# Concept of Parking Study in Kurukshetra

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*Abstract*— Kurukshetra is one of the important cities of Haryana known for its religious and historical importance. It is a mid-sized city having population of about 0.98 lac. Transportation is the key infrastructure of a country. As road transportation gives personal mobility to the person, the vehicle ownership rate has increased at a fast rate. This increase in the number of vehicles has given birth to the problem of parking. The availability of less space in urban areas has increased demand for parking space, especially in shopping centers, public places and office complexes. It also has an impact on transportation development. With the growing population of motor vehicles, the problem of parking has assumed serious proportions in the town. Shortage of parking spaces forces drivers to park their vehicles on the road which further creates lot of problems like congestion, jams, accidents and also reduces effective road width. The objective of this study is to identify the current parking supply and parking demand in Kurukshetra city. The study consists of parking usage survey using fixed period sampling method. It is found that the utilization percentage of on-the-road parking space varies from 126 to 309 percent of all the ten sites considered in the study. The average utilization factor is 214%. At present the demand for parking exceeds the parking space available on the roads for all the ten parking sites. Separate parking lots, in addition to properly marked on-the-road parking bays, need to be provided on the available spaces close to the studied areas to address the problem of parking.

*Keywords:* Parking, Kurukshetra

## I. INTRODUCTION

Parking is an important urban transportation element. It has various long and short- term impacts on individuals, communities and transportation system. Parking also affects the vitality of communities, commercial and business centre, transit system and airports as well as the efficiency of traffic circulation in downtown areas. Parking is one of the major problems that are created by the increase in the vehicle traffic. Transportation is the key infrastructure of a country. As road transportation gives personal mobility to the person, the vehicle ownership rate has increased at a fast rate. This increase in the number of vehicles has given birth to the problem of parking. The availability of less space in urban areas has increased the demand for parking space, especially in shopping centres, public places and office complexes. It also has an impact on transportation development.

With the growing population of motor vehicles, the problem of parking has assumed serious proportions in the towns and cities. Shortage of parking spaces forces drivers to park their vehicles on the kerb side which further creates lot of problems like congestion, jams, accidents and also reduces effective road width. A systematic study of parking characteristics and demand and regulatory measures for controlling the parking is of great help to a traffic engineer as well as a town planners. The increasing concentration of human activity on limited land both in terms of residential activity and commercial activity causes the parking problem. Every car owner would wish to park the car as close as possible to his destination so as to minimize his walking distance. This results in greater demand for parking space in the central business district (CBD) and other areas where the activities are concentrated.

There is a significant and tremendous increase in the demand of parking spaces due to increase of road traffic during the last one decade in small cities as well. This has led to congestion of on-street spaces in the office and shopping area neighbourhoods during peak hours. The parking demand also leads to socio-economic and environmental losses.

## II. KURUKSHETRA BACKGROUND

Kurukshetra is an ancient and historic city in Kurukshetra District, Haryana state, India. Kurukshetra District is located in North Eastern part of Haryana State. It is a city of temples having both historical and religious importance and attracts large number of visitors every year. The importance of the place is attributed to the fact that the Kurukshetra war of the Mahabharata was fought on this land and the Bhagavad Gita was preached on this land during the war when Lord Krishna found Arjuna in a terrible dilemma. Thanesar or Sthaneswar is a historical town located adjacent to what is now the newly created Kurukshetra city. Geographical area of the district is 1530 sq. km. Kurukshetra is around 94 km away from the state capital Chandigarh. Kurukshetra is well connected with NH-1 and has much access by road and rail. Buses of Haryana Roadways and other state corporations ply through Kurukshetra and connect it to Delhi, Chandigarh and other important places. Kurukshetra is situated between 290-52' to 300-12' latitude and 760-26' to 770-04' longitude. Kurukshetra touches Ambala district in the North, Yamunanagar in the East, Karnal in the South, Kaithal in the West and a little part of Patiala in Punjab state of India on north western side. Kurukshetra as a district was created on 23rd January 1973. Kurukshetra has approximately 419 villages. The location of Kurukshetra is shown in Photo to 1.1.

Location of Kurukshetra

*A. Demographics of Kurukshetra District*

According to the 2011 census, Kurukshetra district has a population of 9,64,231 roughly equal to the nation of Fiji or the US state of Montana. This gives it a ranking of 452nd in India (out of a total of 640). The district has a population density of 630 inhabitants per square kilometer. Its population growth rate over the decade 2001-2011 was 16.81 %.

*B. Road Network of Kurukshetra City*

The road network of Kurukshetra city mainly includes a state highway, major district roads and other urban roads coming in and out of the city centre. The state highway that passes through Kurukshetra city is SH-6 and it covers the city from Kurukshetra University 3rd gate to Pipli where it meets NH-1. The total length of the state highway in Kurukshetra city is about 10 km. The highway has four lanes and is provided with bituminous pavement like all the other main roads in the city. There is a flyover on SH-6 over the railway line.

III. TRAFFIC AND PARKING PROBLEMS

One of the problems created by road traffic is parked. Not only do vehicles require street space to move about, but also do they require space to park where the occupants can be loaded and unloaded. It is roughly estimated that out of 8760 hours in a year, a car runs for an average of only 400 hours leaving 8360 hours when it is parked (Kadiyali. L. R. 2007).The increasing concentration of human activity on limited land both in terms of residential activity and commercial activity causes the parking problem. Every car owner would wish to park the car as close as possible to his destination so as to minimize his walking distance. This results in greater demand for parking space in the central business district (CBD) and other areas where the activities are concentrated.

## A. Design of Parking Facility

In cities the problem of parking vehicles is becoming more and more acute day by day. When vehicles are parked on the roadside, even for a short while there is restriction to other vehicles passing by, resulting in congestion and accidents. In shopping centres, public places and localities with offices there is a shortage of parking facilities. Proper design of parking facilities is essential in cities and large towns. Proper design of parking space is very important for the good transporting system. If there will be a lack of parking space and facility, then it will be a chaotic condition for everyone. But designing of any parking space is not an easy job.

Parking facilities may be broadly divided into two types:

1) On-street or kerb parking
2) Off-street parking

### 1) On Street Parking

On street parking means the vehicles are parked on the sides of the street itself. This will usually be controlled by government agencies itself. Common types of on-street parking areas listed below. This classification is based on the angle in which the vehicles are parked with respect to the road alignment. As per IRC the standard dimensions of a car are taken as $5 \times 2.5$ meters and that for a truck is $3.75 \times 7.5$ meters (Tom V. Mathew, 2012).

### a) Parallel Parking

The vehicles are parked along the length of the road. Here there is no backward movement involved while parking or un-parking the vehicle. Hence, it is the safest parking from the accident perspective. However, it consumes the maximum curb length and therefore only a minimum number of vehicles can be parked for a given kerb length. This method of parking produces least obstruction to the on-going traffic on the road since the least road width is used. Parallel parking of cars is shown in Figure2.1. The length available to park an N number of vehicles, L = N/5.9
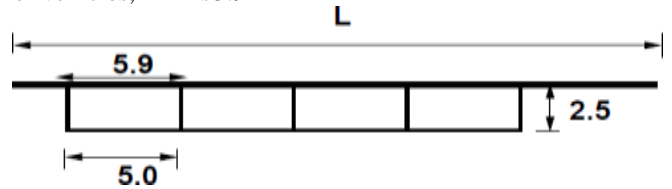


Illustration of Parallel Parking

### b) 30°Parking

In thirty degree parking, the vehicles are parked at 30°with respect to the road alignment. In this case, more vehicles can be parked compared to parallel parking. Also, there is better maneuverability. Delay caused to the traffic is also minimized in this type of parking. An example is shown in Figure2.2. From the Photo to,

$$AB = OB\sin 30° = 1.25,$$
$$BC = OP\cos 30° = 4.33,$$
$$BD = DQ\cos 60° = 5,$$
$$CD = BD − BC = 5 − 4.33 = 0.67,$$
$$AB + BC = 1.25 + 4.33 = 5.58$$
$$\text{For N Vehicles, } L = AC + (N\text{-}1)CE = 5.58 + (N\text{-}1)5$$
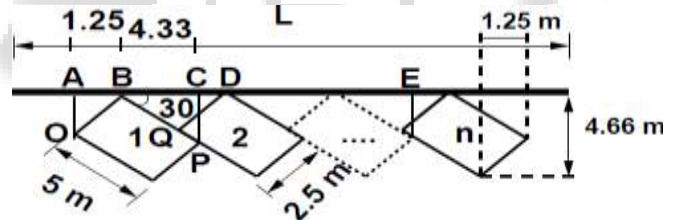$$= 0.58 + 5N$$



Illustration of 30° Parking

### c) 45°Parking

As the angle of parking increases, more number of vehicles can be parked. Hence, compared to parallel parking and thirty degree parking, more number of vehicles can be accommodated in thistype of parking. From the Figure2.3, length of parking space available for parking N number of vehicles in a given kerb is L = 3.54 N+1.77
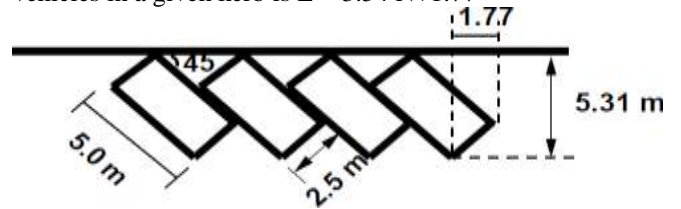


Illustration of 45° Parking

### d) 60°Parking

The vehicles are parked at 60°to the direction of the road. More number of vehicles can beaccommodated in this parking type. From the Figure2.4, length available for parking N vehicles
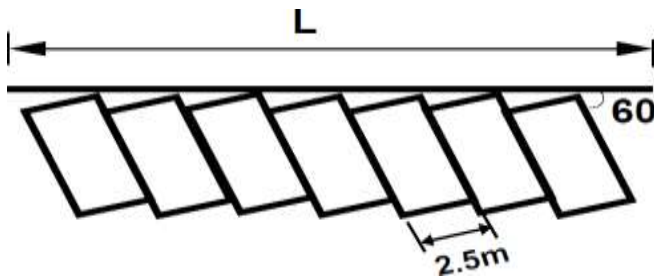=2. 89N+2.16

Illustration of 60° Parking

e)      Right Angle Parking

In the right angle parking or 90°parking, the vehicles are parked perpendicular to the direction ofthe road. Although it consumes maximum width, kerb length required is very little. In this type of parking, the vehicles need complex maneuvering and this may cause severe accidents. This arrangement causes obstruction of the road traffic, particularly if the road width is less. However, it can accommodate a maximum number of vehicles for a given kerb length. An example is shown in Figure2.5, Length available for parking N number of vehicles is L = 2.5N.


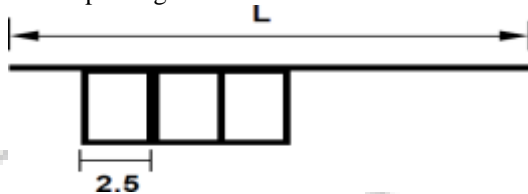Illustration of 90° Parking

*2) Off street Parking*

In many urban centers, some areas are exclusively allotted for parking which will be atsome distance away from the main stream of traffic. Such a parking is referred to as off-street parking. They may be operated by either public agencies or private firms. A typical layout of an off-street parking is shown in Figure2.6.Off street parking can solve a part of the parking problem of major cities. For a satisfactory answer, various types of off-street facilities become unavoidable. The type of off-street facilities commonly considered are.

1) Surface car parking
2) Multi-storey car parking
3) Roof parking
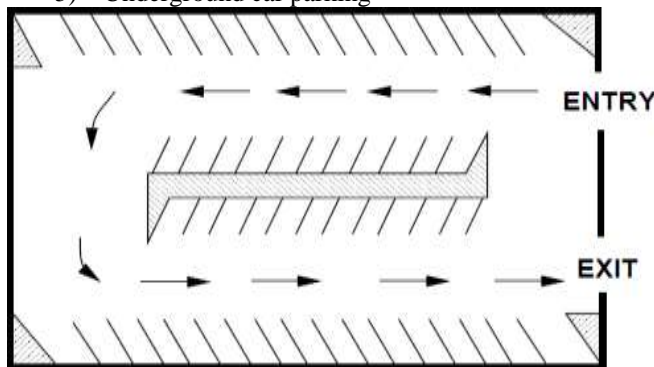4) Mechanical car parking
5) Underground car parking


Fig. 2.6: Illustration of off-street Parking

There are certain basic considerations which govern the location of these facilities. Since these facilities are costly to provide and maintain, a comprehensive study should be done before hand to help determine the location, types and size of these facilities.

Obviously, the prime consideration should be the nearest to the place of usage by the prospective customers. The proposed facilities should be close to major parking generators. Examples of such location are major airport terminals, railway terminals, shopping district, sport stadium, major industrial establishment, office building and commercial establishments. If a car park is intended to serve the car-owners coming from a particular part of the city, it would be preferable to locate the facility on the side of the centre area towards the part of the city from where they come. The facilities should be served by good access streets. It is desirable to locate the facility such that no exit or entrance is within a district of at least 50m from an intersection.

## IV.   PARKING STUDIES

Before taking any measures for the betterment of conditions, data regarding availability of parking space, the 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 this information. Since the duration of parking varies with different vehicles, several statistics are used to access the parking need (Tom V. Mathew, 2012).

*A.  Parking Statistics*

*1) Parking Accumulation*

It is defined as the number of vehicles parked at a given instant of time. Normally this is expressed by accumulation curve. Accumulation curve is a graph obtained by plotting the numbers of bays occupied with respect to time.

*2) Parking Volume*

Parking volume is the total number of vehicles parked at a given duration of time. This does not account for repetition of vehicles. The actual volume of vehicles entered in the area is recorded.

*3) Parking Load*

Parking load gives the area under the accumulation curve. It can also be obtained by simply multiplying the numbers of vehicles occupying the parking area at each time interval with the time interval. It is expressed as vehicle hour.

*4) Average Parking Duration*

It is the ratio of total vehicle hours to the number of vehicles parked Parking duration = Parking load/ Parking volume

*5) Parking Turnover*

It is the ratio of the number of vehicles parked in duration to the number of parking bays available.

Parking turnover = Parking volume/ Number of bays available

This can be expressed as number of vehicles per day per time requirement.

*6) Parking Index*

Parking index is also called occupancy or efficiency. It is defined as the ratio of number of bays occupied in a time duration to the total space available. It gives an aggregate measure of how effectively the parking space is utilized. Parking index can be found out as follows.

Parking index =parking load/parking capacity× 100

## V. PARKING SURVEYS

Parking surveys are conducted to collect the above said parking statistics. The most common parking surveys conducted are in-out survey, fixed period sampling and license plate method of survey (Tom V. Mathew, 2012)

### A. In-out Survey

In this survey, the occupancy count in the selected parking lot is taken at the beginning. Then the number of vehicles that enter the parking lot for a particular time interval is counted. The number of vehicles that leave the parking lot is also taken. The final occupancy in the parking lot is also taken. Here the labour required is very less. Only one person may be enough. But we will not get any data regarding the time duration for which a particular vehicle used that parking lot. Parking duration and turnover is not obtained. Hence we cannot estimate the parking fare from this survey.

### B. Fixed Period Sampling

This is almost similar to in-out survey. All vehicles are counted at the beginning of the survey. Then after a fixed time interval that may vary between 15 minutes to 1 hour, the count is again taken. Here there are chances of missing the number of vehicles that were parked for a short duration.

### C. License plate method of Survey

This results in the most accurate and realistic data. In this case of the survey, every parking stall is monitored at a continuous interval of15 minutes or so and the license plate number is noted down. This will give the data regarding the duration for which a particular vehicle was using the parking bay. This will help in calculating the fare because fare is estimated based on the duration for which the vehicle was parked. If the time interval is shorter, then there are less chances of missing short-term parkers. But this method is very labour intensive.

## VI. PARKING REQUIREMENT

There is some minimum parking requirement for different types of building (IRC-1973).
1) For residential plot less than 300 sq.m. Only community parking space is required.
2) For residential plot area from 500 to 1000Sq.m, minimum one fourth of the open area should be reserved for parking.
3) Offices may require at least one space for every 70sq.m parking area.
4) One parking space is enough for 10 seats in a restaurant
5) Whereas theatres and cinema halls need to keep only one parking space for 20 seats. Thus the parking requirement is different for different land use zones.

## VII. ILL EFFECTS OF PARKING

Parking has some ill-effects like congestion, accidents, pollution, obstruction to fire-fighting operations etc.(Kadiyali. L. R. 2007).

### A. Congestion

Parking takes considerable street space leading to the lowering of the road capacity. Hence, speed will be reduced, journey time and delay will also subsequently increase. The operational cost of the vehicle increases, leading to greater economic loss to the community.

### B. Accidents

Careless manoeuvring of parking and un-parking leads to accidents which are referred to as parking accidents. Common type of parking accidents occur while driving out a car from the parking area, careless opening of the doors of parked cars, and while bringing in the vehicle to the parking lot for parking.

### C. Environmental Pollution

They also cause pollution to the environment because stopping and starting of vehicles while parking and un-parking results in noise and fumes. They also affect the aesthetic beauty of the buildings because cars parked in every available space create a feeling that building rises from a plinth o-f cars.

### D. Obstruction to Fire Fighting Operations

Parked vehicles may obstruct the movement of firefighting vehicles. Sometimes they block access to hydrants and access to buildings.

## VIII. PROHIBITED PARKING

It is desirable to prohibit parking at certain locations and for a period to ensure safety and convenience. Such locations are(Kadiyali. L. R. 2007):

### A. Near Intersection

The capacity of an intersection is greatly reduced if vehicles are allowed to park on the approaches. Visibility is also adversely affected and safety is reduced. It is the general practice to prohibit parking for a distance of about 50m on the approaches to a major intersection.

### B. Narrow Streets

Narrow streets with heavy traffic require that all possible measures should be taken to remove obstacles to traffic flow. Prohibition of parking can have salutary effects on traffic flow and congestion. In busy street of central area, it is generally desirable to prohibit parking on two-way streets less than 5.75 m wide and one way streets less than 4.0m wide.

### C. Pedestrian Crossing

As already mentioned, parking man oeuvres causes accidents and pedestrians are the worst sufferers. Parked cars obstruct the visibility at pedestrian crossing. For these reasons, it is desirable to prohibit parking within about 8 m from the pedestrian crossing.

### D. Structures

Structures such as bridges, tunnels and underpasses generally have a roadway width less than highway and for this reason it is desirable to prohibit parking on them.

### E. Entrance Driveways

The vehicle should be prohibited from parking in front of entrance driveways leading to the house and building. The period for which parking to be prohibited should be determined by a careful analysis of traffic condition.

Normally the period can be from 8 am to 9 am or 6 am to 7 pm, with relaxation on Sunday or such other closed days.

## IX. PASSENGER CAR UNIT(PCU)

PCU is an interference value which is being used to change a vehicle into its equivalent passenger car unit. The equivalent PCUs of different vehicle categories does not remain same under different circumstances. According to (IRC:106-1990) following are the PCU value of different vehicles.
PCU for different type of Vehicle

| | | |
|---|---|---|
| 1. | Two wheeler motorcycle or scooter etc. | 0.5 |
| 2. | Passenger car pick up van | 1.0 |
| 3. | Auto rickshaw | 1.2 |
| 4. | Light commercial vehicle | 1.4 |
| 5. | Truck or Bus | 2.2 |
| 6. | Agricultural tractor trailer | 4.0 |
| | Slow vehicle | |
| 1. | Cycle | 0.4 |
| 2. | Cycle Rickshaw | 1.5 |
| 3. | Tonga (horse drawn vehicle) | 1.5 |

## X. METHODOLOGY OF PARKING STUDY

### A. Methodology

The present study aims at determining parking demand and supply for the mid-size city Kurukshetra having population around 0.96 lac. It also recommends the measures to resolve the problem of parking in Kurukshetra city. The Kurukshetra city in Haryana is selected for the study due to ease of data collection.

The methodology of parking study can be divided into four stages. These are:

### 1) Definition of Study Area

The first stage consists of identifying the study area, location, adjacent streets and parking inventory for identifying the parking spaces serving the main corridors of Kurukshetra city including the existing parking problems.

### 2) Data Collection

There are two types of data collection methodology for study of parking survey. These are:
1) Fixed period sampling for parking demand
2) Parking Supply for parking space availability Fixed Period Sampling

### a) Fixed Period Sampling

The method of fixed period sampling has been followed for collection of the parking data. In this method, all the parked vehicles at the selected site are counted at the beginning of the survey and then after a fixed time interval of 30 minutes for a duration of about 3 to 4 hours during peak hours of parking at the site. The parked vehicle data so collected is converted into PCUs (Passenger Car Unit) by multiplying with corresponding PCU factor. The maximum PCUs per half an hour is taken as the parking demand of the site. The following paragraphs represent the parking demand in respect of all the ten sites selected for the study.

### 3) Parking Supply

Parking supply is calculated by counting the number of vehicles like car, three-wheelers and two-wheelers which were able to fit in parking area available on the road at various study sites during peak hours of parking. The vehicle data so collected is converted into PCUs (Passenger Car Unit) by multiplying with corresponding PCU factor which is described in IRC: 106-1990 and parking supply in terms of passenger car spaces is found out.

### 4) Analysis of Data

The third stage is the data analysis to determine percentage utilization of existing parking in the study area and through these parking characteristic (existing parking) the study can identify the current parking inadequacies to develop proposals to improve parking supply. Determination of current parking demand and is based on parking field survey. The percentage utilization of existing parking area is derived with the help of maximum parking demand and supply statistics.

### 5) Recommendation

The data analysis and the inferences helped in providing certain suggestions and recommending certain measures to control the problem of parking in the area.

## XI. FLOWCHART OF METHODOLOGY OF PARKING STUDY

The research approach used to achieve the study objectives is detailed in Photo to 3.1.



Flowchart of the study

## XII. CONCLUSIONS

Parking takes considerable street space leading to the lowering of the road capacity. This results in reduction of speed and increase in journey time and delay. The operational cost of the vehicles increases leading to great economic loss to the community. It is required to remove haphazard road parking for an efficient transportation system. The present study conducted on ten selected sites of Kurukshetra indicates that the mid-sized cities are also affected by parking problems these days. The main conclusions drawn from the study are.

1) The parking facilities, both on-street as well as off-street, are not properly provided at all the selected sites for the study.
2) None of the selected sites for the study is provided with properly marked on-street parking except some yellow colour parking line towards the edge of carriageway near KachaGher and near Pipli Gate.
3) All the ten parking areas are fully packed to their on-the-road parking capacity and are in- fact overloaded.
4) The utilization percentage of on-the-road parking varies from 126 to 309 percent of all the ten areas considered in the study.
5) Kacha Gher Road has the maximum percentage utilization of the existing on-the-road parking space whereas Kurukshetra University 2nd Gate has the minimum percentage utilization of the existing parking space.
6) The average utilization factor of the existing on-the-road parking space of all the selected sites is 214 %indicating that demand of parking space is more than double the existing parking space available for on-the-road parking.
7) Paid basement parking lots provided at three of the selected sites are found to be sparingly used even during peak parking hours.
8) Ground floor paid parking is used more by the drivers than basement paid parking.
9) When purpose of trip is recreation like watching a movie in the mall, people are ready to pay the parking charges whereas when purpose of trip is shopping / banking / office work of short duration, they try to avoid the paid parking.

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