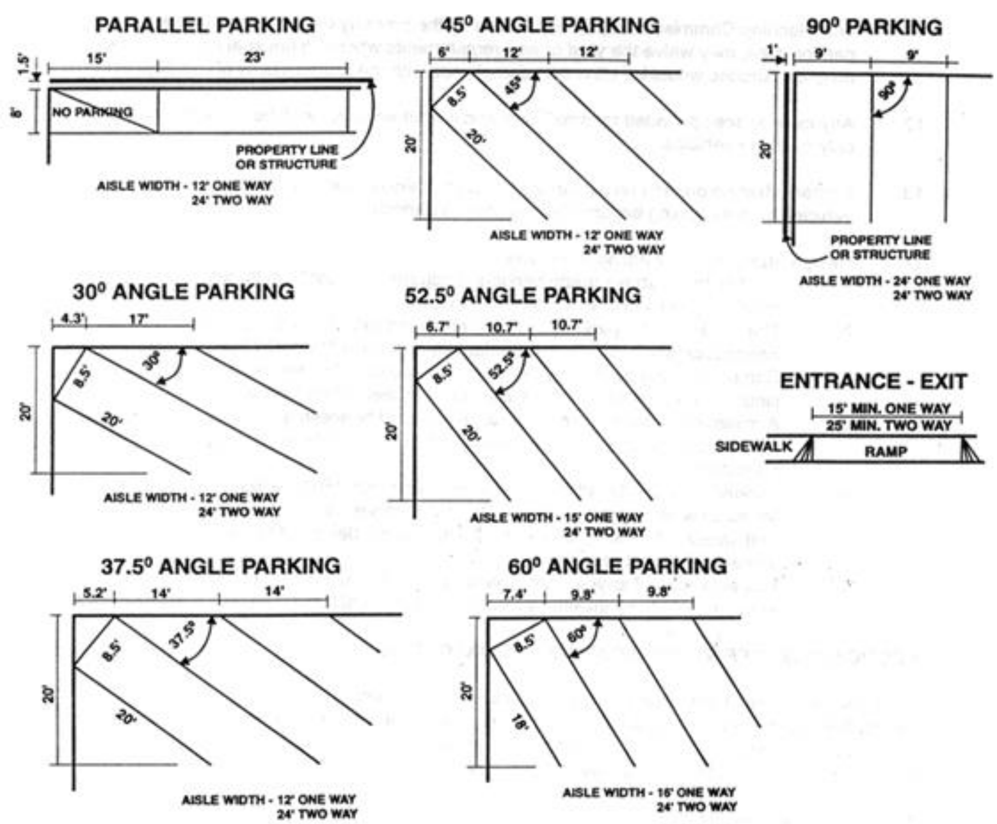

Fig. 1.3 Different Parking Angles

(Source : http://www.south-haven.com)

1.4 PARKING LOT DIMENSIONS

Typical parking stall dimensions vary with the angle at which the stall is arranged in relation to the aisle. Stall widths (measured perpendicular to the vehicle when parked) range from 8-1/2 to 9-1/2 feet. The minimum width for public use parking spaces is 9 feet by 19 feet. Recommended stall dimensions for compacts and similar-sized vehicles are 7-1/2 feet by 15 feet. If a number of such spaces are to be provided, they should be grouped together in a prime area to promote their use. Stall widths for parking lots where shoppers generally have large packages, such as supermarkets and other similar parking facilities, should be 9-1/2 feet or even 10 feet wide.

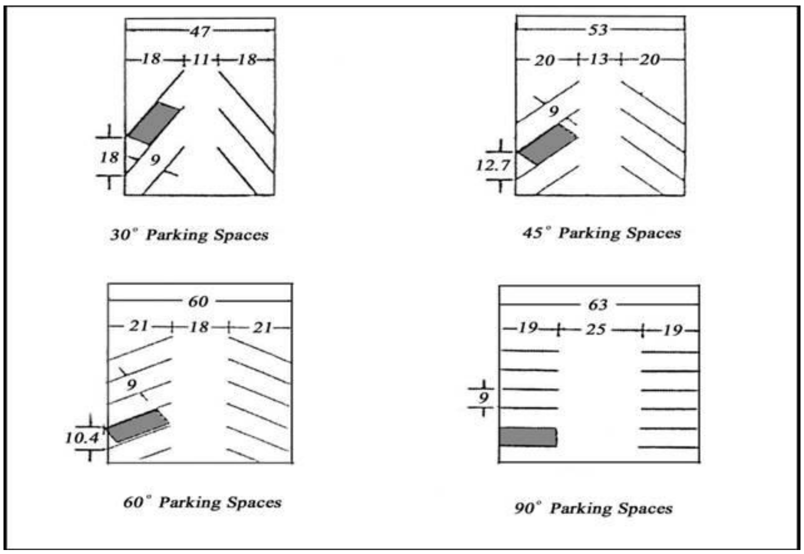

Fig. 1.4 Drive Aisle and Parking Space Dimensions

(Source : http://qcode.us/codes/fountainvalley/view.php?topic=21-21_22-21_22_070)

Table 1.4 Parking Stall and Aisle Dimensions

PARKING STALL AND AISLE DIMENSIONS							
A	B	C	D		E	F	
PARKING ANGLE	STALL WIDTH	LENGTH OF STALL	AISLE WIDTH		WIDTH OF ACCESS DRIVE	BAY WIDTH (CENTER TO CENTER WIDTH OF TWO ROW BAY WITH AISLE BETWEEN)	
			ONE WAY	TWO WAY		ONE WAY	TWO WAY
0°	9 ft.	23 ft.	12 ft	18 ft	20 ft	36 ft	36 ft
30° - 53°	9 ft	18 ft	13 ft	20 ft	20 ft	47-53 ft	54-60 ft
54° - 75°	9 ft	19 ft	18 ft	22 ft	20 ft	60 ft	64 ft
76° - 90°	9ft	19 ft	22 ft	24 ft	20 ft	60 ft	62 ft

CHAPTER 2

LITERATURE REVIEW

2.1 General

This chapter presents the review of history of parking, negative effects of parking, theoretical concepts of parking design and rigid pavement design and traffic survey analysis done by various researchers leading to the present design methodology of parking lot and rigid pavement.

2.2 Theoretical Study

In the early days, cars were more sensitive to weather conditions so they had to be stored in dry garage spaces that looked like any other building.

As cars grew up, as gasoline became an all-weather commodity and cars became comfortable cocoons with sturdy metal shells, garages no longer needed to be impervious to weather. A basic tolerance for ugly parking structures, a particularly soul-killing type of architecture that would blight whole neighborhoods and rend the urban fabric of so many once-walkable downtowns, had entered the American system.

Philip Kennicott explains the exhibit's thesis in full, and also pays a visit to the parking conference. *Donald Shoup*, of course, makes an appearance. *Philip Kennicott* said that early cars were remarkably sensitive little beasts, more hygienic than horses (which left manure in the streets, and sometimes their mortal carcass, too), but also more sensitive to the elements than today's cars. With leather seats, open tops and finicky engines, cars needed protection from cold and rain, and thus early parking garages tended to look like other buildings where we store things. They were often masonry structures, sometimes with windows, built to a scale in line with local neighborhoods. Look at an early garage, and it's not necessarily clear that it's a garage.

The City & Suburban Electric Carriage Company at 6 Denman Street, central London, opened the first multi-storey car park in the UK (and probably the world) in May 1901. The garage had seven floors, 19,000 square feet, space for 100 vehicles and an electric elevator to move the vehiclesbetweenfloors.

In 1902 City & Suburban opened its second garage, a converted building in Westminster known as Niagara that could hold 230 vehicles. At both, electric vehicles were housed, serviced, cleaned, insured and delivered to owners on request.

Khanna & Justo, Highway Engineering describes off-street parking as a separate place way from the kerb.The main advantage of this method is that there is no undue congestion and delay on the road as in kerb parking. But the main drawback is some of the owners will have to walk a greater distance after parking the vehicle. It is also not possible to provide the off-street parking facility at very close intervals. Two basic types of off-street parking facilities are surface parking and multi floor parking garages. It also explains that parking lots may be convenient where sufficient space is available at comparatively low cost. The parking of vehicles may be done by owners or drivers of the car and it is called self parking system. If the vehicle is left by the driver at the entrance space and again collected from there , it is called attendant parking system. Both in parking lots and the multi storey garages, the basic traffic operations consists of five steps, namely, entrance acceptance, storage delivery and exit. Hence some definite space is required in front of the parking lot or garage for vehicles during entrance acceptance and exit operations. This space provided is called reservoir area.

The various terms associated with parking as explained by ***Dr. L.R. Kadiyali (2009)*** are :-

Parking Accumulation: The total number of vehicles parked in an area at a specified moment.

Parking Volume: The number of vehicles parking in a particular area over a given period of time. It is usually measured in vehicles per day.

Parking Load: The area under the parking accumulation curve during a specified period.

Parking Duration: The length of time spent in a parking space.

Parking Index: Percentage of parking bays actually occupied by parked vehicles as compared to the theoretical number available.

Parking Turn-over: Rate of the usage of the available parking space. Parking Production: The parking production is the number of sold hours for parking per place per year. Sold Hours: The number of sold hours is calculated by dividing the total revenue by the tariff.

2.3 Negative Aspects of Parking

While statistics are rarely recorded or analyzed for parking lot accidents, Montgomery County, Maryland was able to shed some light on the hazards of parking lots when they reported that 22% of their total pedestrian-automobile accidents between January 2006 and June 2008 occurred in parking lots.1 When the time range is extended to include crashes from January 2004 – September 2009, the number increases to above 23%, which indicates a fairly consistent metric. The saddest, and probably most surprising, statistics are related to the severity of the collisions.

John A. Stark demonstrates that 19%, almost 1-in-5, of all pedestrian-related parking lot accidents resulted in incapacitating injuries, which underscores the importance of parking lot safety. This emphasizes the point that parking facilities should not focus primarily on driving convenience, but also consider pedestrian safety throughout the entire parking lot. The Federal Highway Administration recommends the placement of parking lots behind commercial buildings to open up store fronts for all pedestrians and reduce the amount of pedestrian-vehicle interactions.By placing parking lots in the rear of the building and not between the storefront and sidewalk, a safer and more vibrant commercial streetscape can be achieved.

John Jakle and *Keith Sculle* (2004) explored the larger issues of parking and land use, including the regulation and commodification of curbside parking spaces. Their research on off-street parking, however, focused on commercial parking lots and garages, rather than private automobile storage. Likewise, Paul Groth (1990) explored the spatial ramifications of off-street lots (as places of destination), rather than private garages (places of origin). The two biggest environmental impacts of parking are a result of vehicle miles traveled and increased impervious surfaces.

The University of Houston, *07/02/2012* has adopted a parking and traffic program to create an orderly traffic flow and equitable parking conditions on campus. Your personal safety, the recognition of others' needs, campus appearance, and applicable laws were prime considerations in the formulation of these regulations.

This program is administered by Parking and Transportation Services (PTS), 3874 Holman St., Suite C Houston, TX 77204 (832-842-1097), and enforced by the PTS Parking Enforcement Unit (713-743-5849).To park on the University of Houston campus you must display a valid UH parking permit unless parked at a parking meter, visitor lot, or a university parking garage. Purchasing a permit does not guarantee a parking place but allows you to park if space is available.
The permit is only transferable between vehicles and NOT between individuals. The registered permit holder is responsible for any parking citation issued to a vehicle displaying their parking permit. In the event the vehicle is not registered with PTS, Motor Vehicle Records from TXDOT will be used to determine responsibility.Park only where your permit allows. Do not park in areas that are not for your use or have a restricted status. Examples of restricted areas are: fire and no parking zones, the grass, sidewalks, along curbs not designated for parking, any unmarked spot, or any place that would disrupt pedestrian or vehicular traffic. If you receive parking citations and do not resolve them, your vehicle will be subjected to tow at your expense. Vehicles may not operate on University of Houston property if they are in violation of state law. Certain low-lying areas of the campus are prone to flooding in heavy rains. The University of Houston is not responsible for any damage or loss of motor vehicles or personal propertycontained in any motor vehicle on campus. Vehicle operators are responsible for familiarizing themselves with current parking rules and regulations.

Anyone who operates a motor vehicle on UH property is asked to register that vehicle with Parking and Transportation Services. Authorized university vehicles and equipment are exempt from registration.For the purpose of these Policies and Procedures, a university holiday is defined by the closing of university business offices.

Parking Measures and Policies Research Review by *D Palmer and CFerris(TRL),May 2010* This paper investigated the evidence about the impact of different types of parking measures and policies on road traffic, congestion and transport safety, car ownership, on the level of carbon emissions from transport, on the activity of businesses, and on townscapes. The focus was mainly though not wholly, on urban areas. It has involved a Systematic Review of evidence from original and relevant studies. The project aimed to support the Department for Transport's analytical and modelling capability in terms of improving its understanding of how economic activity is affected by transport investment and interventions such as parking. For the purposes of this research, the policies and measures considered included pricing (levels, structure and relationship with characteristics of vehicle or user), changes in the supply and location of on-street and off street parking, Park and Ride (P&R), Workplace Parking Levy (WPL), controls on parking provision in new developments, and parking standards in new residential developments. In addition to the intended consequences of parking measures, the review also considered what the literature has to say about unintended or perverse consequences.

In this a six-stage process was undertaken to identify research papers of possible use, extract useful information, consider their findings and their application to the DfT's concerns:

1. Identification of possible papers from journals, reference books etc by virtue of their title or abstract that suggested that the paper might be of relevance;

2. Review of the paper to investigate whether the research reported was relevant to this study;

3. Identification of other research papers in the references for further analysis;

4. Entering the appropriate details in the Access database;

5. Extraction of other relevant information from the document for use in the final report; and

6. Consideration of the utility of the findings for the department of transport , especially the goals set out in DaSTS.

Parking Facilities by Shannon Sanders McDonald,02/06/2015 said that Parking as part of an overall transportation system is one of the crucial issues of our times. As the number of automobiles increases exponentially around the world, the need to house them in close proximity to destinations creates a challenging design problem. The parking facility or lot must foremost deal with the Functional/Operational-as in providing for safe and efficient passage of the automobile and driver. This is a very complex challenge as automotive, engineering and traffic issues relative to site locations must be integrated to create the appropriate solution. Therefore designing the parking facility requires an integrated design approach of many professionals. Parking has often been reduced to the construction of the most minimal stand-alone structure or parking lot without human, aesthetic or integrative considerations. This has given parking a poor public perception and has frequently disrupted existing urban fabric. However, many architects, engineers, and planners have envisioned and constructed far more complex, aesthetic, and integrative structures. This should be the goal of good parking design.

Parking Study for Multiplexes and Commercial Buildings in Vadodara City, Siddharth N. Gupte and Prof. Suresh M. Damodariya,7 July 2014 . In this paper, the various aspects of parking have been described. Various types of parking have been described. Parking is a derived demand. People will tend to park for availing of facilities near the parking zone. Linear regression models have been developed for parking turnover with various independent variables influencing the parking turnover. This paper studies the various aspects of parking. The various terminologies regarding parking have been described. Parking is a derived demand. People will be attracted towards a parking area by the facilities which are provided near the parking area. Linear regression models have been developed between parking turnover and the various independent variables which are influencing parking. Studies must be conducted to collect the required information about the capacity and use of existing parking facilities. In addition, information about the demand for parking is needed. Parking studies may be restricted to a particular traffic producer or attractor, such as a store, or they may encompass an entire region, such as a central business district. Before parking studies can be initiated, the study area must be defined. A cordon line is drawn to delineate the study area. It should include traffic generators and a periphery, including all points within an appropriate walking distance. The survey area should also include any area that might be impacted by the parking modifications. The boundary should be drawn to facilitate cordon counts by minimizing the number of entrance and exit points. Once the study area has been defined, there are several different types of parking studies that may be required.

Jim Gibbons, UConn Extension Land Use Educator, 1999, as more and more people own cars, more and more parking lots become necessary. Unfortunately, parking lots can adversely affect the environment as well as detract from "community character". Paved parking lots are typically designed to collect and concentrate large areas of storm water runoff, which can impact a receiving streams hydrography as well as water quality. Paved parking lots can generate heat, raising the surrounding areas air temperature as well as the temperature of the first flush of storm water which can have significant ecological impacts. The City of Olympia Washington's Public Works Department found that parking lots account for 53% of imperviousness on a commercial site and 15% of multifamily sites. These figures are typical of most communities. Therefore careful attention to their design will go a long way toward protecting your community's water resources. While eighty to ninety percent of all parking demands in America are met by surface parking, many view parking lots as necessary yet unattractive, even hostile places. While we need places to park cars, parking lots in summer can be flame-thrower hot and in winter, ice rink cold and slippery. Parking lots can be real or perceived danger zones, where drivers battle for choice parking spaces and pedestrians try to dodge kamikaze hits from myopic drivers. At night parking lots can become dark, desolate, Stephen King designed, landscapes harboring a rich assortment of imagined shadow lurking predators. Visually parking lots are often urban eyesores and broken tooth gaps in the Pepsodent smile of the urban streetscape.

An introduction of a parking design and simulation model, Wen Long YUE and William YOUNG,1997, this paper is to introduce the procedures involved in the development and validation of a parking design and simulation model, PARKSIM 2, which could be used to evaluate the design of a parking lot layout. The performance measurement on a design will provide quantitative information to parking lot designers enabling them to choose the best iuyout. PARKSIM 2 is a PC-based microscopic, discrete computer simulation model. It can duplicate the vehicle and pedestrian movements as well as the interactions between them in a parking lot. The measurement includes space utilisation, vehicle travel time and conflicts. In current parking lot design process, standards are available to guide the designers on the correct size of parking lot components. Recommended practices for the design of parking lot componenti are plentiful. In Australia, the National Association of Australian State Authorities published the guide to Traffic Engineering Practice (NAASRA, 1982) to aid in the design of parking facilities. Other useful references include Brierley (1972), the Transportation and Traffic Engineering Handbook (ITE,1982) and Ogden and Bennett (1989). However, no reference is available on the investigation of the performance or the ',level of service" of a parking lot. Research into the development of a design tool to estimate the overall performance of a particular parking layout is limited (Fanow, 1984)' The difficulty in developing mathematical models for investigating parking lot performance has long existed. Although the existing references and manuals provide useful information on parking surveys-and design procedures for the individual components of a parking system, methods to gather these components into an overall systematic design are not well described. Moieover, no method is available on the evaluation of the performance of a parking lot. In particular, little effort has been directed at researching into the "level of service" on offitreet parking facilities. The standard of parking lot designs varies with the experience ofthe designers or planning engineers. Therefore, considerations need to be given to the development of procedures to improve the design and management of parking facilities.

An analysis of the spatial distribution of parking supply policy and demand: Young, Beaton, Satgunarajah (department of civil engineering, Monash university, Victoria, Australia,2010) studied the spatial distribution of parking of Melbourne City. Parking facility is one of the important transport facility in urban area specially the central districts having high retail activity & employment opportunities. Parking policies & pricing impacts the entire city transportation & land use. Transport planner & Land use planner look for parking places differently. Spatial integration of parking, land use & transport facility is ignored. Parking influences the spatial distribution of transport use & viability of development. Parking should be considered as at metropolitan level than to consider for a particular region.

Behavioral characteristics of car parking demand(a case study of kolkata): Generalized parking rates are assumed for estimating the parking demand & other parameters are ignored. *Chakrabarty & Mazumdar (Institute of town planner, India journal 7-4, of December 2010)* in this paper took into consideration various behavioral characteristics of parking demand for various trips, location & with various urban areas. Various factors influencing the parking demand & also their influence on each other was tried to find out.

A*nalysis on parking demand of the commercial buildings considering the public transport accessibility: Qin, Xiao, Gan, Pan (nature and science. 2010; 8(3): 63-68), [ISSN: 1545-0740]*analyzed the parking demand of shopping centre & markets from the data obtained by conducting parking demand survey at various locations of Bejing. Relationship between parking demand & transport accessibility was analyzed. Parking demand decreases with good & efficient transport facility. Parking demand rate with different public transport accessibility was determined & a parking demand model with different accessibility was provided.

Attitudes and behavioral responses to parking measures: *Warden, Borgers, TImmermans (Urban planning group, Eindhoven university of technology, March 2006)* studied attitude & behavioral responses of car drivers to planned parking measures at campus of the Eindhoven University of Technology, the Netherlands. In an on-street questionnaire, car drivers were asked their opinion about restricting access to the campus area for cars of nonuniversity car drivers through (i) a barrier, (ii) proper identification when entering the campus area, and (iii) payment. The response of more than 700 car drivers was used in multinomial logit analysis. Most drivers wanted to continue into the University campus by car. Half of the car driver responded they would change their mode of transport or park car outside the campus if they have to pay parking fee. Parking spaces using survey data: Parking spaces are strategic commodities of modern day transport facility. Few dataset allows precisely measuring the use of spaces in terms of population, segments, activity types & duration. *Morency & Trepainer (Interuniversity Research centre on enterprise networks, logistics and transportation (CIRRELT) 2008)* proposed empirical measures & methods 13 regarding the use of parking space in a strategic urban area. Large survey was conducted representing 5% of the population of Montreal. Car driver heading towards the area enquired regarding the type of parking space. Parking spaces were classified according to their jurisdiction (private/public), location (indoor/on the street/outdoor) and rates (free/fee charging/subsidized by the employer). Using these data, statistics describing the use of these spaces are developed. On the one hand, people benefiting from the various types of parking spaces are described in terms of residence location, demographic attributes and type of activity. On the other hand, parking accumulation profiles are developed and summarized by key indicators.

Parking site selection management using fuzzy logic and multi criteria decision making: Population growth, sprawling of cities and increasing of vehicles result in heavy traffic and prolonged city trips. Utilizing public parking regarded as an effective approach to abate traffic load in city centers, in that spaces designated for vehicles parking along the roads would be freed, and consequently the usable space of the roads would increase, which in turn would contribute to the smooth flow of traffic

2.4 SUMMARY OF LITERATURE REVIEW

Parking is one of the major problems that is created by the increasing road traffic. It is an impact of transport development. The availability of less space in urban areas has increased the demand for parking space especially in areas like Central business district. This affects the mode choice also. This has a great economical impact.

Before taking any measures for the betterment of conditions, data regarding availability of parking space, extent of its usage and parking demand is essential. It is also required to estimate the parking fares also. Parking surveys are intended to provide all these information. Since the duration of parking varies with different vehicles, several statistics are used to access the parking need. *The City & Suburban Electric Carriage Company* at 6 Denman Street, central London, opened the first multi-storey car park in the UK (and probably the world) in May 1901. The garage had seven floors, 19,000 square feet, space for 100 vehicles and an electric elevator to move the vehicles between floors. Khanna & Justo, Highway Engineering describes off-street parking as a separate place way from the kerb.The main advantage of this method is that there is no undue congestion and delay on the road as in kerb parking. But the main drawback is some of the owners will have to walk a greater distance after parking the vehicle. It is also not possible to provide the off-street parking facility at very close intervals. Two basic types of off-street parking facilities are surface parking and multi floor parking garages. *John Jakle* and *Keith Sculle* (2004) explored the larger issues of parking and land use, including the regulation and commodification of curbside parking spaces. Their research on off-street parking, however, focused on commercial parking lots and garages, rather than private automobile storage. Likewise, Paul Groth (1990) explored the spatial ramifications of off-street lots (as places of destination), rather than private garages (places of origin). The two biggest environmental impacts of parking are a result of vehicle miles traveled and increased impervious surfaces.

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Shannon Sanders McDonald explained parking as part of an overall transportation system is one of the crucial issues of our times. As the number of automobiles increases exponentially aroundthe world, the need to house them in close proximity to destinations creates a challenging design problem. Therefore designing the parking facility requires an integrated design approach of many professionals. Parking has often been reduced to the construction of the most minimal stand-alone structure or parking lot without human, aesthetic or integrative considerations

2.5 OBJECTIVE OF THE PRESENT STUDY

On the basis of the literature review the following objectives were determined:

- Design of parking lot layouts with an emphasize on theoretical study of parking lot, parking turnover, parking volume, parking load, parking index, parking accumulation, spot study & annual average daily traffic.
- Design of thickness of rigid pavement which is safe under the combined action of wheel load and temperature.
- Theoretical design and arrangement of site configuration in AutoCAD.
- Design of drainage which can prevent the water logging issues on pavement and can increase the durability of parking lot.
- Pavement maintenance and parking facilities which can enhance the aesthetics of parking lot.
- Cost estimation and analysis of the parking lot.

2.6 SCOPE OF STUDY

- Along with the design of thickness of rigid pavement, the designing of rigid pavement with camber can also be done so that drainage problem can be handled efficiently.
- Designing of parking lot layouts in different parking angles i.e. 30^o, 45^o, 60^o angles other than 90^o angle can also be done.
- Design of the parking lot with initial ground improvement can also be carried out.
- The site area is mainly land filled area due to which the estimated cost of the project is a little bit high and this increases the thickness of concrete pavement.
- Parking fee counter can also be constructed if needed.

CHAPTER 3

METHODOLOGY

3.1 SITE OF THE PROJECT

The Project is about parking lot design at a site of dimensions 40.50m × 28 m(rectangle) + Semicircle of radius 14m near guard's hostel in the Jaypee University of Information Technology. The soil at the site is mainly sandy in nature with some coarse aggregates.

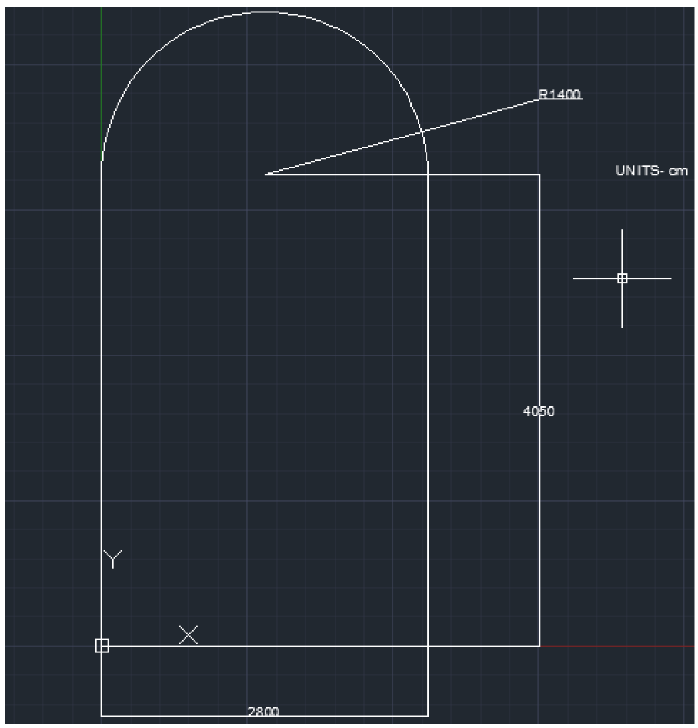


Fig. 3.1 The Plan of the field in AutoCAD

3.2 MAP OF THE CONCERNED SITE AT JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

The concerned site is located in Jaypee University of Information Technology near the guard's hostel. It includes a rectangular area of dimensions 40.50m × 28 m and a semicircle of diameter of 28 m. The Jaypee University Of Information Technology is located at 3-4 km away from Waknaghat and approximately 20-25 km away from Shimla.

Fig. 3.2 Map of the Site

Site investigations being done at the site,

Fig. 3.3(a) Site Photo

Fig. 3.3(b) Side boundary

Fig. 3.3(c) Semicircular boundary

The site area mainly consists of rectangular area of length 40.50 m and width 28 m and a semicircular area of radius 14 m .The site has some undulations along the side boundary.

3.3 ANNUAL AVERAGE DAILY TRAFFIC

Annual average daily traffic, abbreviated AADT, is a measure used primarily in transportation planning and transportation engineering. Traditionally, it is the total volume of vehicle traffic of a highway or road for a year divided by 365 days. AADT is a useful and simple measurement of how busy the road is. Newer advances from traffic data providers are now providing AADT by side of the road, by day of week and by time of day. One of the most important uses of AADT is for determining funding for the maintenance and improvement of Highways.

In the United States the amount of federal funding a state will receive is related to the total traffic measured across its Highway network. Each year on June 15, every state in the United States submits a Highway Performance Monitoring System HPMS report. The HPMS report contains various information regarding the road segments in the state based on a sample (not all of the road segments) of the road segments. In the report, the AADT is converted to Vehicle Miles Traveled (VMT). VMT is the AADT multiplied by the length of the road segment. To determine the amount of traffic a state has, the AADT cannot be summed for all road segments since an AADT is a rate. The VMT is summed and is used as an indicator of the amount of traffic a state has. For federal-funding, formulas are applied to include the VMT and other highway statistics.

In the United Kingdom AADT is one of a number of measures of traffic used by Local Highway Authorities, the Highways Agency and the Department for Transport to forecast maintenance needs and expenditure.

3.4 DATA COLLECTION

To measure AADT on individual road segments, traffic data is collected either by an automated traffic counter or hiring an observer to record traffic. There are two different techniques of measuring the AADTs for road segments. One technique is called continuous count data collection method. This is where sensors are permanently embedded into a road and traffic data is measured all 365 days. The AADT would be the sum of the total traffic for the entire year divided by 365 days. There is a problem with calculating the AADT with this method. The continuous count equipment is not operating for the full 365 days due to being shut down for maintenance or repair. Because of this, seasonal or day-of-week biases might skew the calculated AADT. In 1992, AASHTO released the AASHTO Guidelines for Traffic Data Programs, which identified a way to produce an AADT without seasonal or day-of-week biases by creating an "average of averages." For every month and day-of-week, a Monthly Average Day of Week (MADW) is calculated (84 per year). Each day-of-week's MADW is then calculated across months to calculate an Annual Average Day of Week (AADW) (7 per year). Finally, the AADWs are averaged to calculate an AADT. The United States Federal Highway Administration (FHWA) has adopted this method as the preferred method in the [FHWA Traffic Monitoring Guide**.**

While providing the most accurate AADT, installing and maintaining continuous count stations method is costly. Most agencies are only able to monitor a very small percentage of the roadway using this method. Most AADTs are generated using short-term data collection methods sometimes known as the coverage count data collection method. Traffic is collected with portable sensors that are attached to the road and record traffic data typically for 2 – 14 days. These are typically pneumatic road tubes although other more expensive technology such as radar, laser, or sonar exist. After recording the traffic data, the traffic counts on the same road segment are taken again in another three years. FHWA Traffic Monitoring Guide recommends performing a short count on a road segment at a minimum of every three years. There are many methods used to calculate an AADT from a short-term count, but most methods attempt to remove seasonal and day-of-week biases during the collection period by applying factors created from associated continuous counters. Short counts are taken either by state agencies, local government, or contractors.

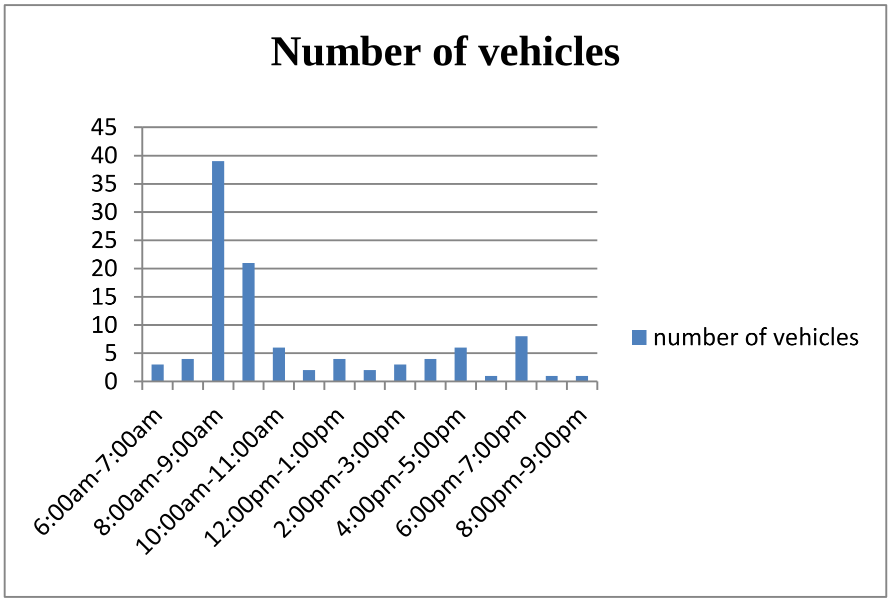
For the years when a traffic count is not recorded, the AADT is often estimated by applying a factor called the Growth Factor. Growth Factors are statistically determined from historical data of the road segment. If there is no historical data, Growth Factors from similar road segments are used.

ADT OF 18th NOVEMBER 2015

Table 3.4.1 No. of vehicles

passing at an interval of time

Time	Number of Vehicles
6:00am-7:00am	3
7:00am-8:00am	4
8:00am-9:00am	39
9:00am-10:00am	21
10:00am-11:00am	6
11:00am-12:00pm	2
12:00pm-1:00pm	4
1:00pm-2:00pm	2
2:00pm-3:00pm	3
3:00pm-4:00pm	4
4:00pm-5:00pm	6
5:00pm-6:00pm	1
6:00pm-7:00pm	8
7:00pm-8:00pm	1
8:00pm-9:00pm	1



Graph 3.4.1 Relation between no. of vehicles with time

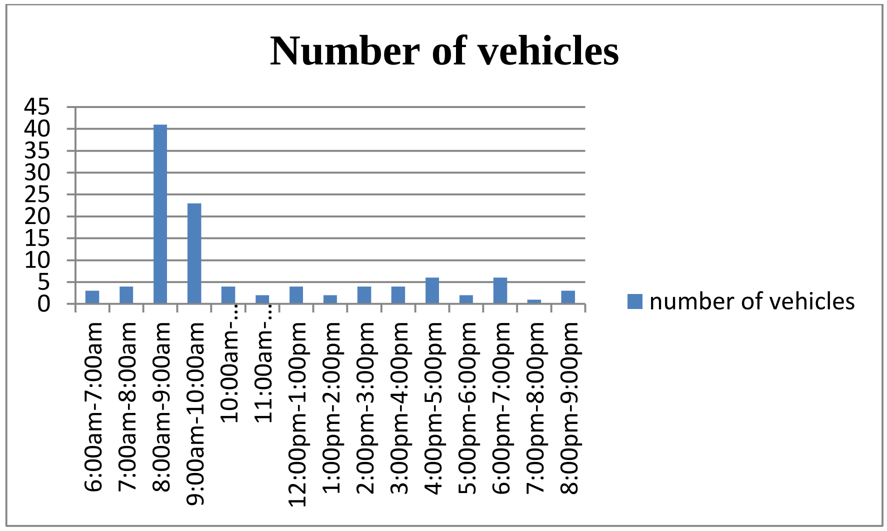
The table and the graph justify the relationship between the number of vehicles and the particular time interval. This graph and the values show that the maximum number of vehicles entering the campus is peak at between 8:00 am to 9:00 am

ADT OF 19th NOVEMBER 2015

Table 3.4.2 No. of vehicles

passing at an interval of time

Time	Number of Vehicles
6:00am-7:00am	3
7:00am-8:00am	4
8:00am-9:00am	41
9:00am-10:00am	23
10:00am-11:00am	4
11:00am-12:00pm	2
12:00pm-1:00pm	4
1:00pm-2:00pm	2
2:00pm-3:00pm	4
3:00pm-4:00pm	4
4:00pm-5:00pm	6
5:00pm-6:00pm	2
6:00pm-7:00pm	6
7:00pm-8:00pm	1
8:00pm-9:00pm	3



Graph 3.4.2 Relation between no. of vehicles with time

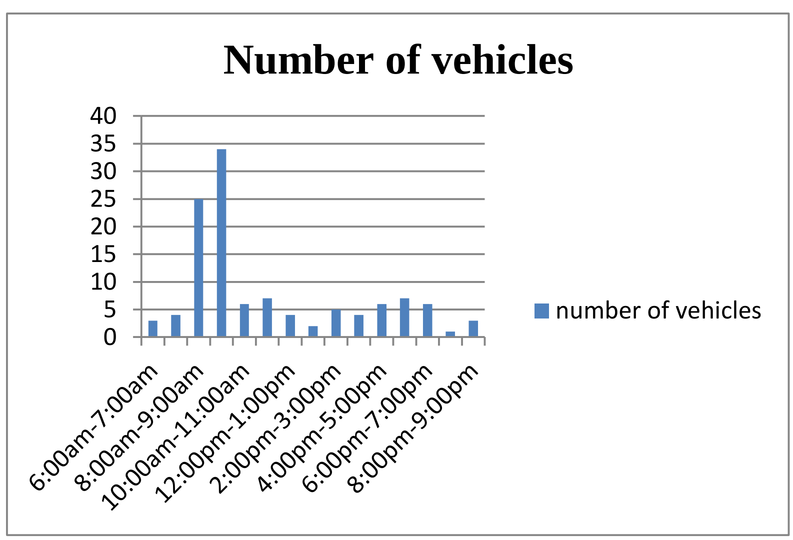
The table and the graph justify the relationship between the number of vehicles and the particular time interval. This graph and the values show that the maximum number of vehicles entering the campus is peak at between 8:00 am to 9:00 am .

ADT OF 20th NOVEMBER 2015

Table 3.4.3 No. of vehicles

passing at an interval of time

Time	Number of Vehicles
6:00am-7:00am	3
7:00am-8:00am	4
8:00am-9:00am	25
9:00am-10:00am	34
10:00am-11:00am	6
11:00am-12:00pm	7
12:00pm-1:00pm	4
1:00pm-2:00pm	2
2:00pm-3:00pm	5
3:00pm-4:00pm	4
4:00pm-5:00pm	6
5:00pm-6:00pm	7
6:00pm-7:00pm	6
7:00pm-8:00pm	1
8:00pm-9:00pm	3



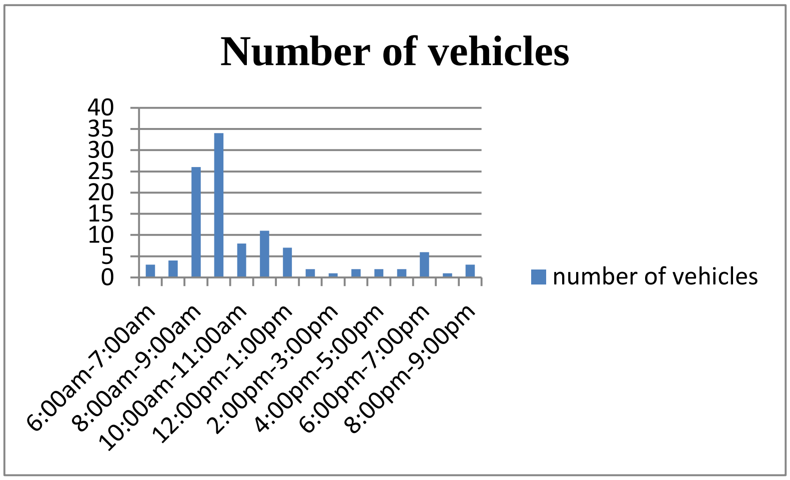
Graph 3.4.3 Relation between no. of vehicles with time

The table and the graph justify the relationship between the number of vehicles and the particular time interval. This graph and the values show that the maximum number of vehicles entering the campus is peak at between 9:00 am to 10:00 am.

ADT FOR 21st NOVEMBER 2015

Table 3.4.4 No. of vehicles passing at an interval of time

Time	Number of Vehicles
6:00am-7:00am	3
7:00am-8:00am	4
8:00am-9:00am	26
9:00am-10:00am	34
10:00am-11:00am	8
11:00am-12:00pm	11
12:00pm-1:00pm	7
1:00pm-2:00pm	2
2:00pm-3:00pm	1
3:00pm-4:00pm	2
4:00pm-5:00pm	2
5:00pm-6:00pm	2
6:00pm-7:00pm	6
7:00pm-8:00pm	1
8:00pm-9:00pm	3



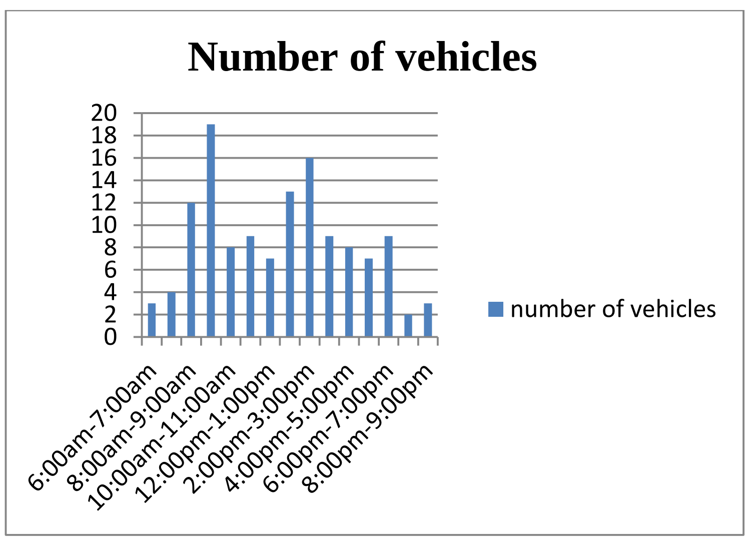
Graph 3.4.4 Relation between no. of vehicles with time

The table and the graph justify the relationship between the number of vehicles and the particular time interval. This graph and the values show that the maximum number of vehicles entering the campus is peak at between 9:00 am to 10:00 am.

ADT FOR 22nd NOVEMBER 2015

Table 3.4.5 No. of vehicles passing at an interval of time

Time	Number of Vehicles
6:00am-7:00am	3
7:00am-8:00am	4
8:00am-9:00am	12
9:00am-10:00am	19
10:00am-11:00am	8
11:00am-12:00pm	9
12:00pm-1:00pm	7
1:00pm-2:00pm	13
2:00pm-3:00pm	16
3:00pm-4:00pm	9
4:00pm-5:00pm	8
5:00pm-6:00pm	7
6:00pm-7:00pm	9
7:00pm-8:00pm	2
8:00pm-9:00pm	3



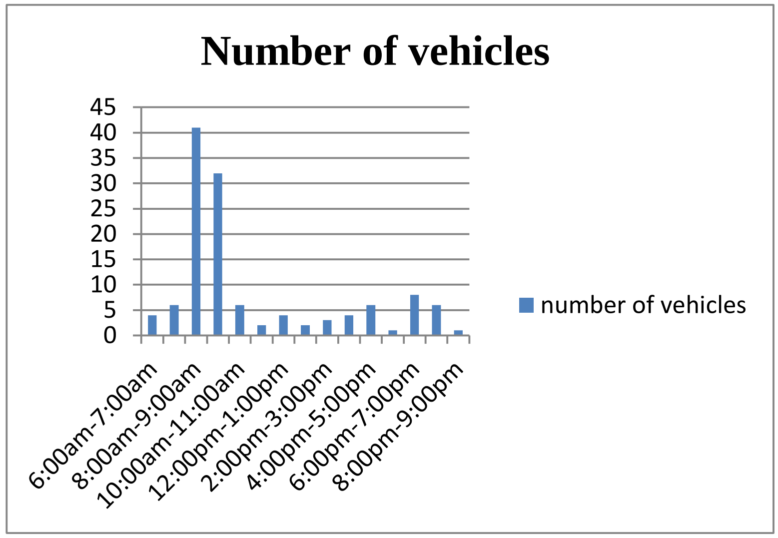
Graph 3.4.5 Relation between no. of vehicles with time

The table and the graph justify the relationship between the number of vehicles and the particular time interval. This graph and the values show that the maximum number of vehicles entering the campus is peak at between 9:00 am to 10:00 am.

ADT FOR 23rd NOVEMBER 2015

Table 3.4.6 No. of vehicles passing at an interval of time

Time	Number of Vehicles
6:00am-7:00am	4
7:00am-8:00am	6
8:00am-9:00am	41
9:00am-10:00am	32
10:00am-11:00am	6
11:00am-12:00pm	2
12:00pm-1:00pm	4
1:00pm-2:00pm	2
2:00pm-3:00pm	3
3:00pm-4:00pm	4
4:00pm-5:00pm	6
5:00pm-6:00pm	1
6:00pm-7:00pm	8
7:00pm-8:00pm	6
8:00pm-9:00pm	1



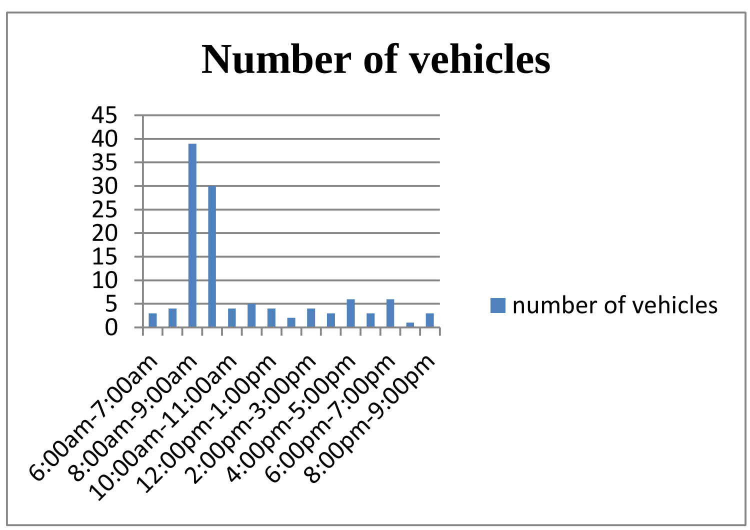
Graph 3.4.6 Relation between no. of vehicles with time

The table and the graph justify the relationship between the number of vehicles and the particular time interval. This graph and the values show that the maximum number of vehicles entering the campus is peak at between 8:00 am to 9:00 am.

ADT FOR 24th NOVEMBER 2015

Table 3.4.7 No. of vehicles passing at an interval of time

Time	Number of Vehicles
6:00am-7:00am	3
7:00am-8:00am	4
8:00am-9:00am	39
9:00am-10:00am	30
10:00am-11:00am	4
11:00am-12:00pm	5
12:00pm-1:00pm	4
1:00pm-2:00pm	2
2:00pm-3:00pm	4
3:00pm-4:00pm	3
4:00pm-5:00pm	6
5:00pm-6:00pm	3
6:00pm-7:00pm	6
7:00pm-8:00pm	1
8:00pm-9:00pm	3



Graph 3.4.7 Relation between no. of vehicles with time

From all the above graphs between number of vehicles and time interval, it is observed that the number of vehicles passing through the main gate of Jaypee University of Information Technology is maximum in between 8:00am-9:00am .So, the average peak hours of traffic flow is between 8:00am-9:00am.

3.5 SPOT SPEED STUDY

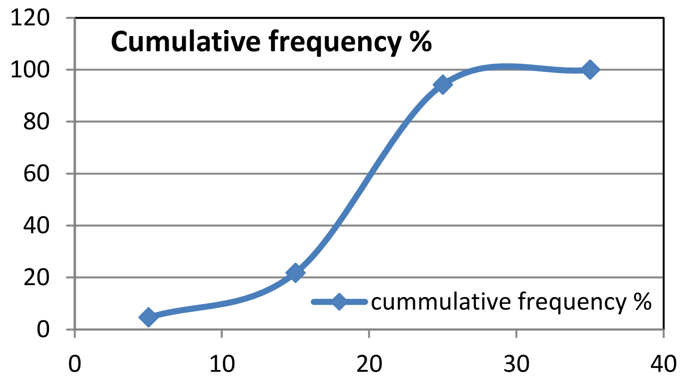
Speed is an important transportation consideration because it relates to safety, time, comfort, convenience, and economics. Spot speed studies are used to determine the speed distribution of a traffic stream at a specific location. The data gathered in spot speed studies are used to determine vehicle speed percentiles, which are useful in making many speed-related decisions. Spot speed data have a number of safety applications, including the following (Robertson 1994):

1 .Determining existing traffic operations and evaluation of traffic control devices
   a. Evaluating and determining proper speed limits
   b. Determining the 50th and 85th speed percentiles (explained below)
   c. Evaluating and determining proper advisory speeds
   d. Establishing the limits of no-passing zones
   e. Determining the proper placements of traffic control signs and markings
   f. Setting appropriate traffic signal timing.
2. Establishing roadway design elements
   a. Evaluating and determining proper intersection sight distance.
   b. Evaluating and determining proper passing sight distance.
   c. Evaluating and determining proper stopping sight distance.
3. Assessing roadway safety questions
   a. Evaluating and verifying speeding problems.
   b. Assessing speed as a contributor to vehicle crashes.
   c. Investigating input from the public or other officials.
4. Monitoring traffic speed trends by systematic ongoing speed studies.
5. Measuring effectiveness of traffic control devices or traffic programs, including signs and markings , traffic operational changes, and speed enforcement programs.

Spot Study of 18th November 2015

Table 3.5.1 Frequency Distribution of Spot Speed Data

Speed range (km/hr)	Mid speed (km/hr)	Cumulative frequency %	Frequency %	Frequency
(0-10)	5	4.59	4.59	8
(10-20)	15	21.83	17.24	30
(20-30)	25	94.24	72.41	126
(30-40)	35	99.99	5.75	10
				174



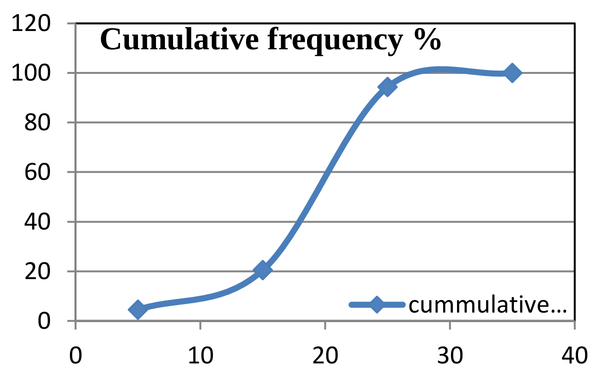
Graph 3.5.1 Cumulative Speed Distribution

From this graph, the 85th, 15th & 98th percentile speeds are found out. The upper speed(85th percentile) is 24 kmph , lower speed(15th percentile) is 10 kmph & speed to check design elements(98th percentile) is 26 kmph. Whereas the 85th percentile speed gives that speed at or below 85% of the vehicles are passing the point or only 15 % of vehicles exceed the speed at that spot. The drivers exceeding 85th percentile speed are usually considered to drive faster than the safe speed under existing conditions & hence this speed is adopted for safe speed limit. The 15th percentile speed represents the lower speed limit.

Spot Study of 19th November 2015

Table 3.5.2 Frequency Distribution of Spot Speed Data

Speed range (km/hr)	Mid speed (km/hr)	Cumulative frequency %	Frequency %	Frequency
(0-10)	5	4.54	4.54	8
(10-20)	15	20.45	15.90	28
(20-30)	25	94.31	73.86	130
(30-40)	35	100	5.68	10
				176



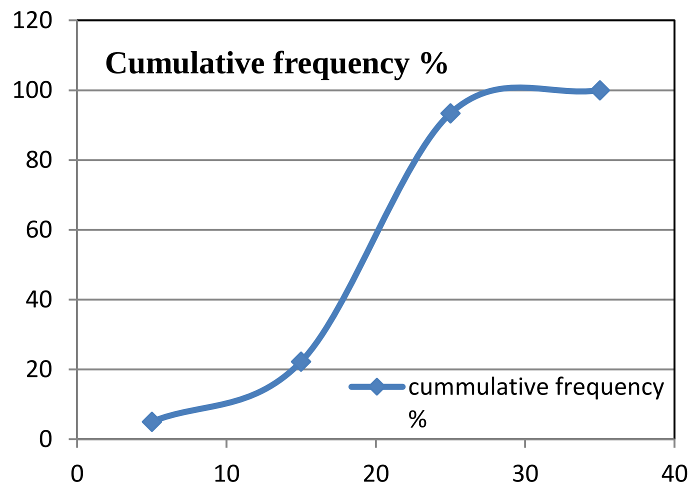
Graph 3.5.2 Cumulative Speed Distribution

From this graph, the 85th, 15th & 98th percentile speeds are found out. The upper speed(85th percentile) is 23 kmph , lower speed(15th percentile) is 12 kmph & speed to check design elements(98th percentile) is 25 kmph. Whereas the 85th percentile speed gives that speed at or below 85% of the vehicles are passing the point or only 15 % of vehicles exceed the speed at that spot. The drivers exceeding 85th percentile speed are usually considered to drive faster than the safe speed under existing conditions & hence this speed is adopted for safe speed limit. The 15th percentile speed represents the lower speed limit.

Spot Study of 20th November 2015

Table 3.5.3 Frequency Distribution of Spot Speed Data

Speed range (km/hr)	Mid speed (km/hr)	Cumulative frequency %	Frequency %	Frequeny
(0-10)	5	5	5	9
(10-20)	15	22.22	17.22	31
(20-30)	25	93.33	71.11	128
(30-40)	35	100	6.67	12
				180



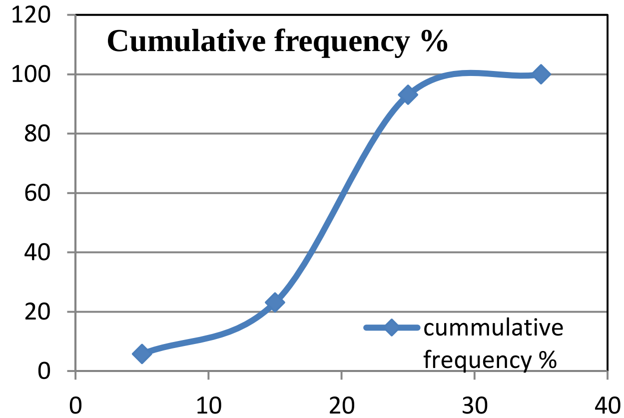
Graph 3.5.3 Cumulative Speed Distribution

From this graph, the 85th, 15th & 98th percentile speeds are found out. The upper speed(85th percentile) is 26 kmph , lower speed(15th percentile) is 11 kmph & speed to check design elements(98th percentile) is 27 kmph. Whereas the 85th percentile speed gives that speed at or below 85% of the vehicles are passing the point or only 15 % of vehicles exceed the speed at that spot. The drivers exceeding 85th percentile speed are usually considered to drive faster than the safe speed under existing conditions & hence this speed is adopted for safe speed limit. The 15th percentile speed represents the lower speed limit.

Spot Study of 21 November 2015

Table 3.5.4 Frequency Distribution of Spot Speed Data

Speed range (km/hr)	Mid speed (km/hr)	Cumulative frequency %	Frequency %	Frequency
(0-10)	5	5.78	5.78	10
(10-20)	15	23.12	17.34	30
(20-30)	25	93.06	69.94	121
(30-40)	35	100	6.93	12
				173



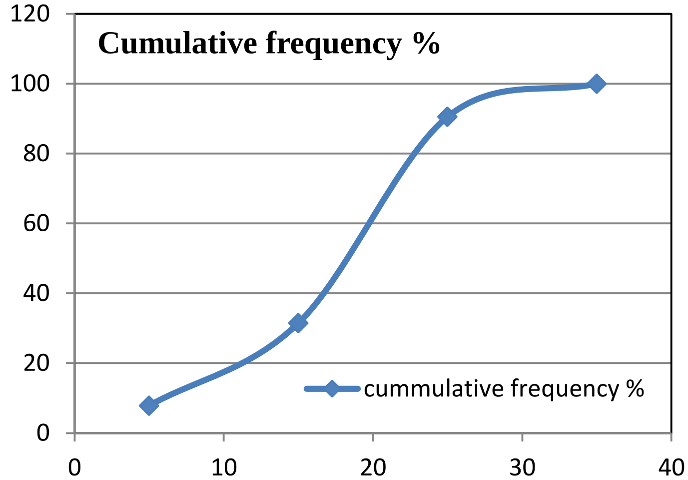
Graph 3.5.4 Cumulative Speed Distribution

From this graph, the 85th, 15th & 98th percentile speeds are found out.The upper speed(85th percentile) is 24 kmph , lower speed(15th percentile) is 10 kmph & speed to check design elements(98th percentile) is 27 kmph. Whereas the 85th percentile speed gives that speed at or below 85% of the vehicles are passing the point point or only 15 % of vehicles exceed the speed at that spot. The drivers exceeding 85th percentile speed are usually considered to drive faster than the safe speed under existing conditions & hence this speed is adopted for safe speed limit. The 15th percentile speed represents the lower speed limit.

Spot Study of 22nd November 2015

Table 3.5.5 Frequency Distribution of Spot Speed Data

Speed range (km/hr)	Mid speed (km/hr)	Cumulative frequency %	Frequency %	Frequency
(0-10)	5	7.87	7.87	10
(10-20)	15	31.49	23.62	30
(20-30)	25	90.55	59.05	75
(30-40)	35	100	9.44	12
				127



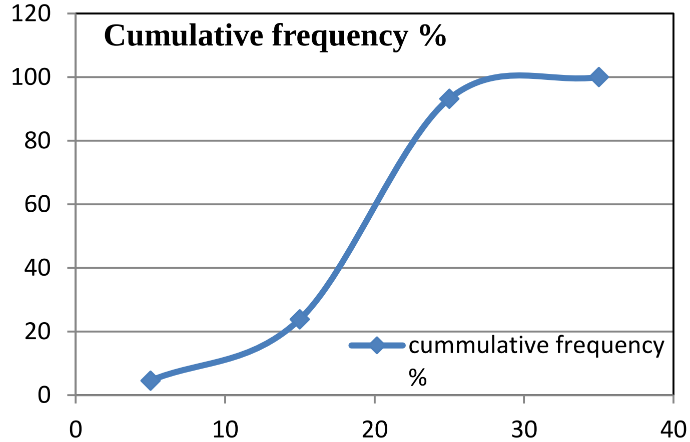
Graph 3.5.5 Cumulative Speed Distribution

From this graph, the 85th, 15th & 98th percentile speeds are found out. The upper speed(85th percentile) is 22 kmph , lower speed(15th percentile) is 8 kmph & speed to check design elements(98th percentile) is 28 kmph. Whereas the 85th percentile speed gives that speed at or below 85% of the vehicles are passing the point or only 15 % of vehicles exceed the speed at that spot. The drivers exceeding 85th percentile speed are usually considered to drive faster than the safe speed under existing conditions & hence this speed is adopted for safe speed limit. The 15th percentile speed represents the lower speed limit.

Spot Study of 23rd November 2015

Table 3.5.6 Frequency Distribution of Spot Speed Data

Speed range (km/hr)	Mid speed (km/hr)	Cummulative frequency %	Frequency %	Frequency
(0-10)	5	4.54	4.54	8
(10-20)	15	23.86	19.31	34
(20-30)	25	93.18	69.31	122
(30-40)	35	100	6.81	12
				176



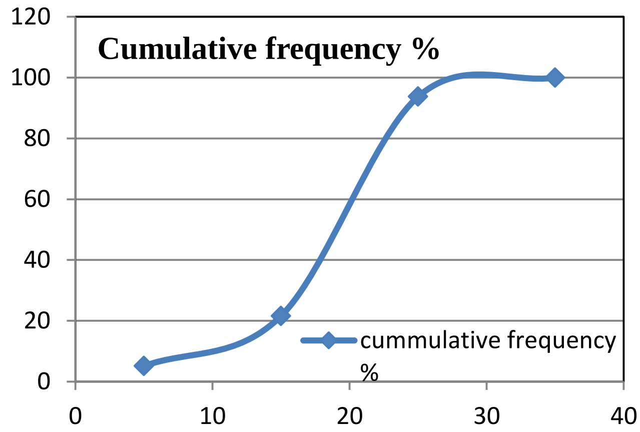
Graph 3.5.6 Cumulative Speed Distribution

From this graph, the 85th, 15th & 98th percentile speeds are found out. The upper speed(85th percentile) is 24 kmph , lower speed(15th percentile) is 10 kmph & speed to check design elements(98th percentile) is 27 kmph. Whereas the 85th percentile speed gives that speed at or below 85% of the vehicles are passing the point or only 15 % of vehicles exceed the speed at that spot. The drivers exceeding 85th percentile speed are usually considered to drive faster than the safe speed under existing conditions & hence this speed is adopted for safe speed limit. The 15th percentile speed represents the lower speed limit.

Spot Study of 24th November 2015

Table 3.5.7 Frequency Distribution of Spot Speed Data

Speed range (km/hr)	Mid speed (km/hr)	Cumulative frequency %	Frequency %	Frequency
(0-10)	5	5.11	5.11	9
(10-20)	15	21.59	16.47	29
(20-30)	25	93.75	72.15	127
(30-40)	35	100	6.25	11
				176



Graph 3.5.7 Cumulative Speed Distribution

From this graph, the 85th, 15th & 98th percentile speeds are found out. The upper speed(85th percentile) is 25 kmph , lower speed(15th percentile) is 11 kmph & speed to check design elements(98th percentile) is 27 kmph. Whereas the 85th percentile speed gives that speed at or below 85% of the vehicles are passing the point or only 15 % of vehicles exceed the speed at that spot. The drivers exceeding 85th percentile speed are usually considered to drive faster than the safe speed under existing conditions & hence this speed is adopted for safe speed limit. The 15th percentile speed represents the lower speed limit.

1.6 PRELIMINARY TESTING ON SOIL

Some tests on the natural soil were carried out in accordance with the procedures outlined in IS 2720-15. The following tests were carried out on the Soil:
In almost all soil tests natural moisture content of the soil is to be determined. The knowledge of the natural moisture content is essential in all studies of soil mechanics. To sight a few, natural moisture content is used in determining the bearing capacity and settlement. The natural moisture content will give an idea of the state of soil in the field.

3.6.1 MOISTURE CONTENT OF THE SOIL SAMPLE

This test is done to determine the water content in soil by oven drying method as per IS: 2720 (Part II) – 1973. The water content (w) of a soil sample is equal to the mass of water divided by the mass of solids. Apparatus required:-

i) Thermostatically controlled oven maintained at a temperature of 110 ± 5°C
ii) Weighing balance, with an accuracy of 0.04% of the weight of the soil taken
iii) Air-tight container made of non-corrodible material with lid
iv) Tongs.

For many soils, the water content may be an extremely important index used for establishing the relationship between the way a soil behaves and its properties. The consistency of a fine-grained soil largely depends on its water content. The water content is also used in expressing the phase relationships of air, water, and solids in a given volume of soil.

PROCEDURE

Clean the container with lid dry it and weigh it (W1),Take a specimen of the sample in the container and weigh with lid (W2),Keep the container in the oven with lid removed. Dry the specimen to constant then weight maintaining the temperature between 1050 C to 1100 C for a period varying with the type of soil but usually 16 to 24 hours. Record the final constant weight (W3) of the container with dried soil sample. Peat and other organic soils are to be dried at lower temperature (say 600) possibly for a longer period. Certain soils contain gypsum which on heating loses its water if crystallization. If its is suspected that gypsum is present in the soil sample used for moisture content determination it shall be dried at not more than 800 C and possibly for a longer time.

OBSERVATIONS AND RECORDING

Table 3.6.1 Observation Table

S.No.	Sample	Weight(gm)
1.	Weight of container with lid W1 gm	20.20
2.	Weight of container with lid + wet soil W2 gm	36.80
3.	Weight of container with lid + dry soil W3 gm	36.20

From the collected data and calculations, the **natural moisture content of the soil sample is 3.75%**, which means the soil is sandy in nature. In sand the moisture content should be less than 5%.

3.6.2 SAND REPLACEMENT METHOD

Determination of field density of cohesion less soil is not possible by core cutter method, because it is not possible to obtain a core sample. In such situation, the sand replacement method is employed to determine the unit weight. In sand replacement method, a small cylindrical pit is excavated and the weight of the soil excavated from the pit is measured. Sand whose density is known is filled into the pit. By measuring the weight of sand required to fill the pit and knowing its density the volume of pit is calculated. Knowing the weight of soil excavated from the pit and the volume of pit, the density of soil is calculated. Therefore, in this experiment there are two stages, namely

1. Calibration of sand density.
2. Measurement of soil density.

The apparatus that is required for the test are Sand pouring cylinder, Calibrating can, Metal tray with, a central hole, Dry sand (passing through 1.18 mm sieve), Balance, Moisture content bins, Glass plate, Metal tray and Scraper tool.

STAGE-1 (CALIBRATION OF SAND DENSITY)

Measure the internal dimensions (diameter, d and height, h) of the calibrating can and compute its internal volume, $\mathbf{V_c} = \pi d^2 h/4$.Fill the sand pouring cylinder (SPC) with sand with 1 cm top clearance (to avoid any spillover during operation) and find its weight ($\mathbf{W_1}$).

Place the SPC on a glass plate, open the slit above the cone by operating the valve and allow the sand to run down. The sand will freely run down till it fills the conical portion. When there is no further downward movement of sand in the SPC, close the slit. Measure the weight of the sand required to fill the cone. Let it be $\mathbf{W_2}$.

Place back this $\mathbf{W_2}$ amount of sand into the SPC, so that its weight becomes equal to $\mathbf{W_1}$ (As mentioned in point-2). Place the SPC concentrically on top of the calibrating can. Open the slit to allow the sand to run down until the sand flow stops by itself. This operation will fill the calibrating can and the conical portion of the SPC. Now close the slit and find the weight of the SPC with the remaining sand ($\mathbf{W_3}$).

STAGE-2 (MEASUREMENT OF SOIL DENSITY)

Clean and level the ground surface where the field density is to be determined and then place the tray with a central hole over the portion of the soil to be tested. Excavate a pit into the ground, through the hole in the plate, approximately 12 cm deep (same as the height of the calibrating can). The hole in the tray will guide the diameter of the pit to be made in the ground.

Collect the excavated soil into the tray and weigh the soil (**W**) and,

Determine the moisture content of the excavated soil.

Place the SPC, with sand having the latest weight of $\mathbf{W_1}$, over the pit so that the base of the cylinder covers the pit concentrically.

Open the slit of the SPC and allow the sand to run into the pit freely, till there is no downward movement of sand level in the SPC and then close the slit.

Find the weight of the SPC with the remaining sand ($\mathbf{W_4}$).

Fig. 3.6.2 Sand Replacement Method

The following observations and calculations have been made ,

Table 3.6.2 Observation Table

S.No	Sample	Values
1	Wt. of pouring cylinder + sand w1	6228.50 gm
2	Wt. of pouring cylinder + sand w2	4594.50 gm
3	Wt. of pouring cylinder + sand after making cone on flat surface w3	3938.40 gm
4	Wt. of sand used in hole w4 = w1-w3	2290.01 gm
5	Wt of sand in cone only w5 = w2-w3	656.01gm
6	Wt of sand in hole only w6 = w4-w5	1634 gm
7	Volume of sand	1021.25 cm^3
8	Wt of tray + excavated soil w7	2984.60 gm
9	Wt of tray only	1295.60 gm
10	Mass of excavated soil w7-w8	1689 gm

3.7 DESIGN OF RIGID PAVEMENT

3.7.1 Overview

As the name implies, rigid pavements are rigid i.e, they do not flex much under loading like flexible pavements. They are constructed using cement concrete. In this case, the load carrying capacity is mainly due to the rigidity ad high modulus of elasticity of the slab (slab action). H. M. Westergaard is considered the pioneer in providing the rational treatment of the rigid pavement analysis.

3.7.2 Modulus of sub-grade reaction

Westergaard considered the rigid pavement slab as a thin elastic plate resting on soil sub-grade, which is assumed as a dense liquid. The upward reaction is assumed to be proportional to the deflection. Base on this assumption, Westergaard defined a modulus of sub-grade reaction K in kg/cm^3 given by K = p/ Δ where Δ is the displacement level taken as 0.125 cm and p is the pressure sustained by the rigid plate of 75 cm diameter at a deflection of 0.125 cm.

3.7.3 Relative stiffness of slab to sub-grade

A certain degree of resistance to slab deflection is offered by the sub-grade. The sub-grade deformation is same as the slab deflection. Hence the slab deflection is direct measurement of the magnitude of the sub-grade pressure. This pressure deformation characteristics of rigid pavement lead Westergaard to the define the term radius of relative stiffness l in cm is given by the equation

$$l = \sqrt[4]{\frac{E.h^3}{12K(1-\mu^2)}}$$

(where *E* is the modulus of elasticity of cement concrete in kg/cm^2 (3.0×105), μ is the Poisson's ratio of concrete (0.15), *h* is the slab thickness in cm and *K* is the modulus of sub-grade reaction.

3.7.4 Critical load positions :

Since the pavement slab has finite length and width, either the character or the intensity of maximum stress induced by the application of a given traffic load is dependent on the location of the load on the pavement surface. There are three typical locations namely the interior, edge and corner, where differing conditions of slab continuity exist. These locations are termed as critical load positions.

3.7.5 Design of joints

Expansion joints -The purpose of the expansion joint is to allow the expansion of the pavement due to rise in temperature with respect to construction temperature. The design consideration are: • Provided along the longitudinal direction, • design involves finding the

joint spacing for a given expansion joint thickness (say 2.5 cm specified by IRC) subjected to some maximum spacing (say 140 as per IRC)

Contraction joints -The purpose of the contraction joint is to allow the contraction of the slab due to fall in slab temperature below the construction temperature.

The design considerations are:

• The movement is restricted by the sub-grade friction

• Design involves the length of the slab given by:

$$L_c = \frac{2\times10^4 S_c}{W.f}$$

where, *Sc* is the allowable stress in tension in cement concrete and is taken as 0.8 kg/cm^2, *W* is the unit weight of the concrete which can be taken as 2400 kg/cm^3 and *f* is the coefficient of sub-grade friction which can be taken as 1.5.

• Steel reinforcements can be use, however with a maximum spacing of 4.5 m as per IRC.

3.7.6 Dowel bars

The purpose of the dowel bar is to effectively transfer the load between two concrete slabs and to keep the two slabs in same height. The dowel bars are provided in the direction of the traffic (longitudinal). The design considerations are:

• Mild steel rounded bars,

• bonded on one side and free on other side

Bradbury's analysis

Bradbury's analysis gives load transfer capacity of single dowel bar in shear, bending and bearing as follows:

$$P_s = 0.785 d^2 F_s$$

$$P_f = \frac{2d^3 F_f}{L_d + 8.8\delta}$$

$$P_b = \frac{F_b {L_d}^2 d}{12.5(L_d + 1.5\delta)}$$

where, *P* is the load transfer capacity of a single dowel bar in shears, bending *f* and bearing *b*, *d* is the diameter of the bar in cm, L_d is the length of the embedment of dowel bar in cm, δ is the joint width in cm, F_s, F_f, F_b are the permissible stress in shear, bending and bearing for the dowel bar in kg/cm^2.

The length of the dowel bar embedded in slab L_d by equating

$$L_d = 5d\sqrt{\frac{F_f(L_d + 1.5\delta)}{F_b(L_d + 8.8\delta)}}$$

3.7.7 Tie bars

In contrast to dowel bars, tie bars are not load transfer devices, but serve as a means to tie two slabs. Hence tie bars must be deformed or hooked and must be firmly anchored into the concrete to function properly. They are smaller than dowel bars and placed at large intervals. They are provided across longitudinal joints.

Step 1: Diameter and spacing:

The diameter and the spacing is first found out by equating the total sub-grade friction to the total tensile stress for a unit length (one meter). Hence the area of steel per one meter in cm^2 is given by;

$$A_s \times S_s = b \times h \times W \times f$$

$$A_s = \frac{b.h.W.f}{100S_s}$$

where, b is the width of the pavement panel in m, h is the depth of the pavement in cm, W is the unit weight of the concrete (assume 2400 kg/cm^2), f is the coefficient of friction (assume 1.5), and S_s is the allowable working tensile stress in steel (assume 1750 kg/cm^2). Assume 0.8 to 1.5 cm φ bars for the design

Step 2: Length of the tie bar:

Length of the tie bar is twice the length needed to develop bond stress equal to the working tensile stress and is given by:

$$L_t = \frac{dS_s}{2S_b}$$

where, d is the diameter of the bar, S_s is the allowable tensile stress in kg/cm2 , and S_b is the allowable bond stress and can be assumed for plain and deformed bars respectively as 17.5 and 24.6 kg/cm^2 .

Rigid pavements are generally used in constructing airports and major highways, such as those in the interstate highway system. In addition, they commonly serve as heavy-duty industrial floor slabs, port and harbor yard pavements, and heavy-vehicle park or terminal pavements. Like flexible pavements, rigid highway pavements are designed as all-weather, long-lasting structures to serve modern day high-speed traffic. Offering high quality riding surfaces for safe vehicular travel, they function as structural layers to distribute vehicular wheel loads in such a manner that the induced stresses transmitted to the subgrade soil are of acceptable magnitudes.

Table 3.7.1 Determination of Modulus of Subgrade

S. No.	**Description**	**Values**	**Units**
1.	Modulus of subgrade(K_s)	$K_s = 40(SF)q_u$	KN/m^3
2.	q_u	$q_u = cN_c + \gamma DN_q + 0.5\gamma BN_\gamma$	KN/m^3
	γ	16.5	KN/m^3
	ϕ	30	Degree
3.	For sand	c = 0	
		$N_q = 22.46^o$	
		$N_c = 37.16^o$	
		$N_\gamma = 19.7^o$	
		Depth(d)=1m	
		Width(b)=3m	
4.	q_u	858.16	KN/m^3
5.	K_s	10.29	KN/m^3

Firstly, we estimated the value of ϕ with the help of γ from the table of empirical values of ϕ in appendix A. The values of N_q, N_c & N_γ are estimated from the ϕ from the graph between N_q, N_c & N_γ and ϕ in appendix A . From the values of N_q, N_c & N_γ, the value of q_u is calculated. And finally the value of modulus of subgrade from empirical relationship which is $K_s = 40(SF)q_u$ KN/m^3 is calculated which comes out to be 10.29 KN/m^3.

Table 3.7.2 Recommended Values from IRC 58: 2002

S. No.	Description	Value	Unit
1.	Width of Expansion joint	3	m
2.	Max. variation in temperature	35	Degree
3.	Thermal coefficient of concrete	0.00001	$^{\circ}C$
4.	Allowable tensile stress in cement concrete during curing	0.8	kg/cm^2
5.	Coefficient of friction	1.5	
6.	Unit weight of cement concrete	2400	kg/m^3
7.	Design wheel load	5100	kg
8.	Radius of contact area	15	cm
9.	Present traffic intensity(design)	125	cv/day
10.	K_s	10	kg/cm^3
11.	Flexure strength of cement concrete	40	kg/cm^2
12.	E value	300000	kg/cm^2
13.	μ value	0.15	
14.	Design load transfer through dowel system	40%	
15.	Permissible flexural strength in dowel bar	1400	kg/cm^2
16.	Permissible shear stress in dowel bar	1000	kg/cm^2
17.	Permissible bearing stress in concrete	100	kg/cm^2
18.	Permissible tensile stress in steel (tie bar)	1400	kg/cm^2
19.	Permissible bond stress in deformed tie bars	24.6	kg/cm^2

The width of expansion joint is assumed to be 3 m. Maximum variation in temperature is assumed to be 35^{o}. Thermal coefficient of concrete is $0.00001^{o}C$. Allowable tensile stress in cement concrete during curing is assumed to be 0.8 kg/cm^2. Let coefficient of friction be 1.5. Unit weight of cement concrete is 2400 kg/m^3. Design wheel load is assumed to be 5100 kg. Radius of contact area is 15 cm. Present traffic intensity(design) is 125 cv/day. K_s is calculated as 10 kg/cm^3. Flexure strength of cement concrete is 40 kg/cm^2. E value & μ value are 300000 kg/cm^2 and 0.15 respectively. Design load transfer through dowel system is 40%. Permissible flexural strength in dowel bar is assumed to be 1400 kg/cm^2. Permissible shear stress in dowel bar is 1000 kg/cm^2 & permissible bearing stress in concrete is 100 kg/cm^2. Permissible tensile stress in steel (tie bar) is 1400 kg/cm^2. Permissible bond stress in deformed tie bars is 24.6 kg/cm^2.

Temperature differential values in the region :

Table 3.7.3 Temperature differential values

Slab thickness, cm	15	20	25
Temperature differential in the slab region, ^{o} C	14.6	15.8	16.3

3.8 SPACING OF JOINTS

In plain jointed concrete pavements, the joint is designed to provide a plane of weakness that will control the formation of transverse cracks. The joint interval is designed so that intermediate (random) transverse cracks do not form.

Now, δ' = 0.5 joint = 0.5×2.5 = 1.25cm

Spacing of Expansion Joint (L_s) = $\frac{\delta'}{100C(T2-T1)} = \frac{1.25}{100\times10\times10^{-6}\times35}$ = **35.7m**

which is less than maximum specified spacing of 140 m and hence acceptable.

Contraction joint spacing in plain CC,

$$L_c = \frac{2\times10^4 S_c}{W.f}$$

$$L_c = \frac{2\times0.8\times10^4}{2400\times1.5} = 4.45 \text{ m}$$

which is less than maximum specified spacing of 4.5m and hence acceptable.

Therefore provide contraction joints at 4.45m spacing and expansion joints at every 8th such joints i.e., 4.45×8 = 35.5m spacing (instead of 35.7) .

Table 3.8 Determination of Spacing of Joints

S. No.	Description	Value	Unit	Remarks
1.	Joint Spacing δ ‘	1.25	cm	
2.	Spacing of Expansion Joint(L_s)	35.7	m	less than 140 m, so acceptable
3.	Spacing of Contraction joint(L_c)	4.45	m	less than 4.5 m, so acceptable

So, provide contraction joints at 4.45 m & expansion joints at every 8^{th} joint i.e. 4 ×4.45 = 35.5m (instead of 35.7 m) .

3.9 PAVEMENT SLAB THICKNESS

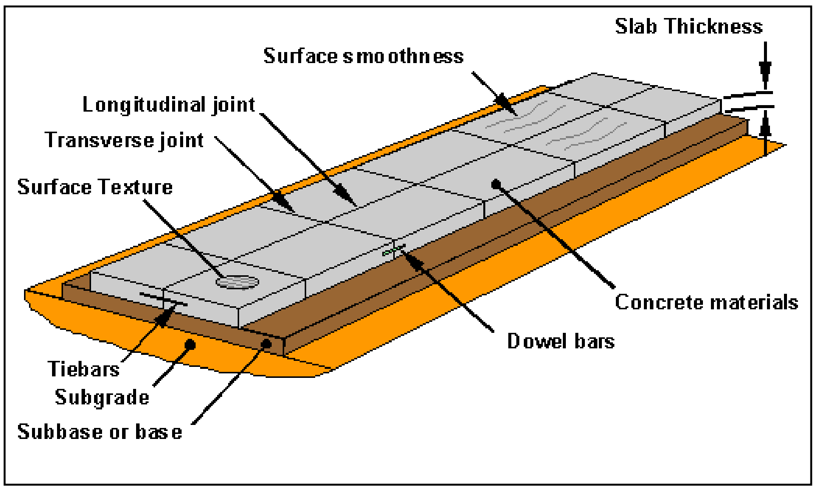


Fig. 3.9 Concrete pavement slab thickness
(Source : https:// http://www.keyword-suggestions.com)

Assume trail thickness of slab (for safe) at f_s greater than 1 be 24 cm.

Radius of relative thickness, $l = [\frac{Eh^3}{12k(1-\mu^2)}]^{1/4}$

$$= [\frac{3\times10^5\times24^3}{12\times10(1-0.15^2)}]^{1/4}$$

= 77.1cm

and, $\frac{Lx}{l} = \frac{445}{77.1} = 6.25$,

$\frac{Ly}{l} = \frac{350}{77.1} = 4.53$,

From Appendix- A

warping coefficient C_x at 6.25 = 0.91 &

warping coefficient C_y at 4.53 = 0.69

Temperature for 24 cm thick slab = 16.1^o

From Appendix- A

warping stress at edge, S_e = 17.8Kg/cm^2

warping stress at corner, S_c = 21.3 Kg/cm^2

Adjustment for Traffic Intensity

Assuming growth rate(as per IRC) = 7.50%

n(years after the last count before the new pavement is open) = 3

So, $A_d = P[(1+r)]^{(n+20)} = 125[(1+0.075)]^{(3+20)} = 660$ cv/day

(for correction if A_d is between 450 to 1000, then no need for correction to thickness of slab)

So, Revised design thickness of the slab is **24 cm**.

3.10 DESIGN OF DOWEL BARS

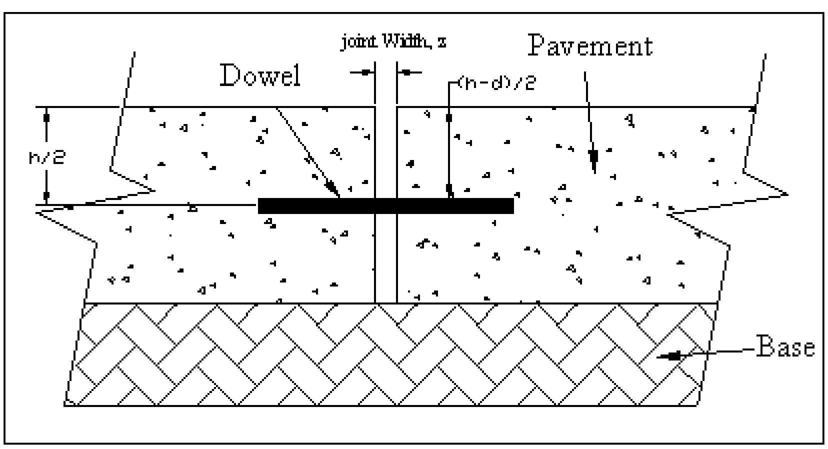


Fig. 3.10 Dowel Bar
(Source:http://www.fhwa.dot.gov/publications/research/infrastructure/pavements/06106/images/image)

Assume dowel bar diameter = 2.5cm

Joint width = 2.5cm

F_f(permissible flexural stress in dowel bar) = 1400kg/cm^2

F_b(permissible bearing stress in concrete) = 100kg/cm2

For equal capacity in bending and bearing

$$L_d = 5d\sqrt{\frac{F_f(L_d + 1.5\delta)}{F_b(L_d + 8.8\delta)}}$$

$$L_d = 5 \times 2.5\sqrt{\frac{1400(L_d + 1.5 \times 2.5)}{100(L_d + 8.8\delta)}}$$

By substituting different values of L_d by trails, the value of L_d is found to be 44.2cm.

So, Length of dowel bar (L_d + joint width) = L_d + 2.5 = 44.7 cm

Therefore, provide 45 cm long dowel bars of 2.5 cm diameter

Actual value of L_d = 42.5cm

Load transfer capacity of single dowel bar

P(shear)= $0.785d^2F_s$ = $0.785\times2.5^2\times1000$ = 4906kg

P(bending)= $2d^2F_t /(L_d=8.8\delta)$

$=\frac{2\times2.5^2\times1400)}{(42.5+8.8\times2.5)}$

= 678kg

P(bearing) = $F_b.L_d^2 \cdot d/12.5(Ld+1.5\delta)$

$= \frac{100\times42.5^5\times2.5}{12.5(42.5+1.5\times2.5)}$

= 781kg

So taking the lowest value for design P(design) = 678 kg .

Load capacity factor required :

Load capacity of the dowel group = $5100 \times \frac{40}{100}$ = 2040 kg

Capacity factor required = $\frac{2040}{678} = 3\ cm$

Spacing of dowel bars :

Radius of relative stiffness for revised slab thickness of 24 cm.

l = $[\frac{3\times10^5\times26^3}{12\times8(1-0.15^2)}]^{1/4}$ = 86.6 cm

effective distance upto which there is load transfer = 1.8l= 1.8×86.6 = 155.9cm

assuming a trail spacing of 35 cm between the dowel bars, the capacity available for the group

$= 1 + \frac{155-35}{155.9} + \frac{155-70}{155.9} + \frac{155-105}{155.9} + \frac{155-140}{155.9}$

= 2.77 < the required value of 3.0cm

Assume dowel spacing of 30 cm.

Capacity factor = $1+ \frac{155-30}{155.9} + \frac{155-60}{155.9} + \frac{155-90}{155.9} + \frac{155-120}{155.9} + \frac{155-150}{155.9}$

= 3.11cm

As the value is greater than the required capacity factor of 3.0, 30 cm spacing of the dowel bars is adequate . therefore provide 2.5cm diameter. Dowel bars at expansion joints , of total length 45cm at a spacing of 30 cm centre to centre.

Table 3.10 Determination of spacing of Dowel bar

S.No.	Description	Value	Unit
1.	Assume dowel bar diameter	2.5	cm
2.	Joint width	2.5	cm
3.	F_f(permissible flexural stress in dowel bar)	1400	kg/cm^2
4.	F_b(permissible bearing stress in concrete)	100	kg/cm^2

3.11 DESIGN OF TIE BARS

Area of steel per meter length longitudinal joints,

$$A_s \times S_s = b \times h \times W \times f$$
$$A_s = \frac{b.h.W.f}{100S_s}$$

$$A_s = \frac{3.5 \times 1.5 \times 24 \times 2400}{100 \times 1400}$$

A_s = 2.16 cm^2 per m length

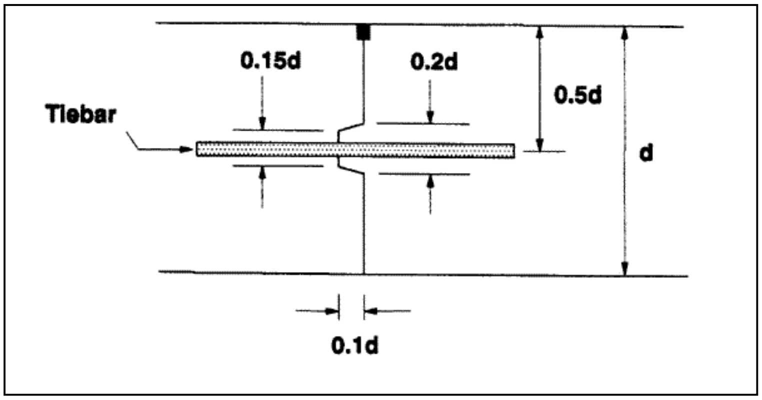


Fig. 3.11 Tie Bars
(Source: http://www.fhwa.dot.gov/pavement/images/t504030/p504030b.gif)

Assuming 1 cm diameter of the bars , cross sectional area of each tie bar a_s=0.785cm^2
Perimeter of the tie bar = 3.14 cm
Number of tie bars required per meter length of joint = $\frac{As}{as} = \frac{2.16}{0.785} = 2.75$
Spacing of tie bar = $\frac{100}{2.75} = 36.3\ cm$
Provide a spacing of tie bar, say 36 cm
Length of plain tie bar, $L_t = \frac{d \times Ss}{2 \times Sb} = \frac{1.5 \times 1400}{2 \times 24.6} = 29\ cm$

The length of tie bar may be increased by 5 cm for tolerance in placement.
Therefore provide 1cm diameter deformed tie bars, 29 cm in length a spacing of 36 cm

Table 3.11 Determination of spacing of Tie bar

S. No.	Description	Value	Unit
1.	Tie bars		
i.	b	3.5	Cm
ii.	f	1.5	
iii.	h	24	Cm
iv.	w	2400	kg/m^3
v.	S_s	1400	kg/cm^2
vi.	As=(b.f.h.w)/100.S_s	2.16	cm^2per m length

3.12 AUTOCAD DESIGN OF PARKING LOT

AutoCAD is a computer-aided design (CAD) program used for 2-D and 3-D design and drafting. AutoCAD is developed and marketed by Autodesk Inc. and was one of the initial CAD programs that could be executed on personal computers. AutoCAD was initially derived from a program called Interact, which was written in a proprietary language.. Later, it came to support custom objects through a C++ application programming interface. The modern version of the software includes a full set of tools for solid modeling and 3-D. AutoCAD also supports numerous application program interfaces for automation and customization. We have used the AutoCAD 2014 to design the parking lot.Several possible Layouts that can be drawn are as follows:

a) 90^{o} One way one flow traffic with exit & entry separately

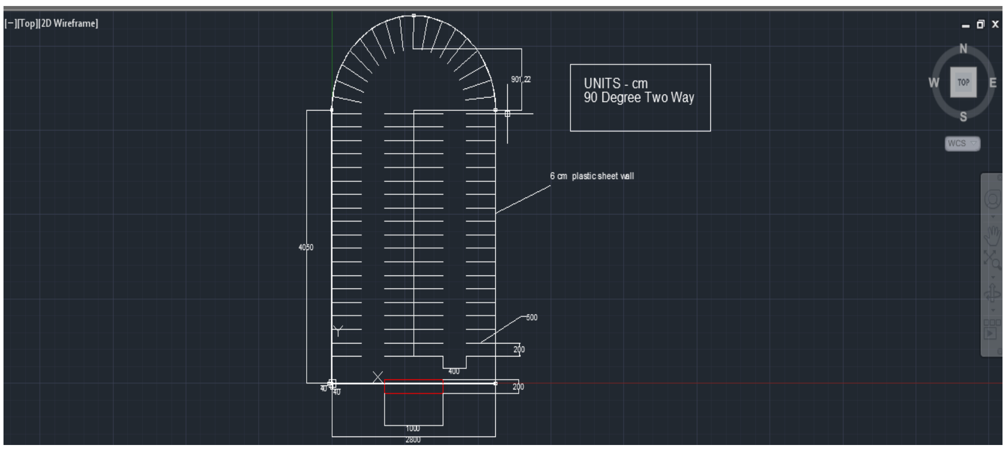


Fig. 3.12(a) 90^{o} One way one flow traffic with exit & entry separately

The 90^{o} pattern of the layout provides maximum parking spaces and this pattern suits when the parking area is limited i.e. less area. The layout plan has one entrance way and one exit way. In addition to this a plastic membrane sheet of thickness 6 cm is also provided instead of a R.C.C. wall to provide maximum area for the parking. The site has the dimensions, rectangular area of 40.50 m × 28 m & semicircular area of 28 m diameter. The one way one flow design provides smooth flow of traffic so it is preferable. The current design of parking uses 90^{o} parking because the parking area is limited.

b) 90^{o} One way one flow traffic with exit & entry combined

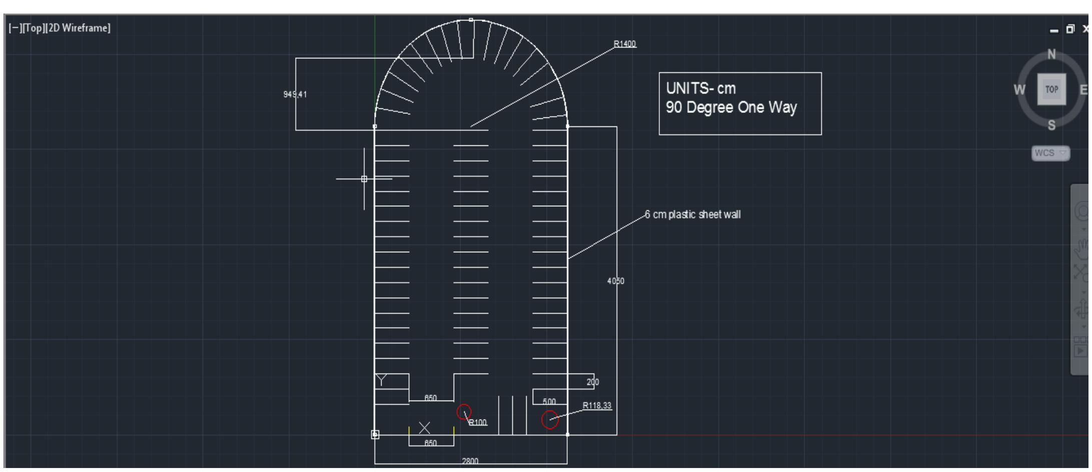


Fig. 3.12(b) 90^{o} One way one flow traffic with exit & entry combined

The 90^o pattern of the layout provides maximum parking spaces and this pattern suits when the parking area is limited i.e. less area. The layout plan has one entrance way only. In addition to this a plastic membrane sheet of thickness 6 cm is also provided instead of a R.C.C. wall to provide maximum area for the parking. The site has the dimensions , rectangular area of 40.50 m × 28 m & semicircular area of 28 m diameter. The one way flow with entry & exit combined is less efficient in terms of smooth traffic flow than two way flow.

c) 45^o one way one flow traffic with exit & entry separately

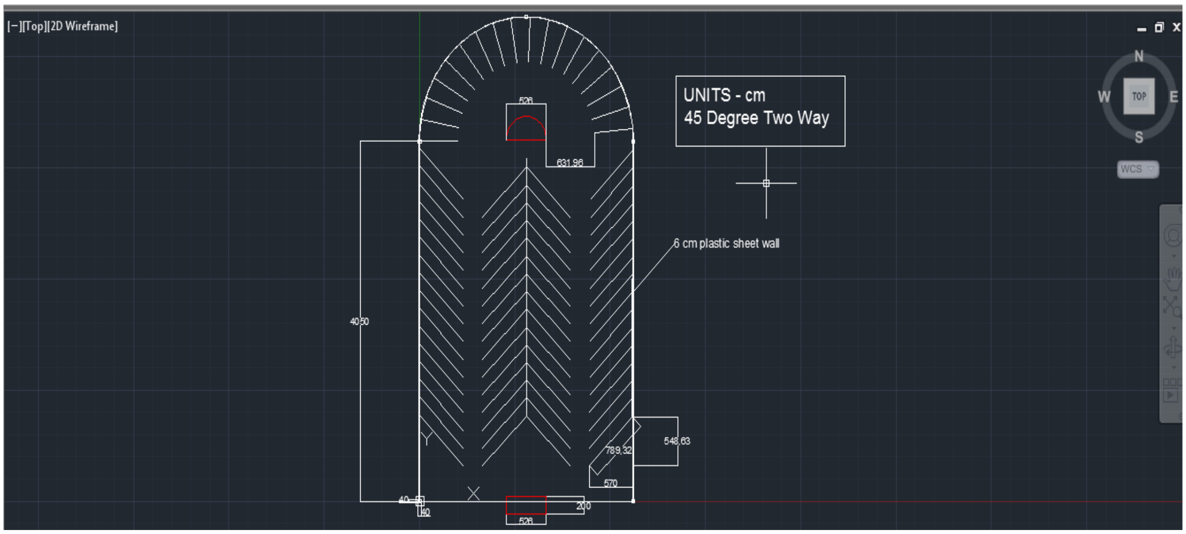


Fig. 3.12(c) 45^o one way one flow traffic with exit & entry separately

The 45^o parking is preferable in those sites where sufficient parking area is available. The layout plan has one entrance way and one exit way.The 45^o parking accumulates lesser number of parking vehicles as compared to 90^o parking.So, for the given site 45^o parking may be provided but it will not help much in the parking problems that are being faced currently in the univesity.

d) 45^o one way one flow traffic with exit & entry separately

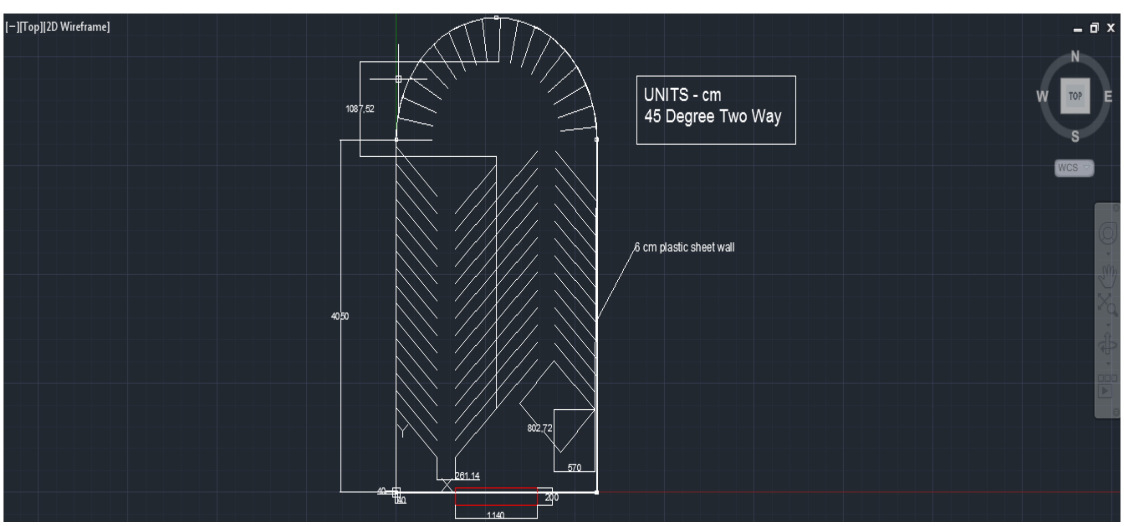


Fig.3.12(d) 45^{o}one way one flow traffic with exit & entry separately

The 45^{o} parking is preferable in those sites where sufficient parking area is available. The layout plan has one entrance way only.The 45^{o} parking accumulates lesser number of parking vehicles as compared to 90^{o} parking.So, for the given site 45^{o} parking may be provided but it will not help much in the parking problems that are being faced currently in the univesity.

e) 45^{o} One way one flow traffic with exit & entry combined

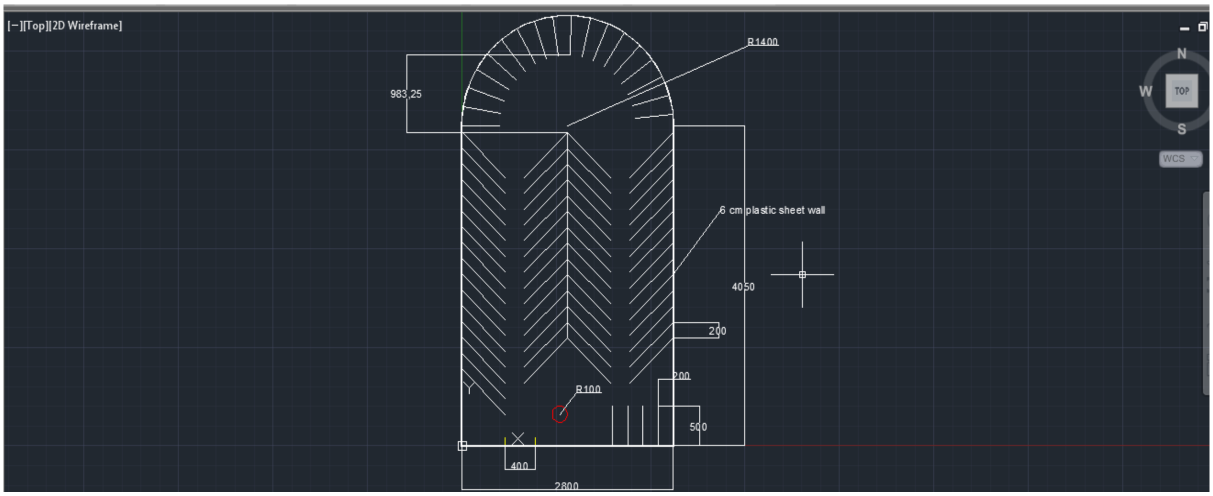


Fig. 3.12(e) One way one flow traffic with exit & entry combined

The 45^{o} parking is preferable in those sites where sufficient parking area is available. The layout plan has one entrance way and one exit way,the only difference is that parking stalls are lay out in different orientation as compared to the above layout. The 45^{o} parking accumulates lesser number of parking vehicles as compared to 90^{o} parking.So, for the given site 45^{o} parking may be provided but it will not help much in the parking problems that are being faced currently in the univesity.

f) 45^{o} One way one flow traffic with exit & entry combined

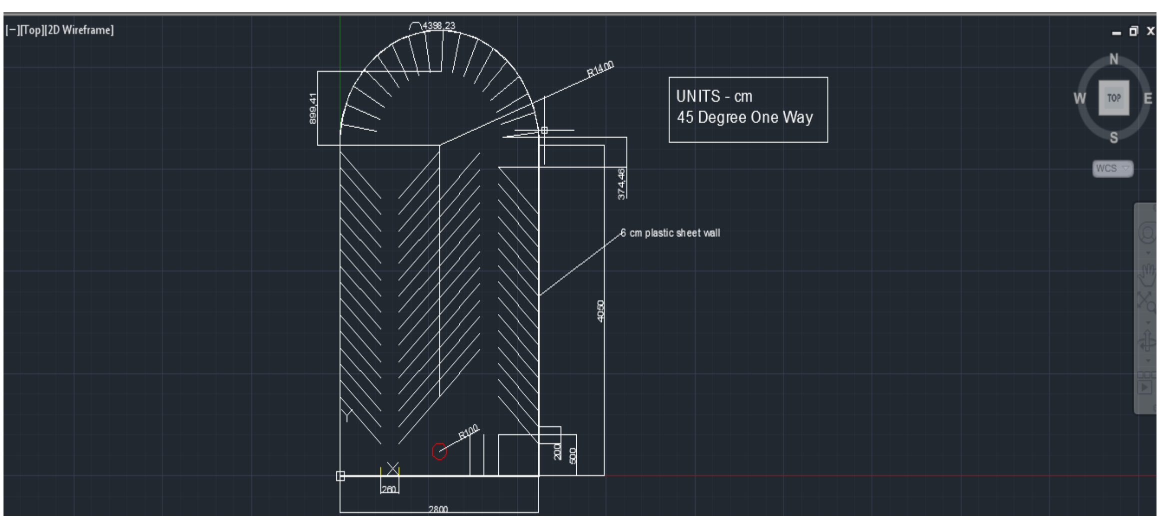


Fig. 3.12(f) 45^{o} One way one flow traffic with exit & entry combined

The 45° parking is preferable in those sites where sufficient parking area is available. The layout plan has one entrance way and one exit way.the only difference is that parking stalls are lay out in different orientation as compared to the above layout. The 45° parking accumulates lesser number of parking vehicles as compared to 90° parking.So, for the given site 45° parking may be provided but it will not help much in the parking problems that are being faced currently in the univesity.

Out of the six parking layouts, the first one i.e. 90° parking design with one way traffic flow with entry & exit separately is the best option because it allows maximum parking spaces and also the traffic flow will be smooth because entry and the exit are provided separately. All other parking layouts can be possible but they are not allowed maximum parking spaces and hence efficiency is less.

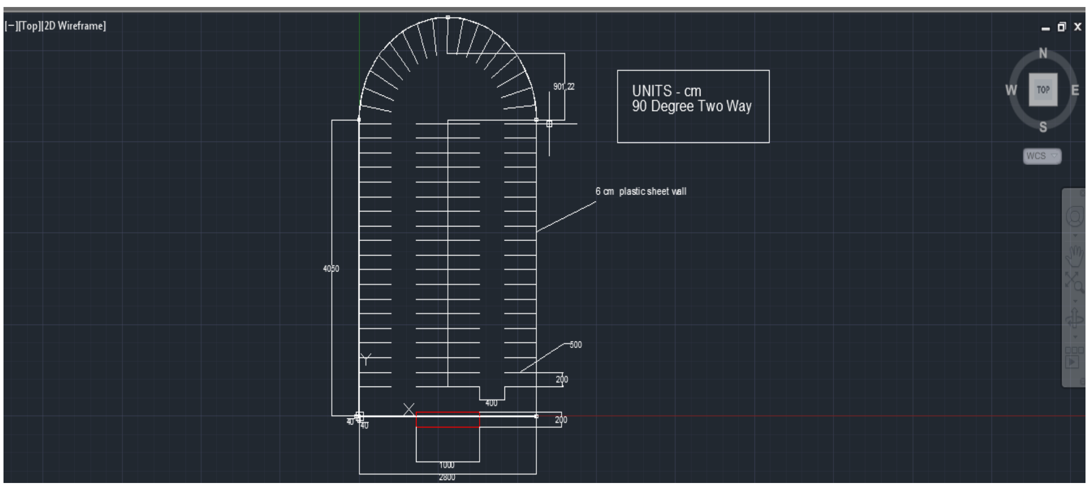


Fig. 3.12(g) 45° One way one flow traffic with exit & entry combined

3.13 PAVEMENT DRAINAGE

3.13.1 Introduction

Highway drainage is the process of remaining and controlling excess surface and subsoil water with in the right of way. Highway engineering is an engineering discipline branching from civil engineering that involves the planning, design, construction, operation, and maintenance of roads, bridges, and tunnels to ensure safe and effective transportation of people and goods. Highway engineering became prominent towards the latter half of the 20th Century after World War 2. Standards of highway engineering are continuously being improved. Highway engineers must take into account future traffic flows, design of highway intersections/interchanges, geometric alignment and design, highway pavement materials and design, structural design of pavement thickness, and pavement maintenance.

The installation of suitable surface and sub surface drainage system is an essential part of highway design and control. MCADAM said that "if water passes through a road and fill the native soil, the road whatever may be its thickness losses support and goes to pieces".

3.13.2 Importance of highway drainage

- Sustained contact of water with bituminous pavements causes failures due to stripping of bitumen from aggregates.
- Erosion of soil from top of un surfaced roads and slopes of embankment.
- Excess moisture in soil sub grade causes considerable lowering of its stability.
- Excess water in shoulders and pavement edges causes considerable damage.

3.13.3 Design of drainage

Design of drainage follows two phases namely the Hydrologic analysis and Hydraulic analysis.

Hydrologic analysis.

Generally we'll be able to provide peak flow rates for the design of our main drains. Consultants are therefore required to seek this information from us prior to commencing the design of our main drains.Where we're unable to provide peak flow rates the consultant will be required to calculate them using the methods described below.

Method 1 - The Rational Method

The Rational Method is generally used to calculate design peak flow rates throughout the pipeline drainage system, provided the drainage catchment is less than 400 hectares. The method doesn't allow for flood storage effects. Therefore, when there are or will be retarding basins in the system, suitable adjustments must be made for the basin outflows, or an alternative method providing for flood storage effects must be used.

The peak flow rate resulting from a storm with an average recurrence interval (ARI) of Y years is calculated using the following formula:

$$Q = (C_y.I_y.A) / 360 \ (m^3/s)$$

Where,

Q = peak flow rate resulting from storm ARI of Y Years

C_y = runoff coefficient for design event having an ARI of Y Years (dimensionless)

A = area of catchment (hectares)

I_y = rainfall intensity (mm/hr) corresponding to a particular storm duration and ARI. The duration is set equal to a sub-catchment time of concentration.

The following guidelines are provided for use of the Rational Method, including values we require to be used:

1. The downstream design peak flow rate shouldn't be less than the upstream flow rate for a piped system
2. Partial area effects should be considered in the design

The applicable average recurrence interval, runoff coefficient, area of catchment and design average rainfall intensity will be determined as shown below.

Hydraulic analysis.

This portion is determined by examining the elevations of inlets, the slopes and parts full for each pipe section as well as the pipe sizing to determine the most efficient and cost effective design options

$Q = A.V$

where Q is already determine in hydrologic analysis and V is equal to 0.3-0.5 m/sec for sandy soil.

Hydraulic calculations are required to design our drains and channels. This section deals with the methods required to be used for hydraulic design. A Hydraulic Grade Line (HGL) analysis is required for all designs to ensure water flows through underground pipes and overland flow systems in the manner intended. The finished surface level of developed land is a primary consideration when determining hydraulic grade requirements.

General freeboard requirements

Freeboard is the height above a defined flood level, typically used to provide a factor of safety in, for example, the setting of floor levels and levee crest levels (i.e. design flood event). Freeboard compensates for effects such as wave action, localized hydraulic behavior settlement of levees and sedimentation in waterways, which increase flood levels or reduce the level of protection provided by levees. Freeboard also provides protection from floods that are marginally above the defined flood level. However, freeboard should not be relied upon to provide protection for flood events larger than the defined flood event.

Manning's formula

Manning's formula is:

$$V = \frac{1}{n}.R^{2/3}.S^{1/2}$$

where,

V = the mean velocity of flow (m/s)

g = acceleration due to gravity (9.8 m/s2)

R = the hydraulic radius (m)

= D/4 for pipes flowing full

D = the actual internal diameter of the pipe (m)

S = the hydraulic grade

n = roughness coefficient = 0.013 for concrete pipes

Calculations of Hydrologic analysis

$Q = C.I.A_d$

C = 0.9 (for CC pavements)

I = Value determined from graph

A_d = 1441/1000 (in 1000 m^2)

t1 = inlet time for storm water to flow from the remotest point in drainage area to the drain inlet.

t2 = the time for water to flow through the drain between the inlet and outlet point.

From the chart , Appendix -A

t1 = 6 min

t2 = 40.50/0.5 = 1.35 min

Duration of time of concentration = t1+t2 = 6 + 1.35 = 7.35 min

Drainage Area, Ad = 1441/1000= 1.441

i = 220 mm/hr from the graph of rainfall intensity Vs duration curve

Q= C. i. Ad

Q = 0.9× 220 × 1.441

Q = 0.0778 m^3 /sec

Calculations of Hydraulic analysis

Q = A.V

Q = Already determined from hydrologic analysis

V = Allowable velocity of flow m/sec= 0.5m/sec

A= Area of cross section of channel (m^2)

From this, A = Q/ V is calculated

A = 0.0778/ 0.5= 0.155 m^2

Now the longitudinal slope of drain is determined from manning's formula

$$V = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Assume bottom width = 0.5 m and

slope of 1 vertical to 1.5 horizontal and

depth of flow as d

So, top width = 0.5 + 3d

Hence, Area, A = $\frac{1}{2}$ (0.5+3d+0.5) d

$3d^2+d-0.31 = 0$

Solving , d= 0.195 m

Assume free board of 4.5 cm

Average depth = 0.195+0.045 = **0.24m**

Wetted perimeter= $0.5+(\sqrt{0.195^2 + (1.5 \times 0.195)^2}) \times 2 = 1.20$m.

Now, $R = \frac{A}{P} = \frac{0.155}{1.20} = 0.13$

$S = (\frac{V \times n}{R^{\frac{2}{3}}})^2 = (\frac{0.5 \times 0.013}{0.13^{\frac{2}{3}}})^2 = 0.000642$, 1 in 1557 m longitudinal slope

3.14 HIGHWAY MAINTENANCE

3.14.1 Introduction

Highway maintenance is essential in order to preserve the road in its originally constructed condition, protect adjacent resources and user safety, and provide efficient, convenient travel along the route. Unfortunately, maintenance is often neglected or improperly performed resulting in rapid deterioration of the road and eventual failure from both climatic and vehicle use impacts. It follows that it is impossible to build and use a road that requires no maintenance.

In order to plan for road maintenance needs, it is important to keep a complete set of "as built" plans and records of all maintenance operations and observations. The as built plan should contain the following:

1. Complete job index
2. Complete history of project from planning stage to construction
3. Photographic records
4. Exact location and observations of any unstable conditions in relation to the road location
5. Exact location of culverts and other drainage features
6. Wet areas that may have required additional excavation and replacement with more suitable ballast backfield materials
7. All major changes made to the original plan.

Probably the most valuable tool for any maintenance program is the knowledge and experience gained by individuals performing the maintenance. Every effort should be made to retain competent, knowledgeable, and experienced individuals in these positions not only from the standpoint of instituting and executing a good maintenance program, but for future road planning needs as well.

3.14.2 Scope of highway maintenance

The main purpose of highway maintenance is to maintain the highway network for the safe and convenient movement of people and goods. The core objectives of highway maintenance are to deliver a safe, serviceable and sustainable network, taking into account the need to contribute to the wider objectives of asset management, integrated transport, corporate policy and continuous improvement.

Highway maintenance is a wide ranging function, including:

- Routine maintenance providing works or services to a regular consistent schedule, generally for cleaning and landscape maintenance.
- Programmed maintenance providing larger schemes primarily of resurfacing, reconditioning or reconstruction to a planned schedule.
- Reactive maintenance responding to inspections, complaints or emergencies.
- Regulatory maintenance inspecting and regulating the activities of others.

- Winter service providing salting and clearance of snow and ice.
- Providing a planned emergency response for adverse weather conditions and other emergencies.

There are a number of related functions which could affect, or be affected by, highway maintenance activity. These include:

- Asset management (a strategic approach to the management, operation, preservation and enhancement of the highway infrastructure).
- Network management (the maintenance of the highway network and traffic operation). highway development control (the assessment of the impacts of land use changes on the transport system and the identification of measures to mitigate these impacts).
- Street cleansing, including integrated street management town centre management, including use of public space.
- Maintenance of sustainable drainage systems and the operation of public transport services.

When maintenance activity is being planned and programmed the potential for joint working and co-ordination with others will be explored. When such joint works are planned then it is expected that full consultation will be undertaken with affected parties before a final decision on the scheme is made.

A "whole life" approach aims to minimize the long term costs of maintaining a section of road. It may be, for instance, that the overall lowest cost option could be by carrying out a more extensive maintenance operation now, if this reduces the number of occasions when routine maintenance is needed in the future. The "cost" of maintenance works needs to include a consideration of the disruption and congestion that works cause.

3.14.3 Classification of highway maintenance works

Proper road maintenance contributes to reliable transport at reduced cost, as there is a direct link between road condition and vehicle operating costs (VOC). An improperly maintained road can also represent an increased safety hazard to the user, leading to more accidents, with their associated human and property costs. Examples of ways in which different countries contract road maintenance services. In general, road maintenance activities can be broken into four categories:

Routine works.

These are works that are undertaken each year that are funded from the recurrent budget. Activities can be grouped into cyclic and reactive works types. Cyclic works are those undertaken where the maintenance standard indicates the frequency at which activities should be undertaken. Examples are verge cutting and culvert cleaning, both of which are dependent on environmental effects rather than on traffic levels. Reactive works are those where intervention levels, defined in the maintenance standard, are used to determine when maintenance is needed. An example is patching, which is carried out in response to the appearance of cracks or pot-holes.

Periodic works.

These include activities undertaken at intervals of several years to preserve the structural integrity of the road, or to enable the road to carry increased axle loadings. The category normally excludes those works that change the geometry of a road by widening or realignment. Works can be grouped into the works types of preventive, resurfacing, overlay and pavement reconstruction. Examples are resealing and overlay works, which are carried out in response to measured deterioration in road conditions. Periodic works are expected at regular, but relatively long, intervals. As such, they can be budgeted for on a regular basis and can be included in the recurrent budget. However, many countries consider these activities as discrete projects and fund them from the capital budget.

Special works.

These are activities whose need cannot be estimated with any certainty in advance. The activities include emergency works to repair landslides and washouts that result in the road being cut or made impassable. Winter maintenance works of snow removal or salting are also included under this heading. A contingency allowance is normally included within the recurrent budget to fund these works, although separate special contingency funds may also be provided.

Development.

These are construction works that are identified as part of the national development planning activity. As such, they are funded from the capital budget. Examples are the construction of by-passes, or the paving of unpaved roads in villages.

3.15 PARKING FACILITIES

Parking facilities can be both indoor and outdoor, public or private. It can be a parking garage, or a parking space that belongs to the property of a person's house. Different types of parking facilities are listed below:

3.15.1 Parking garages

A parking garages is also called car park, parking structure, parking building, parking ramp, parkade or parking deck.

There are several types of parking garages:

Single level parking garage

A single level parking garage is a parking garage that only has only one floor.

Multilevel or multi-storey parking garage

Multilevel or multi-storey parking garages are parking garages that have multiple floors to park at. The design of a multilevel parking garage can be very different. The most common design is a garage with ramps to move from one level to another. Less common are parking garages that use lifts to go from level to level. Then there are also parking garages with robotic systems that move cars from one level to another. The floors of the parking garage can either go up, down or both.

Underground parking garage

An underground parking garage has levels below the surface and none above ground. Most often underground parking garages are located in city centers where there's not much space available to build a parking facility, but there is a big need to build one.

3.15.2 Carports

Carports are usually **located on people's driveways next to their house**. These carports are covered places where one or more cars can be stalled. They are private property that comes with the house. Car ports do not have four walls: Normally they only have one or two walls and sometimes they are attached to a wall of the house it belongs to. Car ports offer protection from bad weather conditions like rain and snow.

Parking spaces on the side of the street

Also parking spaces on the side of the road where metered or spaces that are laid out for the use of parking, are considered parking facilities. Commonly you can identify such spaces because there are one or more squares lined out with yellow or white paint that fit one car. You as a driver are supposed to park your car in between the squares. In other areas there aren't any parking spaces drawn on the streets. This usually only happens in residential areas where it isn't crowded.

Automated Parking System (APS)

An Automated Parking System or APS **i**s a mechanical system that moves cars from the entry to an available parking space. It uses multiple levels and stacks cars vertically to use as less land as possible to park as many cars as possible. It's entirely automatic and doesn't require any staff. Automated Parking Systems are sometimes also called:

- Mechanical Parking System
- Robotic Parking System
- Rotary Parking System
- Automatic Parking
- Stacker Parking

Automatic parking systems are very space efficient. You can simply stack all the cars plus the parking space doesn't have to be as wide as in a conventional parking lot. You can stack more cars in a compact space, because cars are moved by platforms and lifts. The system doesn't need as much space to park as a human does. There's no need for ramps, pedestrian areas etc.

Semi-Automated Parking System

A Semi-Automated Parking System uses a mechanical system to move cars to their parking space, only it needs a human action to work, either by the driver or an attendant. This action can be as simple as pushing a button.

3.16 Cost estimation and analysis

3.16.1 Introduction

Project underestimation of resources and costs is one of the most common contributors to project failure. As such, project managers should be knowledgeable of and consider the various industry techniques and tools in the definition and execution of project cost estimation. As defined by the Project Management Body of Knowledge (PMBOK), cost estimation is the iterative process of developing an approximation of the monetary resources needed to complete project activities. Project teams should estimate costs for all resources that will be charged to the project. This includes but is not limited to:

- Labor
- Materials
- Equipment
- Services
- Software
- Hardware
- Facilities
- Contingency Costs

A cost estimate is the approximation of the cost of a program, project, or operation. The cost estimate is the product of the cost estimating process. The cost estimate has a single total value and may have identifiable component values. A problem with a cost overrun can be avoided with a credible, reliable, and accurate cost estimate. An estimator is the professional who prepares cost estimates. There are different types of estimators, whose title may be preceded by a modifier, such as building estimator, or electrical estimator, or chief estimator.

Since a cost estimate is the approximation of the cost of a project or operation, then estimate accuracy is a measure of how closely the estimate is able to predict the actual expenditures for the project or operation. This can only be known after the project is completed.

3.16.2 Details of measurement and calculation of quantities

Table 3.16.2 Details of measurement and calculation of quantities

Sl No	Description of Item	Unit	Dimensions				Remarks
			Length(m)	Breadth(m)	Thickness(m)	Quantity	
1	**Earthwork Excavation** below ground level upto depth of 0.45 m as per the direction of Engineer-in-Charge	cum	40.50m(rectangular area)+ 14m radius(semicircle)	28	0.45	649.00	
2	**Back filling** of Sub-base course with well graded granular soil	cum	40.50m(rectangular area)+ 14m radius(semicircle)	28	0.127	183.00	well graded granular soil
3	**Compaction** (supplying, laying and rolling with 10 Tonne Roller up to 6 - 10 passes per layer to corrected width , depth and camber **granular sub-base of 127mm** compacted thickness in one layer with Grade - 1 crushed rock aggregate conforming to IRC-19 with approved material and grading all compete as per the drawing, specification and direction of the engineer in charge)	cum	40.50m(rectangular area)+ 14m radius(semicircle)	28		649.00	
4	Laying in position & curing **Reinforced Cement Concrete of (M30)**, Using 10 mm & 20 mm Graded Aggregate & Coarse sand(**as provided by the owner)**, at all Location including all cost of Labor, T & P etc Complete as per the direction of Engineer-in-charge).	cum	40.50m(rectangular area)+ 14m radius(semicircle)	28	0.244	336.00	M30 grade concrete mix
	4.1 Cement (OPC)	Number of bags				2688.00	
	4.2 Fine aggregates	kg/m^3				570.00	
	4.3 Coarse aggregates (max. size should nott exceed 1/4th of slab thickness	kg/m^3				1301.00	20 mm size
	4.4 Water	lt/m^3				160.00	water used should be clean & free from injurious
5	Placing of **Reinforcement Steel (Tie bars and Dowel bars)**	Number of tie bars & dowel bars					
	5.1 Tie bars		0.29	0.001		9 per 4.5m & 746 in	
	5.2 Dowel bars		0.45	0.025		8 per 3.5m & 720 in	
6	Lighting poles (Electrical poles)	Number of poles				7.00	
7	Side fencing						
8	Road Markings (Glow in dark paints)	Rs/m				503.00	

3.16.3 Abstract for cost

Table 3.16.3 Abstract for cost

S No.	Description of Item	Unit	Quantity	Unit rate	Amount
1	Earth Work in Excavation	cum	649.00	612.5	397,512.50
2	Back Filling	cum	183.00	245	44,835.00
3	Compaction(granular subbase layer)	cum	183.00	3600	658,800.00
4	Reinforced cement concrete M30	cum	336.00	570	191,520.00
	4.1 Cement(OPC)	Number of bags	2,688.00	358	962,304.00
	4.2 Fine aggregates	cuf	2,811.00	45	126,495.00
	4.3 Coarse aggregates	cuf	6,415.00	48	307,920.00
5	Reinforcement				
	5.1 Tie bars	kg	135.00	64	8,640.00
	5.2 Dowel bars	kg	1246.00	64	79,744.00
6	Lighting poles	Number of poles	7.00	16250	113,750.00
7	Side fencing	kg	714.00	90	64,260.00
8	Road Markings (Thermoplastic road marking paint)	Rs/m	503.00	85	42,755.00
				TOTAL	**2,998,535.50**

Unit rate includes labor charges. The Himachal Pradesh , Department of Labour and Employment specifies the following labour rate,

Un-skilled Workers Rs. 180.00 per day or Rs. 5400 per month

Semi-skilled Rs. 195.55 per day or Rs. 5867 per month

Skilled Rs. 224.17 per day or Rs. 6725 per month

Highly skilled Rs. 237.12 per day or Rs. 7114 per month

Concrete ratio is 1:0.46:3.5

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 RESULTS

4.1.1General

As per the described methodologies, the preliminary tests and experiments were carried out on the soil sample to study the various parameters and characteristics of the sample that was to be used for the rigid pavement design. The results obtained in different tests have been discussed below:
The traffic volume count per day for Jaypee University Of Information Technology stands as follows:

- Total No. Of Registered Vehicles(4 wheeler) = 39
- Total No. Of Registered Vehicles(2 wheeler) = 10
- Total No. Of Unregistered Vehicles(4 wheeler) = 87
- Total No. Of Unregistered Vehicles(2 wheeler) = 12

The optimum moisture content of soil sample is 3.75%.Wet density of soil comes out to be 1.65 g/cm^3 and Dry density of soil comes out to be 1.59 g/cm^3. The void ratio of soil is 0 .67. Degree of saturation of soil is calculated as 14.8%. The Modulus of subgrade, K_s =10 kg/cm^3. Thickness of proposed concrete slab comes out to be 24 cm. Spacing of expansion and contraction joints are calculated as 35.5 m & 4.45 m. Length of dowel bars(provided) is 45cm, 2.5cm-dia @30 cm spacing and Length of tie bars(provided) is 29 cm, 1.0 cm-dia @36 cm spacing. The cross sectional area of the drain comes out to be 0.155m^{2}and depth of drain is calculated as 0.24m. From calculations the longitudinal slope of drain comes out to be 1 in 1577. At last the estimated Cost of the project is Rs 29,98,535.5 .

4.2 DISCUSSIONS

- Providing suitable parking spaces is a challenge for traffic engineers and planners in the scenario of ever increasing vehicle population. It is essential to conduct traffic surveys in order to design the facilities. Different types of parking layout, surveys and statistics were discussed in this report.
- Several factors affecting pavement design were discussed, the most important being wheel load. Since pavements are designed to take moving loads, slow moving loads and static loads can be detrimental to the pavement. Temperature also influences pavement design especially the frost action which is very important in cold countries.

  The factors that affect the pavement design are contact pressure, wheel load, axle configuration, moving loads & repetition of loads.

- Vehicle composition shows that sixty percent of total traffic was light vehicles. Only thirteen percent was buses. The reason for high proportion of light vehicle is the proximity of the location to residential area of high income group people. The light vehicles were not highly occupied. But buses were almost fully occupied. It can be assumed that, more people were travelling by bus.
- 59 percent of traffic flow was towards Science Lab which indicates tidal flow towards south-east. It was morning rush hour. So flow was higher towards the city center. Only 41 percent of traffic was flowing towards north-west. If another vehicle count was done in evening rush hour, opposite scenario might be seen.
- To draw flow fluctuation curve, it was assumed that volume for six continuous hours were counted, although all vehicles were counted within one hour. Each group counted vehicles for 30 minutes. Flow rate was calculated from that short count data and plotted. The flow fluctuation curve shows a peak at 08:00-09:00 hrs.
- Subgrade inspection is an important part of any concrete parking lot construction project. The subgrade is the foundation upon which the concrete is supported. Poor preparation of the subgrade can result in detrimental effects on performance. The soils at the parking lot site and the intended borrow areas should be observed and if necessary, sampled and tested to the soil types and identify any problem conditions.
- Soil strength is an important physical property affecting plant growth and seedling emergence. Soil strength is defined as the amount of force required to move or rearrange soil particles. It is affected by three main factors; moisture content, soil texture, and bulk density.
- Water content is the most important factor determining soil strength. The lower the soil water content, or the drier the soil, the greater the soil strength. Soils that are saturated, or waterlogged have weak soil strengths.
- Bulk density is the third factor affecting soil strength. As bulk density of a given soil increases soil strength also increases. Bulk density is the oven dry weight of soil divided by the volume or space occupied by the soil. Remember that soil is composed of solids and pores, and the greater the bulk density the greater the amount of solids, and the smaller the amount of pore space. For a particular soil type, as bulk density increases, soil strength increases.
- The slope of your parking lot plays a significant role in the effectiveness of your parking lot drainage system. You need to ensure your parking lot slopes enough to force water to run to those areas you intend it to.
- Drainage at a property is often overlooked, but when something goes wrong, the results can be devastating. There have been many cases in our country of water getting into units because of a poor drainage system. In the winter, there is the additional danger of water freezing into ice, which can result in a whole slew of problems.
- Depending on the location of the parking space, there can be regulations regarding the time allowed to park and a fee paid to use the parking space. When the demand for spaces outstrips supply vehicles may overspill park onto the sidewalk, grass verges and other places which were not designed for the purpose.

- Ideally, pavement maintenance would be mostly preventive, so that roads are always in good shape and distresses are never present. A well-planned maintenance program, in conjunction with a pavement management system, can help achieve this in a cost-effective way. At the same time, it's wise to ensure that you have the capacity to make repairs when necessary. This will help you respond to unforeseen developments and maintain the structural integrity of the system. You might say that a complete pavement maintenance philosophy isn't just about prevention or repair, it should cover both.
- A cost estimate is the approximation of the cost of a program, project, or operation. The cost estimate is the product of the cost estimating process. The cost estimate has a single total value and may have identifiable component values. A problem with a cost overrun can be avoided with a credible, reliable, and accurate cost estimate. An estimator is the professional who prepares cost estimates.

CHAPTER 5

CONCLUSION

5.1 General

This chapter presents the overview of the work carried out till now which included preliminary testing on soil to determine various characteristics of soil. The salient conclusions drawn from the work.

5.2 Conclusions and Remarks

Following conclusions were drawn from the work carried out:

- The CBR specimen was failed, it shows that the soil was mainly cohesionless in nature.
- The bearing capacity of the soil has enough value to withstand the forces transferred from the vehicles.
- Due to the limited area available at the site, 90^o parking is opted from among the various parking patterns like 30^o, 45^o& 60^o. Also, one way one flow traffic is preferred as it allows smooth flow of the traffic as compared to one way two flow traffic.
- From the traffic volume study and survey, it is observed that the maximum peak hours in the university are during the morning (8:00AM-9:00AM) and evening (4:00PM-6:00PM).Also the traffic problems are most likely to occur on the days of registration and counseling, so the parking lot should be designed to accommodate maximum number of vehicles.
- Provided a proper drainage system of drain depth of 0.24m and cross section area of $1.55m^2$ which can help in proper drainage during the time of rainy seasons.
- Proper maintenance of pavement which can prevent defects and enhance the durability of the pavement.
- The project cost is quite high because of the increased thickness of concrete pavement for safety factor.

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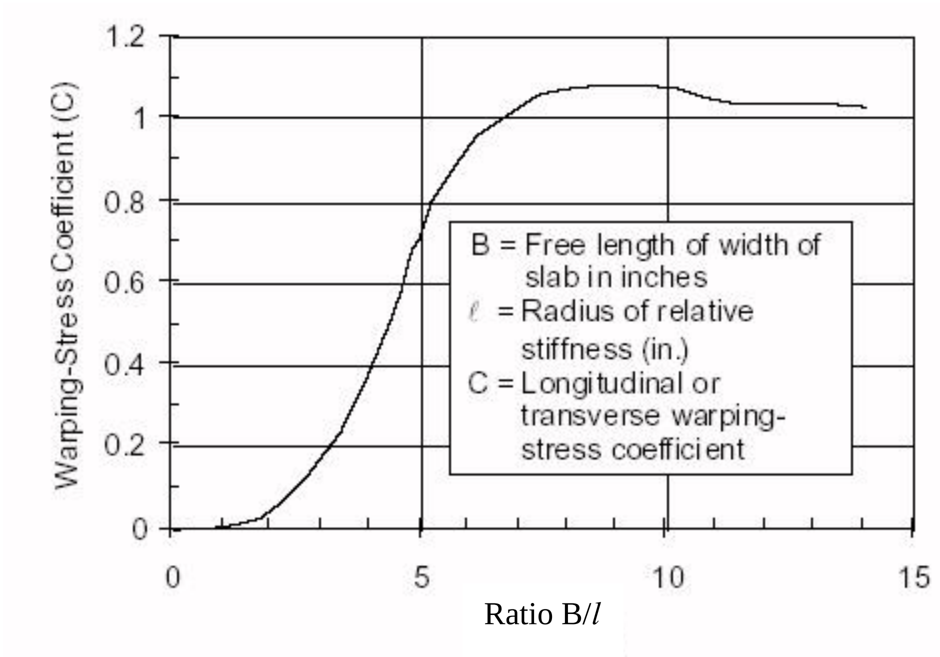
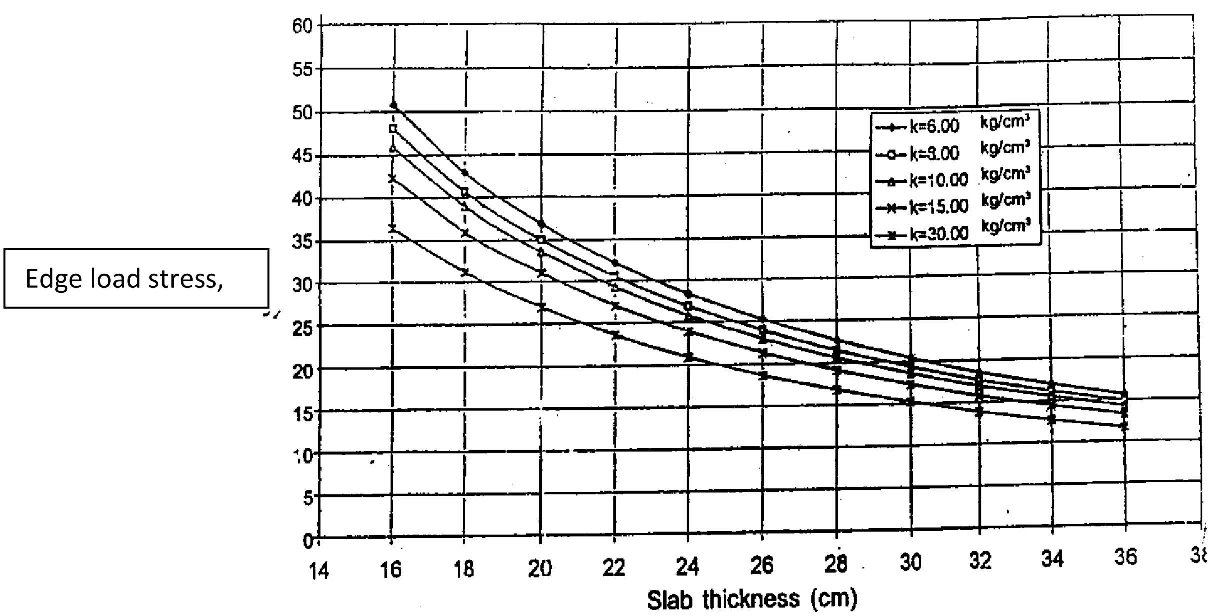
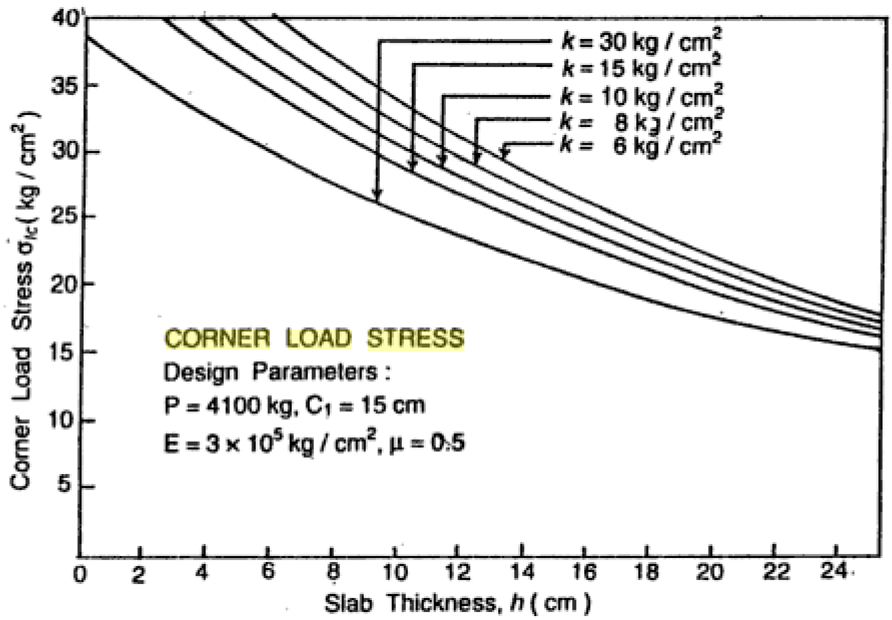
APPENDIX-A

GRAPHS DETERMINING STRESS IN RIGID PAVEMENT

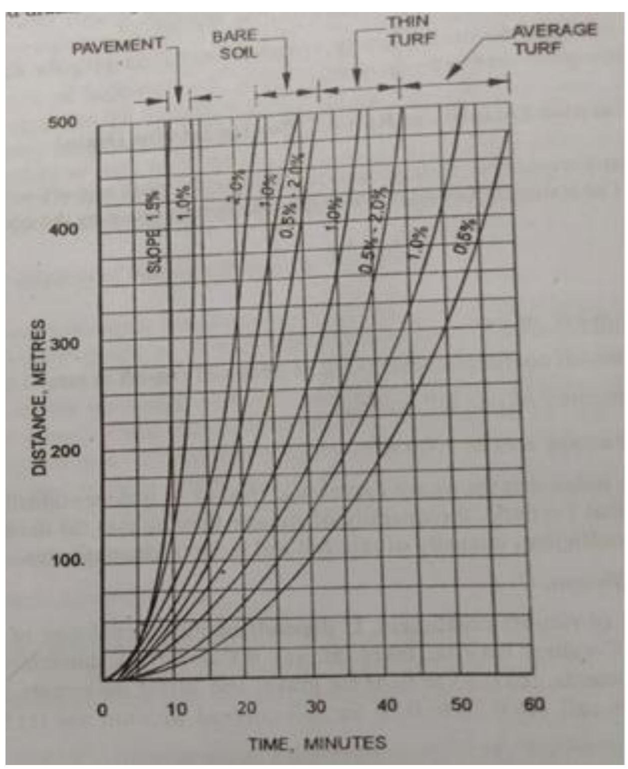




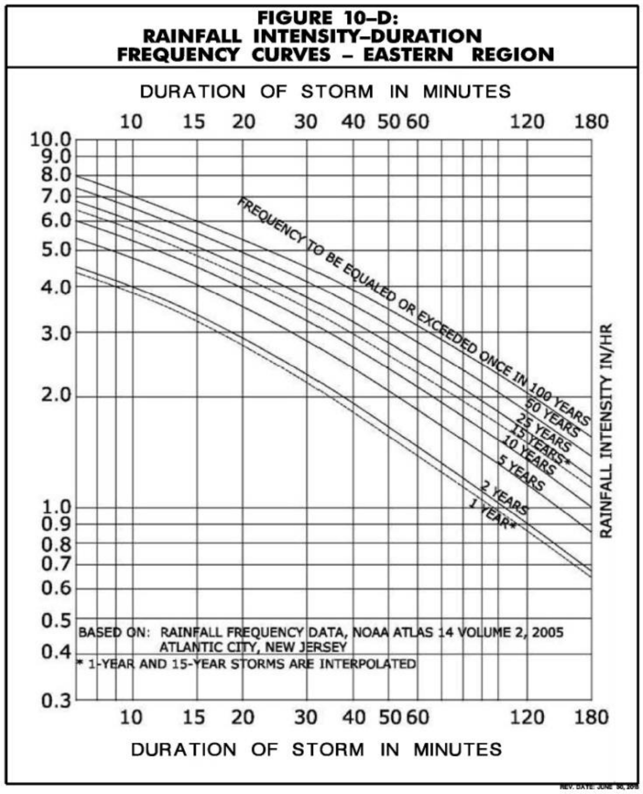
Design Chart for Calculation of Edge load stress



Design Chart for Calculation of Edge load stress



Time of flow to inlet

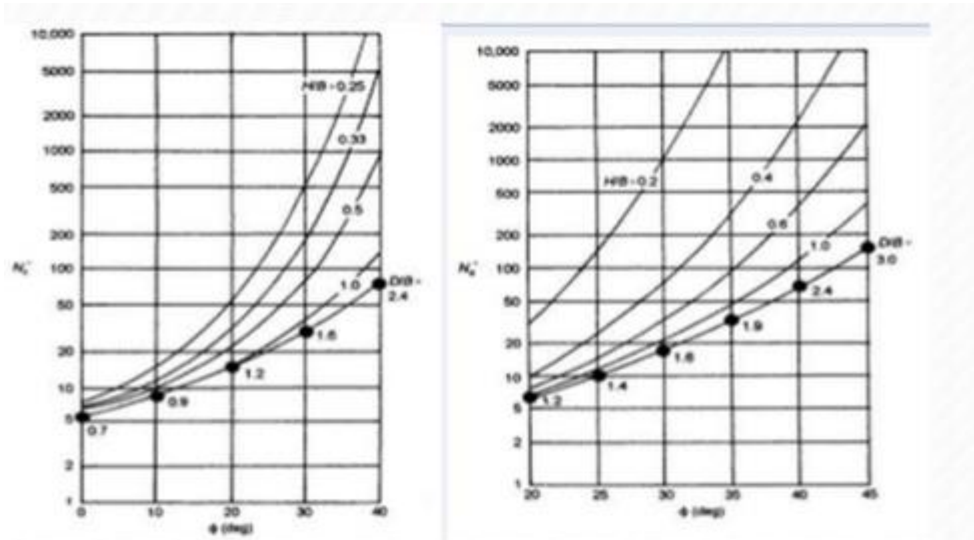


Rainfall intensity duration curve

Empirical values for ϕ, D_r, and unit weight of granular soils based on the SPT at about 6 m depth and normally consolidated [approximately, $\phi = 28° + 15° D_r$ ($\pm 2°$)]

Description		Very loose	Loose	Medium	Dense	Very dense
Relative density D_r		0	0.15	0.35	0.65	0.85
SPT N'_{70}:	fine	1–2	3–6	7–15	16–30	?
	medium	2–3	4–7	8–20	21–40	> 40
	coarse	3–6	5–9	10–25	26–45	> 45
ϕ:	fine	26–28	28–30	30–34	33–38	< 50
	medium	27–28	30–32	32–36	36–42	
	coarse	28–30	30–34	33–40	40–50	
γ_{wet}, kN/m^3		11–16*	14–18	17–20	17–22	20–23

* Excavated soil or material dumped from a truck has a unit weight of 11 to 14 kN/m^3 and must be quite dense to weigh much over 21 kN/m^3. No existing soil has a D_r = 0.00 nor a value of 1.00. Common ranges are from 0.3 to 0.7.



Mandel and Salencon's bearing capacity factor Nc, Nq
values for rigid base