Parking

Transportation Systems Engineering

Introduction

Adverse Impacts

Requirements

Adverse Impacts

- Congestion

  - Parking takes considerable street space leading to the lowering of the road capacity

  - Speed will be reduced

  - Journey time and delay will also subsequently increase

  - Operational cost of the vehicle increases leading to great economical loss to the community

- Safety

  - Careless maneuvering of parked vehicles causes accidents

  - Obstruction to fire fighting operations

Adverse Impacts

- Environmental pollution

    – Stopping and starting of vehicles while parking and unparking results in noise and fumes

    – Affect the aesthetic beauty of the buildings

    – Cars parked at every available space creates a feeling that building rises from a plinth of cars.

Parking requirements

- **Residential plot area**

  - Less than 300 sq.m require only community parking space.

  - For residential plot area from 500 to 1000 sq.m

  - Minimum 1/4th of the open area should be reserved for parking

  - Offices may require at least one space for every 70 sq. m. as parking area

  - One parking space is enough for 10 seats in a restaurant

  - Cinema halls need to keep 1 parking space for 20 seats.

Type of Parking

On-Street

Off-Street

On street parking

- **General**

  – Vehicles are parked on the sides of the street

  – Parking bay standard by IRC   Car   5 x 2.5 m

  Truck   3.75 x 7.5 m

- **Common types**

  – Parallel parking

  – 30° parking

  – 45° parking

  – 60° parking

  – 90° or Right angle parking

On street parking

- Parallel parking

  – Vehicles are parked along the length of the road

  – No backward movement involved while parking or unparking the vehicle

  – Most safest parking from the accident perspective

  – Consumes the maximum curb length and therefore only a minimum number of vehicles can be parked for a given kerb length

  – Least obstruction to the on-going traffic since least road width is used
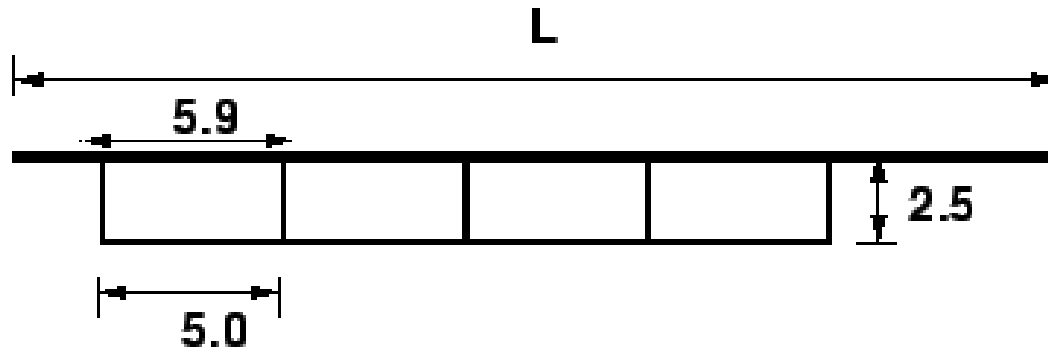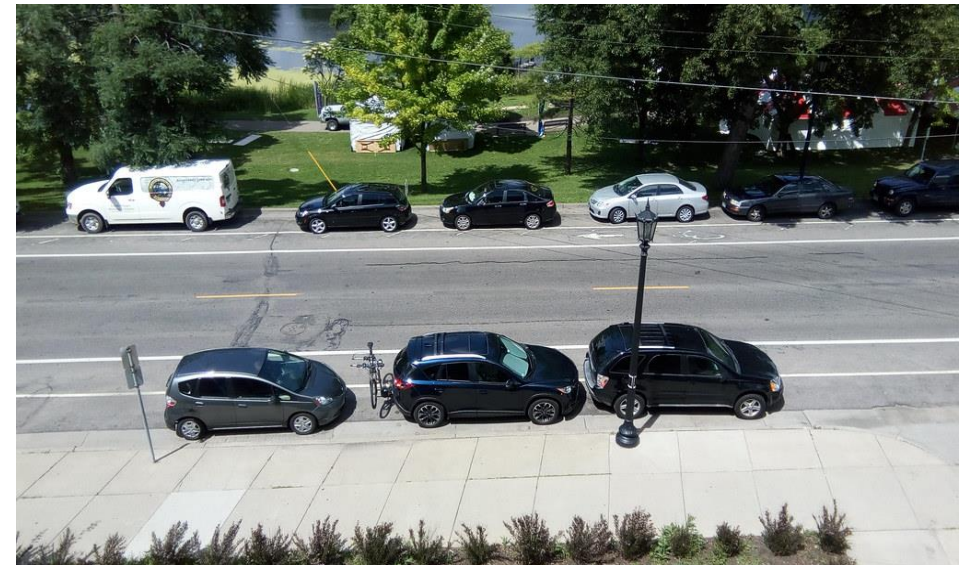
On street parking

- **Parallel Parking**

Illustration of parallel parking

Length required to park N vehicles
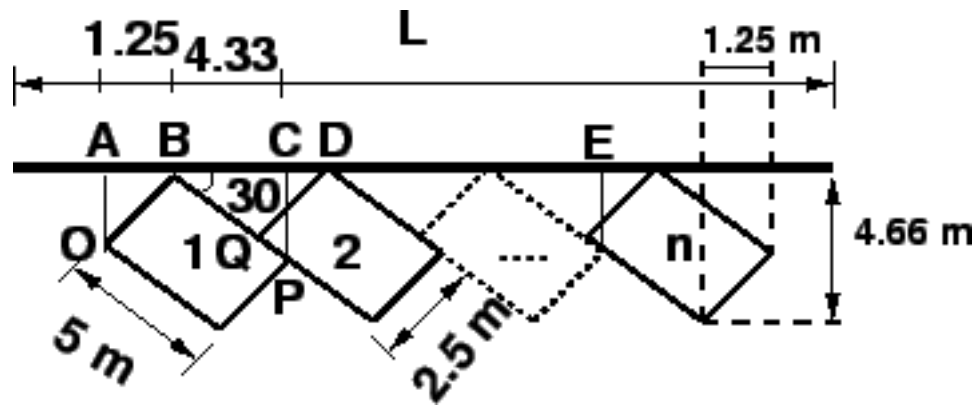
$$L = N\ 5.9$$

On street parking

- **30° parking**
  - Vehicles parked at 30° w. r. to the road alignment
  - Accommodate more vehicles than parallel parking
  - Delay caused to the traffic is minimum and better maneuverability

On street parking

- ### 30^0 parking

$$
\begin{aligned}
AB &= OB\sin 30° = & 1.25, \\
BC &= OP\cos 30° = & 4.33, \\
BD &= DQ\cos 60° = & 5, \\
CD &= BD - BC = 5 - 4.33 = & 0.67, \\
AB + BC &= 1.25 + 4.33 = & 5.58
\end{aligned}
$$

For N vehicles, L = AC + (N-1)CE = 5 N + 0.58
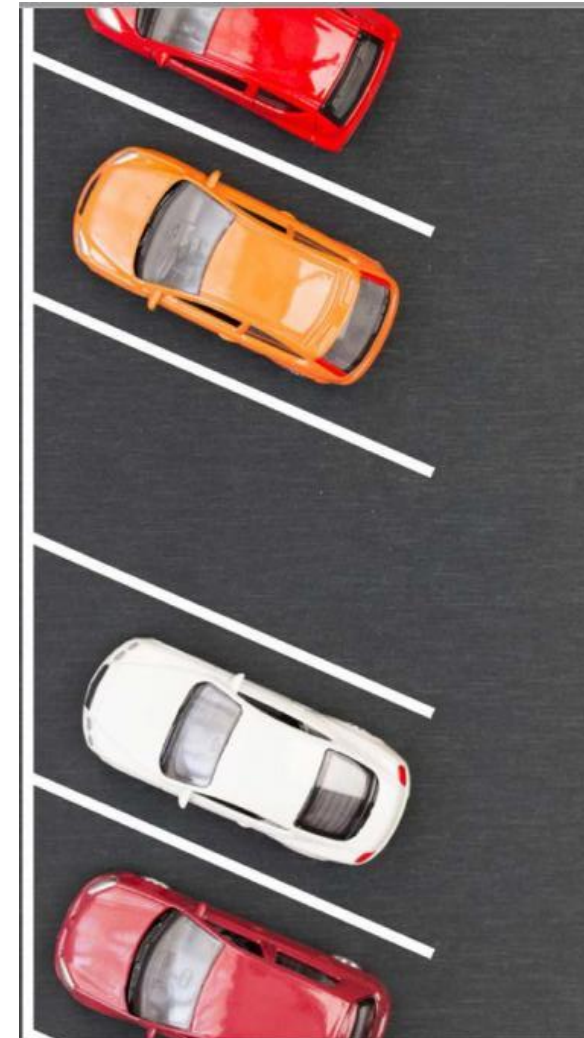
On street parking

- 45^0 parking

  - More number of vehicles can be parked

  - Compared to parallel parking and 30^0 parking, more number of vehicles can be accommodated

  - Length of parking space

  - L = 3.54 N+1.77

On street parking

- 60^0 parking

  - Vehicles are parked at 60^0 to the direction of road

  - More number of vehicles can be accommodated

  - Length required to park N vehicles

L = 2.89 N + 2.16
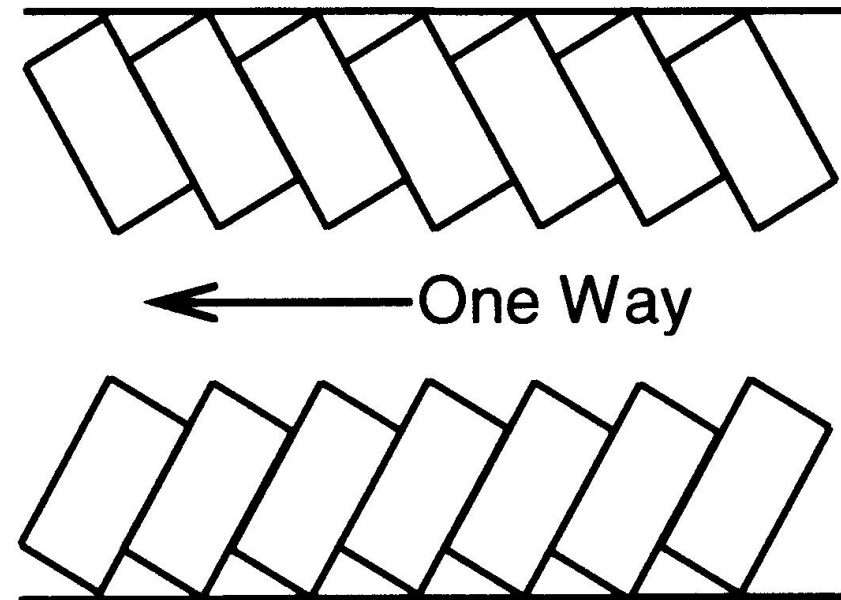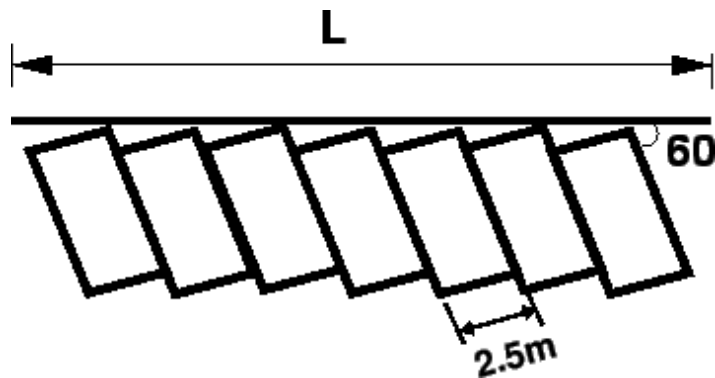
On street parking

- **Right angle parking**

  – Bays perpendicular to the direction of the road

  – Consumes maximum width

  – Kerb length required is very little

  – Vehicles need complex maneuvering

    - may cause severe accidents

    - causes obstruction to the road traffic

  – Can accommodate maximum number of vehicles for a given kerb length

On street parking

- **Right angle parking**
  - Length available for parking N vehicle
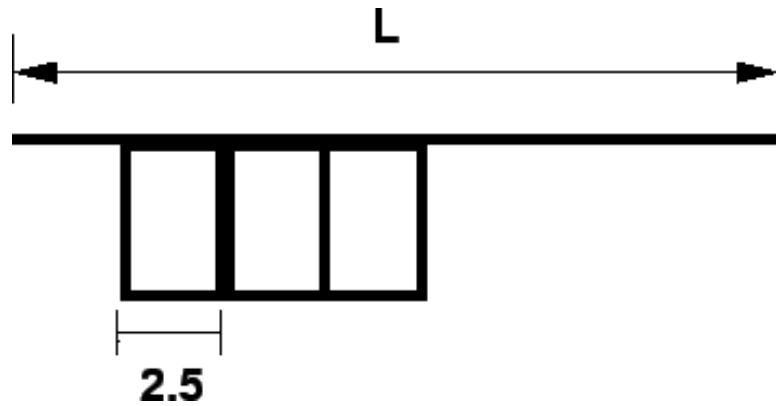
Illustration of 30^0 parking

  - L = 2.5N
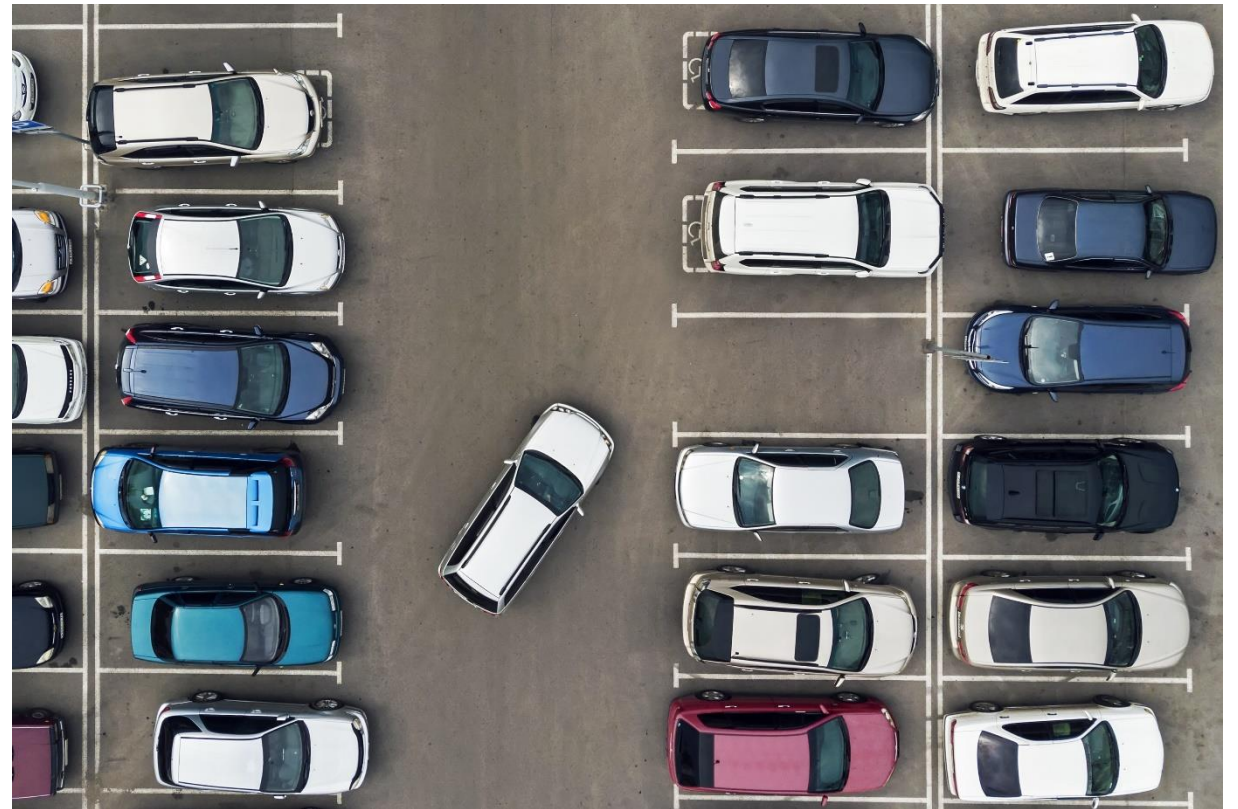
Off street parking

- **Off-street Parking**
  - Areas exclusively allotted away from the main stream of traffic
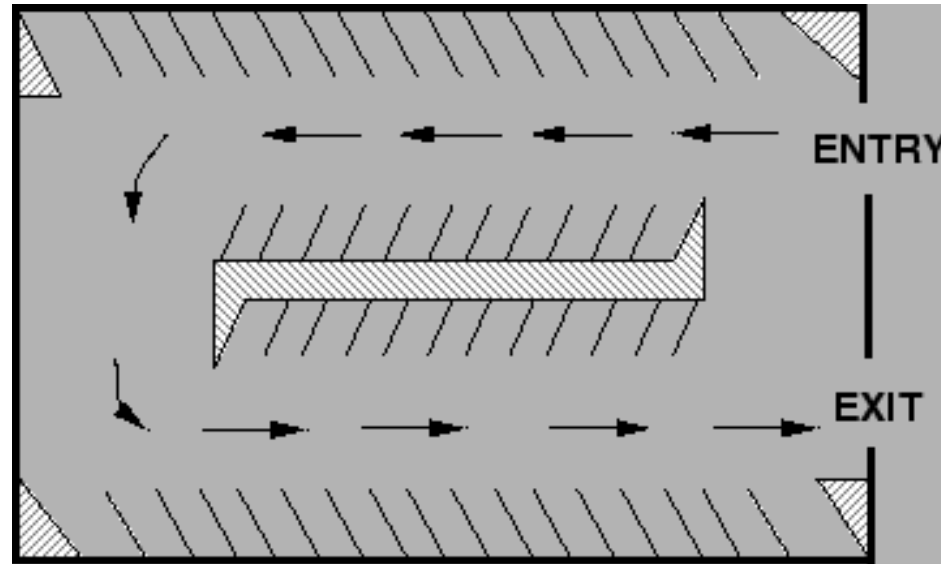
Illustration of off-street parking
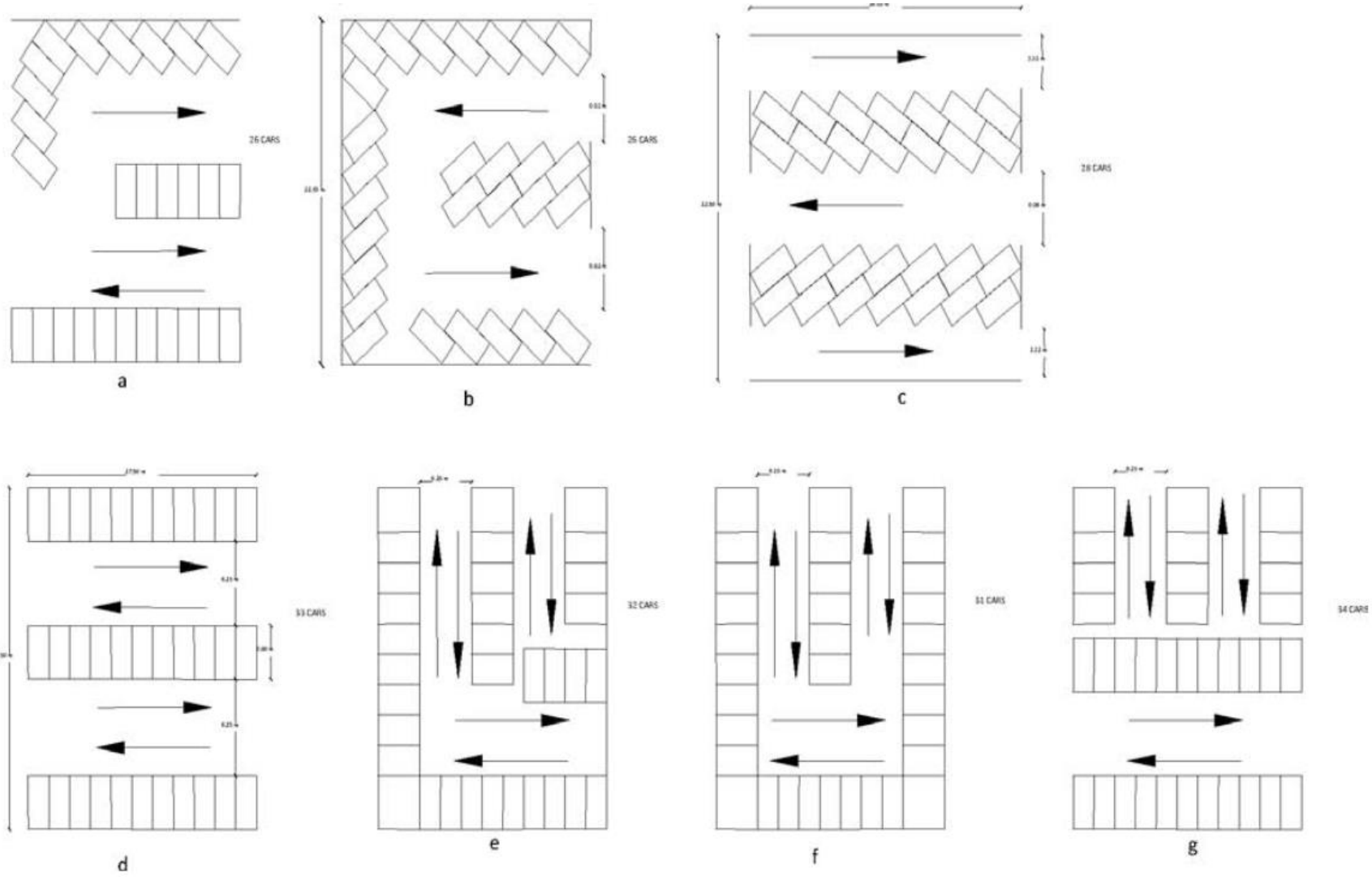
Off street parking

Off street parking - MLCP
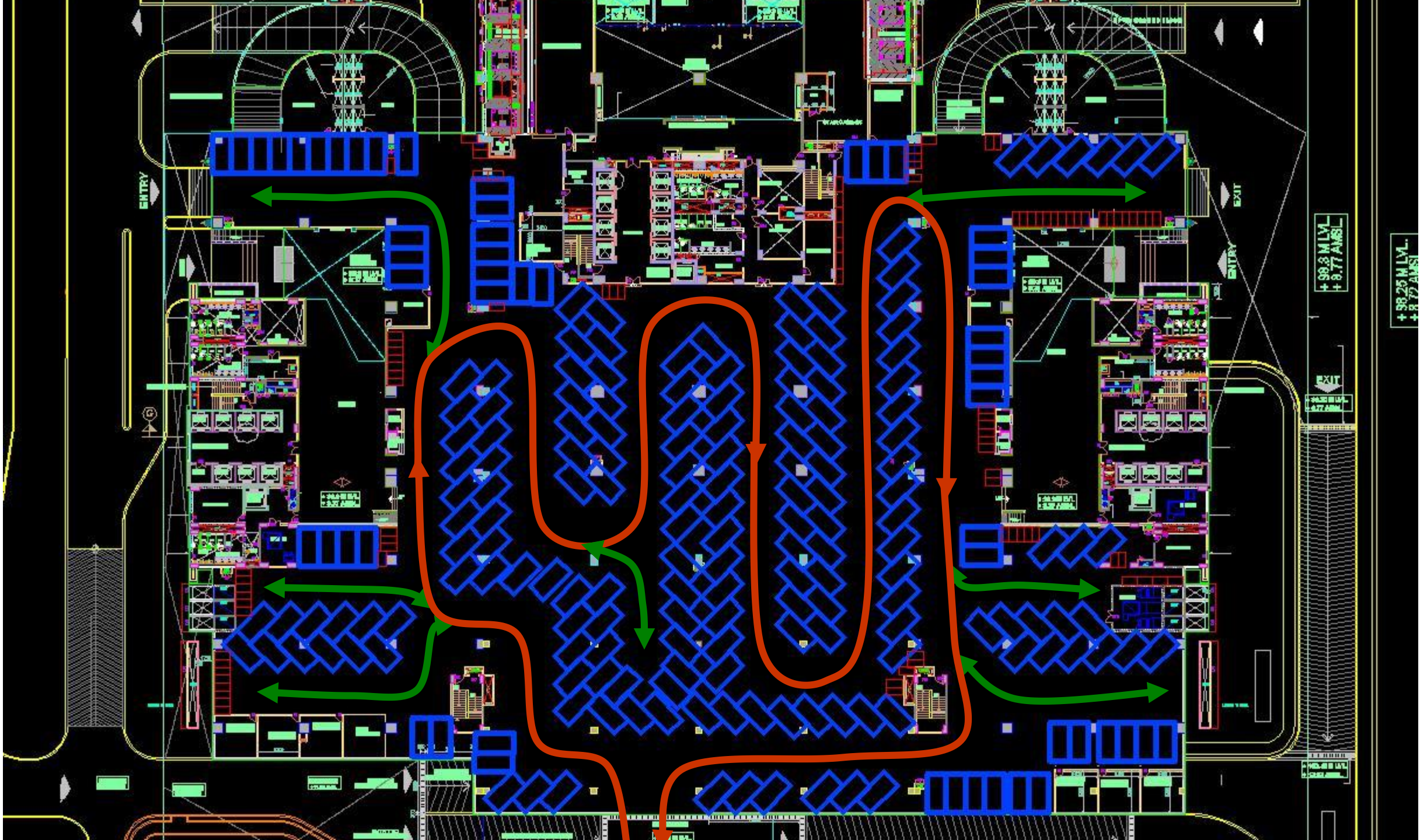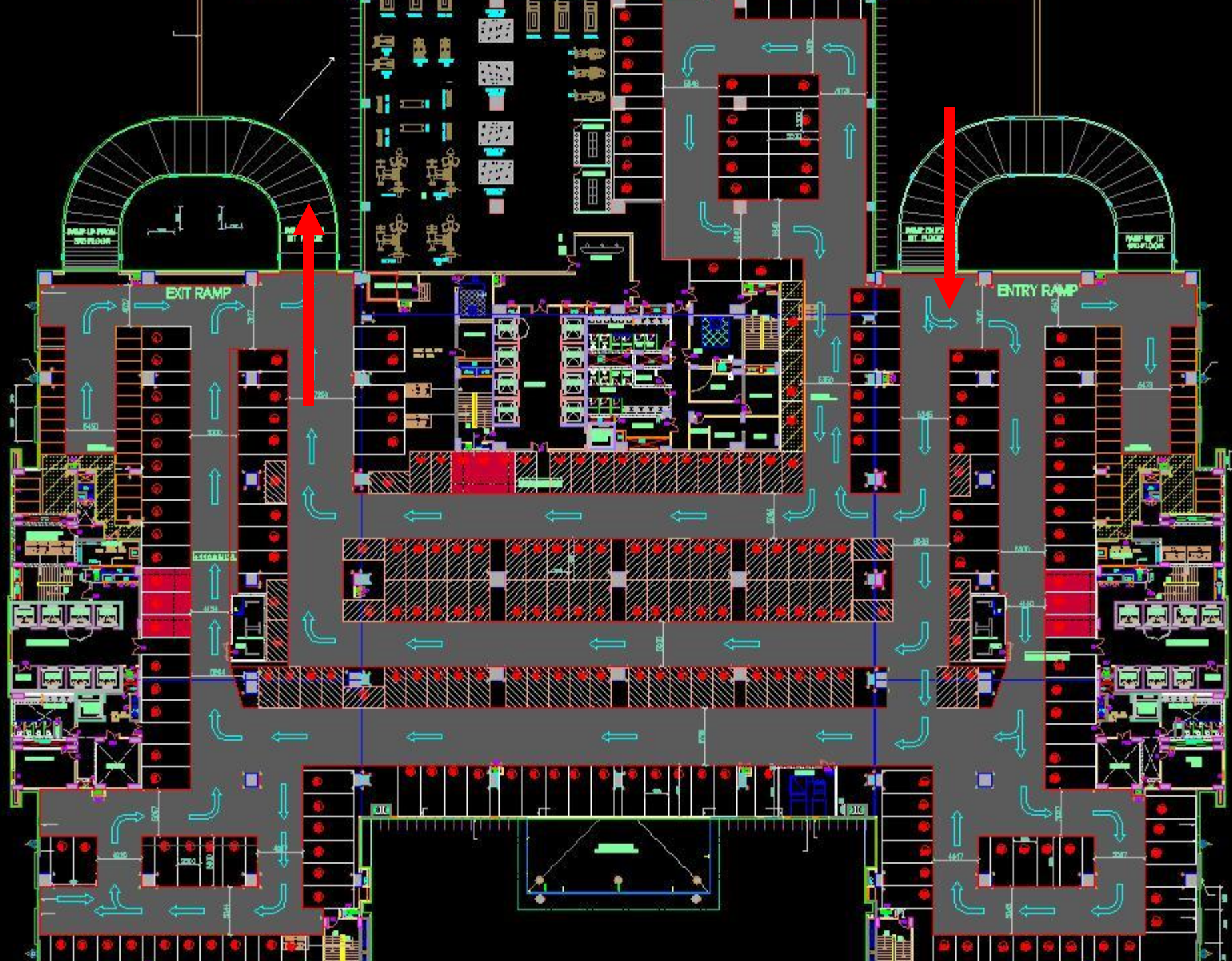
Parking statistics

Accumulation

Load

Index

Volume

Duration

Turnover

Parking statistics

1. Parking accumulation

   – Number of vehicles parked at a given instant of time

   – Expressed thorough accumulation curve by plotting the number of bays occupied with time

2. Parking volume

   – Total number of vehicles parked at a given duration

   – Does not account for repetition of vehicles

Parking statistics

3. Parking load

 – Area under accumulation curve

 – Product of the number of vehicles occupying the parking area at each time interval and the time interval

 – Expressed as vehicle hours.

4. Average parking duration

 – Ratio of total vehicle hours to the no. of vehicles parked

$$Average\ Parking\ Duration = \frac{Parking\ Load}{Parking\ Volume}$$

Parking statistics

5. Parking Turnover

 – Ratio of number of vehicles parked in a duration to number of parking bays available

$$Parking\ Turnover = \frac{Parking\ Volume}{No.of\ bays\ available}$$

 – Expressed as vehicles/bay/time duration

Parking statistics

6. **Parking index**

    – Ratio of no. of bays occupied in a time duration to the total available

$$Parking\ Index = \frac{Parking\ Load}{Parking\ Capacity} \times 100$$

    – Also called occupancy or efficiency

    – An aggregate measure of how effectively the parking space is utilized

Parking statistics

Numerical Example

Bays and occupancy
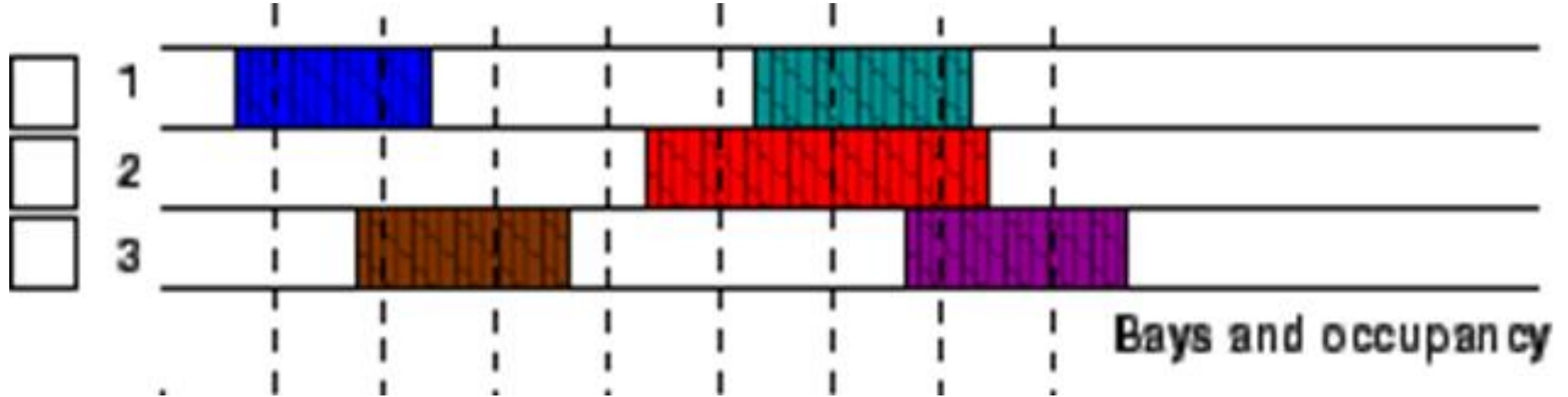
Parking statistics

Solution

1. **Accumulation curve**

Bays and occupancy
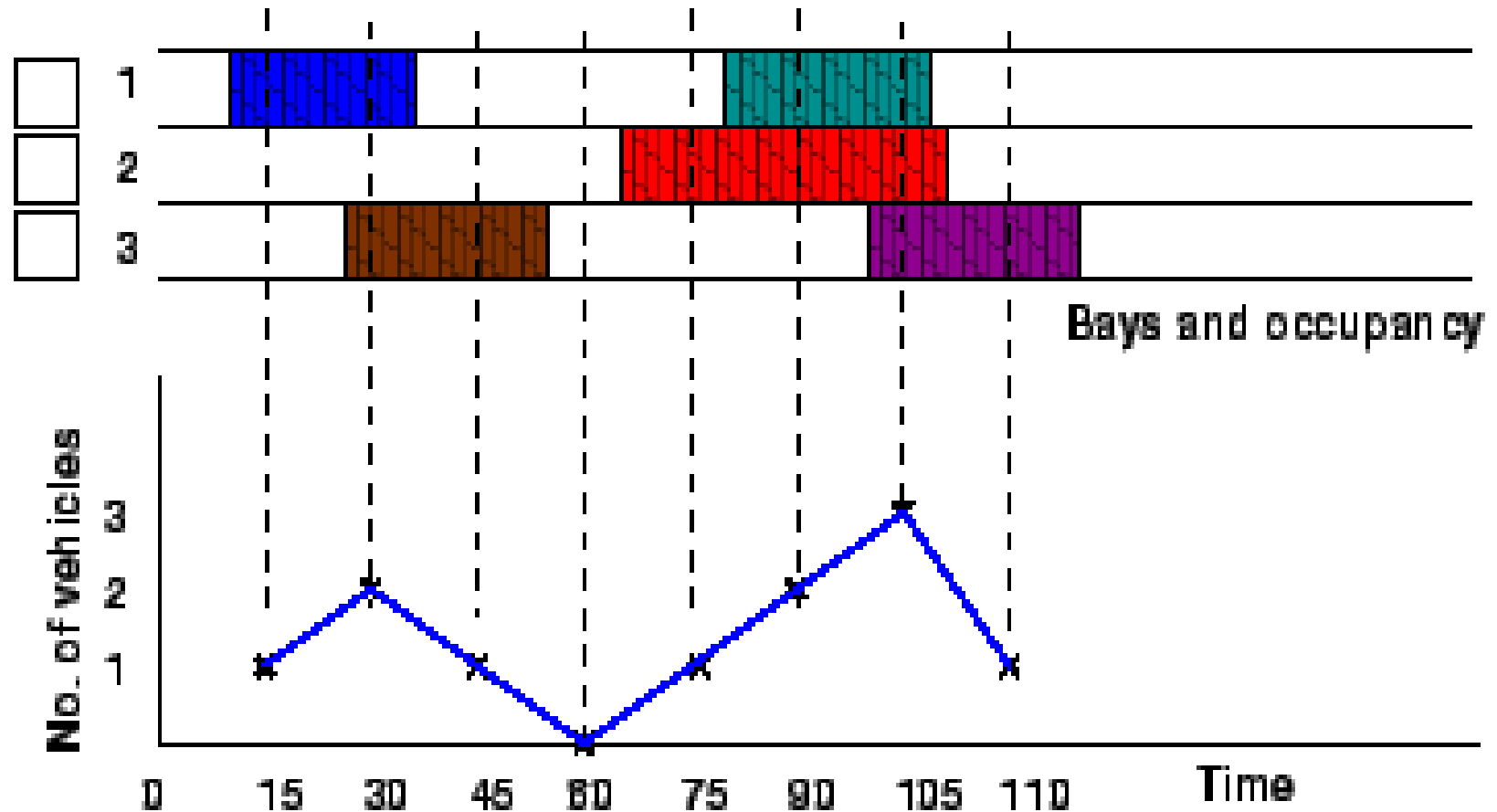
Parking accumulation curve

Parking statistics

Statistics	Computation
2. Parking volume	5 vehicles/2 hour **2.50** veh./hr
3. Parking load	(1+2+1+0+1+2+3+1)15/60 = 11 x 15/60 **2.75** veh-hour
4. Av. parking duration	2.75 veh hours / 5 vehicle **33.0** mts
5. Parking turnover	5 veh/ 2 hours per 3 bays **0.83** veh/hr/bay
6. Parking index	$\dfrac{2.75\ veh.\ hours}{3 \times 2\ veh.\ hours} \times 100$ **45.8** %

Statistics	Computation
2. Parking volume	5 vehicles/2 hour **2.50** veh./hr
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1. Accumulation curve

Parking Surveys

In-Out

Fixed Period

License Plate

Parking surveys

- General

  - To collect the parking statistics

  1. in-out survey

  2. fixed period sampling

  3. license plate method of survey

Parking surveys - In-out survey

- **Procedure**

  1. Count the no of vehicles at the beginning

  2. Count the no of vehicles entering the parking area at each time interval

  3. Count the no of vehicles leaving the parking area at each time interval

  4. Count the no of vehicles at the end of the time period

- **Discussion**

  - Details of any specific vehicle used that parking lot cannot be obtained

  - Parking duration and turn over is not obtained

  - Not suitable for on-street parking, good for off-street parking

Parking Surveys - Fixed Period Sampling

- **Procedure**

  - All vehicles are counted at the beginning of the survey

  - Count is taken again at the end of fixed time intervals (15/30/60 mts)

- **Discussion**

  - Similar to in-out survey

  - Suitable for both on-street and off-street parking areas

  - Needs less manpower

  - Will miss short-term parking

Parking Surveys - License Plate Method

- **Procedure**

  - Every parking bay is monitored at the end of every interval

  - License plate number is noted down for each bay

- **Discussion**

  - Most accurate and almost exhaustive data

  - Duration of every individual vehicle using each bay is available

  - Shorter time interval reduces chance of missing short-term parking

  - This method is most labor intensive

In-out survey

Numerical Example

1. From an in-out survey conducted for a parking area

2. Size = **40** bays

3. Initial count = **25**

4. Time interval = **5** mts

5. Table gives survey data

6. Find the accumulation, total parking load, average occupancy and efficiency of the parking lot

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

In-out surveys: Example solution

(25+3-2=26)

Time	In	Out	Accumulation
(1)	(2)	(3)	(4)
5	3	2	26
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	

In-out surveys: Example solution

Time	In	Out	Accumulation
(1)	(2)	(3)	(4)
5	3	2	26
10	2	4	24
15	4	2	26
20	5	4	27
25	7	3	31
30	8	2	37
35	2	7	32
40	4	2	34
45	6	4	36
50	4	1	39
55	3	3	39
60	2	5	36

In-out surveys: Example solution

Time	In	Out	Accumulation	Occupancy
(1)	(2)	(3)	(4)	(5)
5	3	2	26	65 → 26/40*100=65%
10	2	4	24	
15	4	2	26	
20	5	4	27	
25	7	3	31	
30	8	2	37	
35	2	7	32	
40	4	2	34	
45	6	4	36	
50	4	1	39	
55	3	3	39	
60	2	5	36	

In-out surveys: Example solution

Time	In	Out	Accumulation	Occupancy
(1)	(2)	(3)	(4)	(5)
5	3	2	26	65
10	2	4	24	60
15	4	2	26	65
20	5	4	27	67.5
25	7	3	31	77.5
30	8	2	37	92.5
35	2	7	32	80
40	4	2	34	85
45	6	4	36	90
50	4	1	39	97.5
55	3	3	39	97.5
60	2	5	36	90

In-out surveys: Example solution

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

26*5=130 veh.mts

In-out surveys: Example 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

AVG **80.63** %

License Plate : Example problem

Numerical

Example

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

License Plate : Example solution

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

Present -1

Absent - 0

License Plate : Example solution

Bay	Time				Time				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	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

License Plate : Example solution

Bay	Time				Time				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	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	

License Plate : Example solution

Bay	Time				Time				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	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				

10/12

License Plate : Example solution

Bay	Time				Time				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	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

Thank You

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