Chapter 38

Parking

38.1 Overview

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.

38.2 Parking studies

Before taking any measures for the betterment of conditions, data regarding availablity 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.

38.2.1 Parking statistics

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 the graph obtained by plotting the number of bays occupied with respect to time.

Parking volume: Parking volume is the total number of vehicles parked at a given duration of time.

Parking load : Parking load gives tthe area under the accumulation curve. It can also be obtained by simply multiplying the number of vehicles with the time interval. It is expressed as vehicle hours.

Average parking duration: It is the ratio of total vehicle hours to the number of vehicles parked.

Parking turnover: It is the ratio of number of vehicles parked in a duration to the number of parking bays available.

Parking index: Parking index is also called occupancy or efficieny. 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:

$$parking\ index = \frac{parking\ load}{parking\ capacity} \times 100 \tag{38.1}$$

38.3 Parking surveys

There are three major types of parking surveys. They are

1. **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 wont get any data regarding the time duration for which a particular vehicle used that parking lot. Parking duration and turn over is not obtained. Hence we cannot estimate the parking fare from this survey.

2. **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 i hour, the count is again taken. Here there are chances of missing the number of vehicles that were parked for a short duration.

3. **License plate method of survey**: This results in the most accurate and realistic data. In this case of survey, every parking stall is monitored at a continuous interval of 15 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 intervalis shorter, then there are less chances of missing short-term parkers. But this method is very labour intensive.

38.4 Ill effects of parking

Parking has got some ill-effects like congestion, accidents, obstruction to fire-fighting operations etc.

Congestion: By parking, there will be loss in the street space which leads 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 great economical loss to the community.

Accidents: Careless maneuvering of parking and unparking 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.

Obstruction to fire fighting operations: Parked vehicles may obstruct the movement of firefighting vehciles. Sometimes they block access to hydrants and acess to buildings.

Environmental pollution: They also cause pollution to the environment because stopping and starting of vehicles while parking and unparking results in noise and fumes. They also affect the aesthetic beauty of the buidings because cars parked at every available space creates a feeling that buliding rises from a plinth of cars.

38.5 Parking requirements

There are some minimum parking requirements for different types of building. For residentail plot area from 101 to 300 sq.m only community parking sapce is required. For residential plot area from 500 to 1000 sq.m, minimum one-fourth of the open area should be reserved for parking. For offices, atleast one space for every 70 sq.m should be kept aside for parking facility of vehicles. One parking space is enough for 10 seats in a

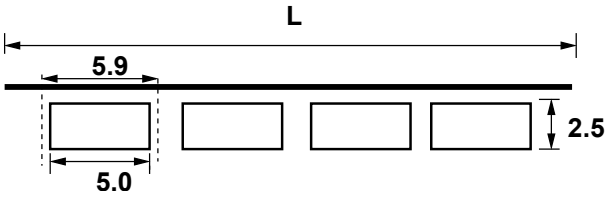

Figure 38:1: Illustration of parallel parking

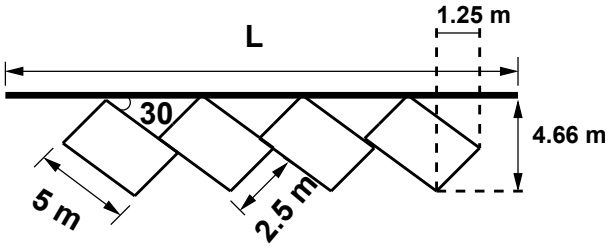

Figure 38:2: Illustration of 30° parking

restaurant where as theatres and cinema halls need keep only 1 parking space for 20 seats. Thus the parking requirements are different for different land use zones.

38.6 On street parking

On street parking means the vehicles are parked on the sides of the street itself. This will be usually controlled by government agencies itself. Common types of on-street parking are as 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 is taken as 5× 2.5 and that for a truck is 3.75× 7.5 .

1. Parallel parking: The vehicles are parked along the length of the road. Here there is no backward movement involved while parking or unparking the vehicle. Hence it is the most safest parking from the accident perspective. But it consumes the maximum curb length and therefore only a minimum number of vehicles can be parked for a given kerb length. Since it consumes least width of the road it produces least obstruction to the on-going traffic on the road. Parallel parking of cars is shown in figure 38:1. The number of vehicles that can be parked , N = $\frac{L}{5.9}$

2. 30° parking: Here more vehicles can be parked compared to parallel parking. Also there is better maneuverablity. It causes minimum delay to traffic. An example is shown in figure 38:2. From the figure, it is clear that the number of vehicles that can be parked, N = $\frac{L-1.25}{5}$

3. 45° parking: As the angle of parking increases, more number of vehicles can be parked. Hence compared to parallel and thirty degree parking, more number of vehicles can ne accommodated in this type of parking. From figure 38:3, number of vehicles that can be parked ,N = $\frac{L-1.77}{3.54}$

4. 60° parking: Here also more number of vehicles can be accomodated. From the figure 38:4, number of vehicles that can be parked, N = $\frac{L-2.16}{2.89}$

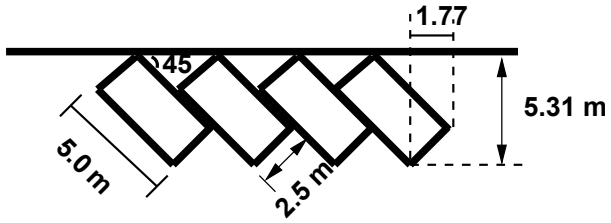

Figure 38:3: Illustration of 45° parking

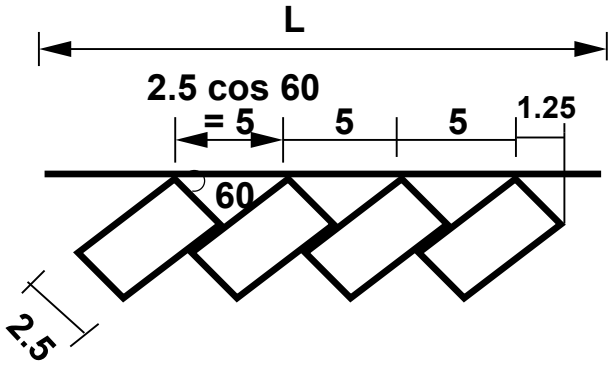

Figure 38:4: Illustration of 60° parking

5. Right angle parking: Here the vehicles are parked perpendicular to the direction of the road. Hence it consumes maximum width. Curb length required is very little. Hence there are chances of severe accidents. Also it causes obstruction to the road traffic. But it can accommodate maximum number of vehicles. An example is shown in figure 38:5.

38.7 Off street parking

There will be some area exclusively allotted for parking which will be at some 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 example of an off-street parking is shown in figure 38:6.

Example 1

From an In-out survey conducted for a parking area consisting of 40 bays, the initial count was found to be 25. The number of vehicles coming in and out of the parking lot for a time interval of 5 minutes is as shown in the table. Find the accumulation, total parking load, average occupancy and efficiency of the parking lot.

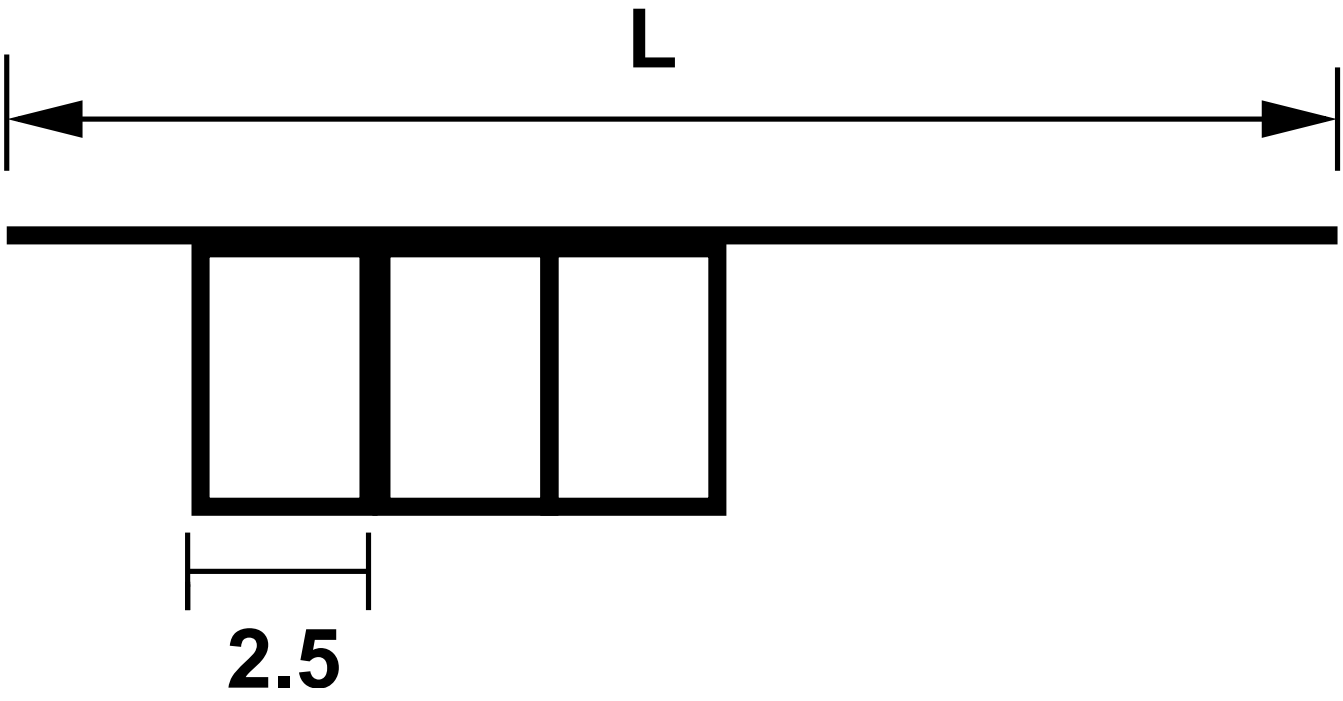

Figure 38:5: Illustration of 90° parking

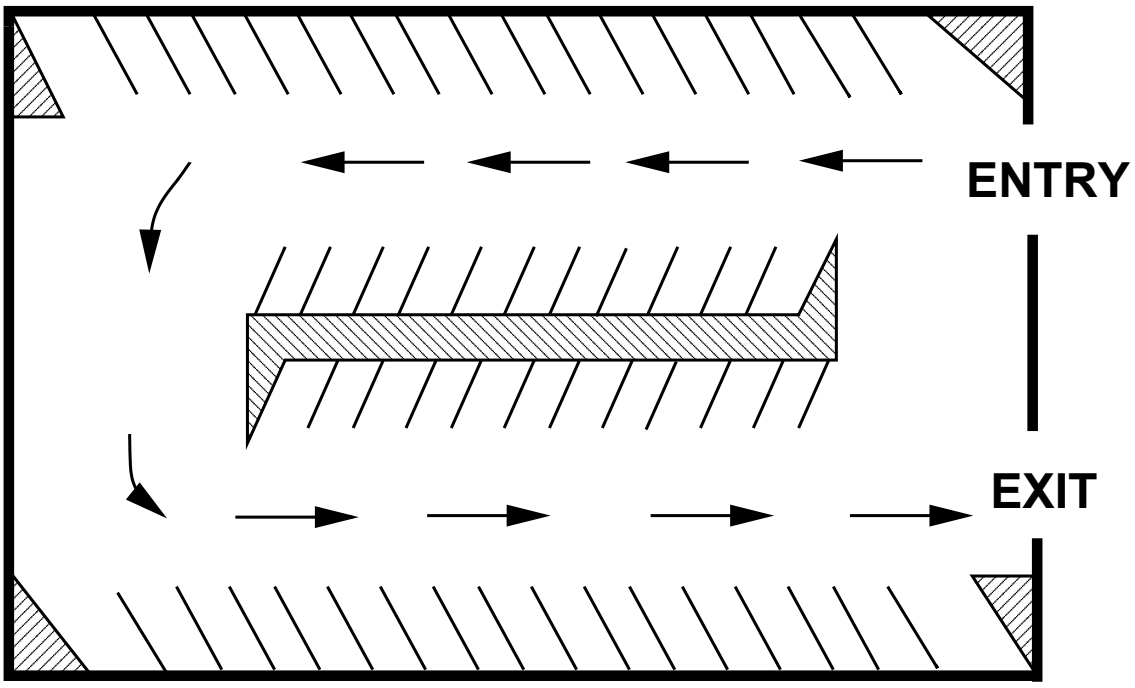

Figure 38:6: Illustration of offstreet parking

Time	In	Out
5	3	2
10	2	4
15	4	2
20	5	4
25	7	3
30	8	2
35	2	7
40	4	2
45	6	4
50	4	1
55	3	3
60	2	5

Solution

Time (1)	In (2)	Out (3)	Accumulation (4)	Occupancy (5)	Parking load (6)
5	3	2	26	65	130
10	2	4	24	60	120
15	4	2	26	65	130
20	5	4	27	67.5	135
25	7	3	31	77.5	155
30	8	2	37	92.5	185
35	2	7	32	80	160
40	4	2	34	85	170
45	6	4	36	90	180
50	4	1	39	97.5	195
55	3	3	39	97.5	195
60	2	5	36	90	180

- Accumulation can be found out as initial count plus number of vehicles that entered the parking lot till that time minus the number of vehicles that just exited for that particular time interval. For the first time interval of 5 minutes, accumulation can be found out as 25+3-2 = 26. It is being tabulated in column 4.
- Occupancy is given by equation 38.1. For the first time interval of five minutes, $Parking\ index = \frac{26}{40} \times 100$ = 65%. The occupancy for the remaining time slot is similarly calculated and is tabulated in column 5.

  Average occupancy is the average of the occupancy values for each time interval. Thus it is the average of all values given in column 5 and the value is 80.63%.
- Parking load is tabulated in column 6. It is obtained by multiplying accumulation with the time interval. For the first time interval, Parking load = 26 × 5 = 130 vehicle minutes.
- Total parking load is the summation of all the values in column 5 which is equal to 1935 vehicle minutes or 32.25 vehicle hours

Example 2

The parking survey data collected from a parking lot by license plate method is s shown in the table below. Find the average occupancy, average turn over, parking load, parking capacity and efficiencyof the parking lot.

Bay	Time			
	0-15	15-30	30-45	45-60
1	1456	9813	-	5678
2	1945	1945	1945	1945
3	3473	5463	5463	5463
4	3741	3741	9758	4825
5	1884	1884	-	7594
6	-	7357	-	7893
7	-	4895	4895	4895
8	8932	8932	8932	-
9	7653	7653	8998	4821
10	7321	-	2789	2789
11	1213	1213	3212	4778
12	5678	6678	7778	8888

Solution

1	2	3	4	5	6	7	8	9	10
Bay	Time				Time				
	15	30	45	60	15	30	45	60	Turn over
1	1456	9813	-	5678	1	1	0	1	3
2	1945	1945	1945	1945	1	1	1	1	1
3	3473	5463	5463	5463	1	1	1	1	2
4	3741	3741	9758	4825	1	1	1	1	3
5	1884	1884	-	7594	1	1	0	1	2
6	-	7357	-	7893	0	1	0	1	2
7	-	4895	4895	4895	0	1	1	1	1
8	8932	8932	8932	-	1	1	1	0	1
9	7653	7653	8998	4821	1	1	1	1	3
10	7321	-	2789	2789	1	0	1	1	2
11	1213	1213	3212	4778	1	1	1	1	3
12	5678	6678	7778	8888	1	1	1	1	4
	Accumulation				10	11	9	11	
	Occupancy				0.83	0.92	0.75	0.92	2.25

Solution Code the given data. If a vehicle occupies that bay for that time interval, then it has a code 1. This is shown in columns 6, 7, 8 and 9 of the tables corresponding to the time intervals 15,30,45 and 60 seconds. Turn over is computed as the nunber of vehicles present in that bay for that particular hour. For the first bay, it is counted as 3. Similarly, for the second bay, one vehicle is present throughout that hour and hence turnout is 1 itself This is being tabulated in column 10 of the table.

Parking volume = Sum of the turn over in all the bays = 27 veh/sec

Average duration is the average time for which the parking lot was used by the vehicles It can be calculated as sum of the accumulation for each time interval × time interval divided by the parking volume $=\frac{(10+11+9+11)\times 15}{27} = 22.78$

Accumulation for a time interval is the total of number of vehicles in the bays 1 to 12 for that time interval. Accumulation for first time interval of 15 minutes = 1+1+1+1+1+0+0+1+1+1+1+1 = 10

Occupancy for that time interval is accumulation in that particular interval divided by total number of bays. For first time interval of 15 minutes, occupancy = (10×100)/12 = 83%

Average occupancy is found out as the average of total number of vehicles occupying the bay for each time interval. It is expressed in percentage. Averge occupancy = $\frac{0.83+0.92+0.75+0.92}{4} \times 100 = 85.42\%$.

Average turn over = $\frac{\text{Sum of turn}-\text{over}}{\text{Total number of bays}} = 2.25$

Parking capacity = number of bays × number of hours = 12× 1 = 12 vehicle hours

Parking load = total number of vehicles accumulated at the end of each time interval × time = $\frac{(10+11+9+11)\times 15}{60}$ = 10.25 vehicle hours

Efficiency = $\frac{\text{Parking load}}{\text{Total number of bays}} = \frac{10.25}{12} = 85.42\%$.

38.8 Summary

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 or plan the fares. Different types of parking layout, surveys and statistics were discussed in this chapter.

38.9 Problems

1. The parking survey data collected from a parking lot by license plate method is shown in table below. Find the average occupancy, average turnover, parking load, parking capacity and efficiency of parking lot.

Bay	Time			
	0-15	15-30	30-45	45-60
1	1501	1501	4021	-
2	1255	1255	1255	1255
3	3215	3215	3215	3215
4	-	-	3100	3100
5	1623	1623	1623	-
6	2204	2204	-	-

1	2	3	4	5	6	7	8	9	10
Bay	Time				Time				
	15	30	45	60	15	30	45	60	Turn over
1	1501	1501	4021	-	1	1	1	0	2
2	1255	1255	1255	1255	1	1	1	1	1
3	3215	3215	3215	3215	1	1	1	1	1
4	-	-	3100	3100	0	0	1	1	1
5	1623	1623	1623	-	1	1	1	0	1
6	2204	2204	-	-	1	1	0	0	1
	Accumulation				5	5	5	3	
	Occupancy				0.83	0.83	0.83	0.5	

Solution Code the given data. If a vehicle occupies that bay for that time interval, then it has a code 1. This is shown in columns 6, 7, 8 and 9 of the tables corresponding to the time intervals 15,30,45 and 60 seconds. Turn over is computed as the nunber of vehicles present in that bay for that particular hour. For the first bay, it is counted as 2. Similarly, for the second bay, one vehicle is present throughout that hour and hence turnout is 1 itself This is being tabulated in column 10 of the table. Total turn over in all the bays or parking volume= 2+1+1+1+1+1 = 7 veh Average duration is the average time for which the parking lot was used by the vehicles It can be calculated as sum of the accumulation for each time interval $\times$ time interval divided by the parking volume $=\frac{(5+5+5+3)\times 15}{7} = 38.57$ minutes Average occupancy is found out as the average of total number of vehicles occupying the bay for each time interval. It is expressed in percentage. Averge occupancy $= \frac{0.83+0.83+0.83+0.5}{4} \times 100 = 75\%$.

Average turn over $= \frac{\text{Sum of turn}-\text{over}}{\text{Total number of bays}} = \frac{7}{6}$=1.17

Parking capacity = number of bays $\times$ number of hours = 6$\times$ 1 = 6 vehicle hours

Parking load = total number of vehicles accumulated at the end of each time interval $\times$ time $= \frac{(5+5+5+3)\times 15}{60}$ = 4.5 vehicle hours

Efficiency $= \frac{\text{Parking load}}{\text{Total number of bays}} = \frac{4.5}{6} = 75\%$.