Problem of Parking in Alwar City and their Possible Solutions

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Abstract: With rapid industrialization, vehicle density in major cities is increasing quickly, challenging transportation planners to provide adequate parking. The problem was identified in a high-density market area in Alwar City, Rajasthan. The Ghanta Ghar and Hope Circus areas, key business centers, were chosen for the study, conducted in four stages. First, a traffic volume study was done manually. The second stage involved a parking study divided into parking volume and occupancy using an in-out survey technique and a stakeholder survey. The third stage involved a parking space inventory, reviewing existing facilities and identifying additional parking spaces. The final stage presented solutions for the parking issue. Parking occupancy during peak hours was found to be 217%, with improper marking, poor enforcement, and outdated design standards observed. Recommendations included multi-story parking, new parking areas, improved bay designs, better communication, enforcement, and operational efficiency for managing parking.

***Keywords*: Traffic studies; Parking demand; Parking occupancy; Parking space inventory; Congestion**

1. INTRODUCTION

Parking refers to temporarily placing or leaving a vehicle in a designated area, typically called a parking lot, parking garage, or parking space. It is a process where a vehicle is brought to a halt and left unattended for a certain period of time. Parking is necessary because it allows vehicles to be safely stored while not in use, preventing them from obstructing traffic or causing inconvenience to others. Parking spaces are often marked and designated by painted lines, signage, or other indicators to guide drivers in positioning their vehicles correctly. Proper design of the parking is very important for a good transportation system.

About 21 crore two-wheelers and 7 crore four-wheelers were registered in India till 2022 [1]. The automobile sector has grown by 12.5% in the financial year 2024. A total of 2,38,53,463 vehicles of all categories were sold in the year 2023-24 [2]. With this increase in vehicle population, the problems of parking is also increasing year on year. The main reasons for parking problems are the increase in vehicle population and the lack of sufficient parking spaces. Cities and urban areas grapple with parking challenges, highlighting a disparity between the demand for parking (the number of vehicles requiring spaces) and the available parking supply (number of parking spaces sufficient for automobiles in need of park the vehicle).

The parking scenario in India varies greatly depending on the city and the specific area within the city. However, there are some general trends and challenges that can be observed across the country: Many cities in India lack sufficient parking infrastructure to accommodate the growing number of vehicles. The number of vehicles far exceeds the available parking spaces, leading to congestion and haphazard parking. In busy areas with high demand for parking, people often resort to illegal parking, such as parking on sidewalks, in no-parking zones, or in front of fire hydrants. This further exacerbates traffic congestion and creates inconvenience for pedestrians and other users. This lack of enforcement contributes to the chaotic parking situation and creates a sense of impunity among violators. Effective parking management strategies, such as implementing parking permits, time limits, and parking fees, are often lacking or not properly enforced. This leads to a lack of turnover in parking spaces, making it difficult for people to find available spots. In cities with inadequate public transportation systems, people are+ more reliant on private vehicles, which further increases the demand for parking. The lack of viable alternatives to private vehicles puts additional pressure on the already limited parking spaces. The construction of malls, shopping centres, and residential complexes often does not adequately account for parking needs. Insufficient parking facilities in these areas contribute to the parking problem, as visitors and residents have limited places to park their vehicles.

Addressing the parking problem in India requires a multi-faceted approach, including the development of more parking infrastructure, stricter enforcement of parking regulations, implementation of efficient parking management systems, promotion of sustainable transportation options, and better urban planning to incorporate parking needs into the design of commercial and residential areas.

Clear markings and signage are crucial for efficient parking. Parking spaces should be well- marked

with lines, numbers, or other identifiers to facilitate organization and navigation.
Directional signs, including entrance, exit, and pedestrian crossings, should be placed strategically.

Table 1: Parking space required (According to IRC SP:12-2015) [3]

Vehicle	Space required (in m^2)
Car	20-36 sq. m.
Buses	55-60 sq. m
Trucks	55-60 sq. m
Three wheelers	10-15 sq. m

As parking norms are generally prescribed in terms of Equivalent Car Units (ECU), following factors shall be used to convert other vehicles into equivalent car units-

Table 2: Equivalent car unit (ECU) (According to IRC SP:12-2015) [3]

Vehicle Type	ECU
Car/taxi	1.00
Two wheeler	0.25
Auto	0.50
Bicycle	0.10
Trucks/buses	2.50
Emergency vehicles	2.50
Rickshaw	0.8

A parking bay refers to any designated area within a parking facility intended for vehicle parking, typically identified by surface markings.

Two-wheelers- 2m x 1m
Four wheelers- 5m x 2.5m (car)
Low floor buses- 14m x 3.5m Three wheelers- 3m x 1.6m
Truck- 7.5m x 3.75m

Many researchers have carried out studies related to parking issues in civil engineering applications. Lambang et al. [2021] [4] proposed a study for reducing congestion and resolving parking issues in Makassar City, Indonesia. This study was conducted in three stages using parking surveys, congestion levels and public perceptions of parking. The study indicated that the severe congestion incidents in Makassar are due to crossroads, T-junctions, U-turns, parking, and complex occasions resulting in travel service reductions. Janak et al. [2020] [5], Subhadip et al. [2017] [6], Chen and Zhang [2011] [7] reviewed the demand and characteristics of parking systems in urban areas. Indrajit Roy [2016] [8], Diganta et al. [2015] [9] and Yousif and Purnawan [1999] [10] conducted a study to investigate the street parking demand and impact of on-street parking on traffic flow characteristics. Stark and Klementschitz [2008] [11] examined the potential impacts and feasibility of implementing off-street parking regulations for shopping facilities. Arjun and Nagakumar [2014] [12] investigated on-street parking utilization using the license plate method in Basavangudi, Bangalore. The study employed a straightforward approach, which involved three main stages: preparation, survey, and analysis. During the preparation phase, relevant literature on parking was collected and area characteristics were examined. The survey phase comprised primary surveys, such as volume counts, and an exploration of commuter behavior. The results revealed a notable increase in parking demand during the evening hours, especially in proximity to hotels and restaurants. These findings emphasize the necessity for a revised parking policy in the area to address the observed parking demand patterns effectively. Ali et al. [2016] [13] explored the potential of vehicle-to-vehicle communication to enhance the CO-Park cooperative car parking system. It was told that CO-Park operates via wireless communication among intelligent agents within vehicles, ensuring efficient utilization of parking spaces. The CO-Park app enabled vehicles to share information wirelessly, significantly impacting parking dynamics within the lot. Through simulations and experiments, it has been shown that the CO-Park approach substantially reduces parking search time. Specifically, this method can decrease average search time by up to 57% compared to non-cooperative approaches.
Summarizing the literature reviewed in this study:

- Congestion point, travel time, degree of speed and delay, vehicle volume and road capacity at the place of study should be observed.
- Improper on-street parking can create many problems related to congestion.
- New techniques and technologies need to be adopted to solve parking problems.
- Stakeholders play an important role in providing efficient information regarding the existing facilities in the study area.

The following are the objectives of this study:

1. To determine the total peak-hour traffic in the selected stretch from the traffic volume study.
2. To determine the parking demand and parking occupancy in the selected area of study.
3. To conduct stakeholder survey and parking inventory studies of the selected stretch.
4. To propose a feasible solution to overcome congestion and parking problems.

2. ABOUT STUDY AREA

Alwar district is the major city in Rajasthan, located at 27° 34’ north latitude and 76° 7’ east longitude [14]. Alwar district is spread across 108 Sq km area and the total population of 445000 with a population density of 4100/km^2 as in 2024 [15]. The Aravalli Hills stretch across the western and southwestern parts of the town. Alwar enjoys excellent connectivity to New Delhi and Jaipur via railway and roads, and it is conveniently reachable from Haryana and Uttar Pradesh as well. With its rich historic and cultural heritage, Alwar has emerged as a prominent hub for tourism, trade, commerce, education, and healthcare facilities. Total number of vehicles in Alwar district: 770918 (as in 2017) [16]. Hope Circus and Ghanta Ghar are significant

market centers in Alwar city, but they suffer from exacerbated congestion and parking issues, particularly during peak traffic hours and festive seasons. The study areas includes Ghanta Ghar, Hope Circus, Bajaja Bazaar, Pansari Bazaar, Church Road, and Tahsil Road of Alwar city. These areas face notable traffic congestion due to the absence of permanent parking spaces. Traffic violations persist despite the establishment of one-way regulations on several roads, such as those from Hope Circus to Ghanta Ghar, Pansari Bazaar to Ghanta Ghar, and Andevali Gali to Ghanta Ghar. This study aims to address the parking challenges in these specific areas.

3. METHODOLOGY AND DATA WORK

Alwar is one of the district headquarters in the Rajasthan state. In view of the existing number of vehicles in the city and their growth rate, the available parking facilities are insufficient. This is the need of the hour to make the movement of traffic smooth, the basic infrastructural facilities need to enhance including better parking facilities, In the present study, an attempt has been made to solve the parking problem in the two prime locations of Alwar City.

The present study is divided into four stages. In Stage I, a traffic volume study was conducted in the study area. The traffic volume data was collected manually on all the seven legs of the selected stretch. The traffic volume data was collection from 10 A.M. to 10 P. M. The survey was conducted as per the provisions of IRC SP:19-2001 [17].

In Stage II, the parking demand was find out based on in-out survey technique. The in-out method was used. The parking capacity was determined in this parking bays were counted. And parking occupancy was also determined. It is the ratio of number of vehicles (parking demand plus initially counted vehicles) to available number of parking bays. The space required for parking was determined as per the specifications provided in IRC SP:012-2015 [18].

In the Stage III of the study, parking space inventory study was carried out. In this study, the review of existing parking facilities in the area was determined. Also, the available government land where parking facilities could be recommended by government were explored and presented. In this stage, redesign of on-street existing parking was done. Also, the proposed off-street parking method was recommended to streamline the parking problem in the area. An online survey was conducted with the shopkeepers in the study area through a questionnaire in which one hundred-two responses were received and analyzed.

In the stage IV, the result and conclusions based on the detailed parking studies were presented. The various stages of this research are presented in Fig. 1 and line diagram of the study area is shown in Fig. 2.

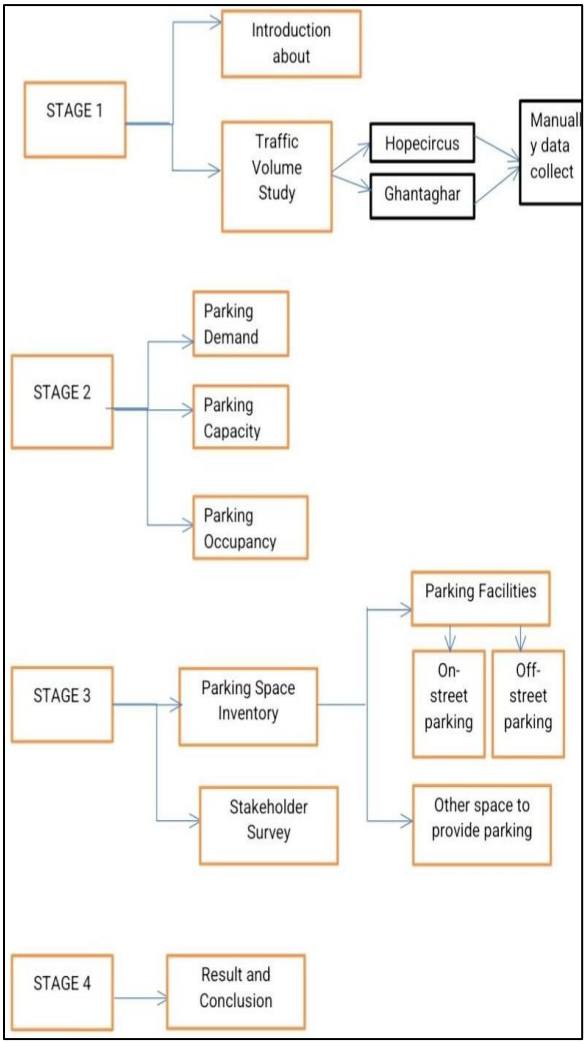

Figure 1: Stages of research work

4. ANALYSIS OF DATA

The data collected from the study area was analyzed to determine the traffic volume study, parking demand, parking capacity, parking accumulation, parking occupancy, and parking space inventory.

4.1. Traffic Volume Study

This study analyzed traffic data from various modes including bikes, cars, autos, and bicycles. The data was gathered through an IN-OUT survey conducted at Ghanta Ghar and Hope Circus, from 10:00 AM to 10:00 PM. To determine the total traffic in terms of Equivalent Car Units (ECU), the collected data was multiplied by the ECU factor. The results are presented in Tables 3, 4, 5 and 6.

4.2. Parking Demand

This study examines parking demand to assess the required number of parking bays in the study area. The assessment relies on the IN-OUT survey method, which collects data on vehicles entering and exiting the study area.

Parking demand calculated by IN-OUT=Demand

Table 3: Ghanta Ghar IN vehicle count survey

TIME (IN HOURS)	BIKES	ECU (BIKE=0.25)	AUTOS	ECU (AUTO=0.5 0)	CARS	ECU (CAR=1.00)	BI-CYCLES	ECU (BICYCLE= 0.10)	TOTAL
10:00AM- 11:00AM	575	143.75	1238	619	50	50	7	0.7	813.45
11:00AM- 12:00PM	502	125.5	1154	577	70	70	9	0.9	773.4
12:00PM- 13:00PM	628	157	1131	565.5	48	48	12	1.2	771.7
13:00PM- 14:00PM	609	152.25	865	432.5	46	46	8	0.8	631.55
14:00PM- 15:00PM	517	129.25	855	427.5	49	49	11	1.1	606.85
15:00PM- 16:00PM	448	112	806	403	51	51	6	0.6	566.6
16:00PM- 17:00PM	472	118	873	436.5	62	62	4	0.4	616.9
17:00PM- 18:00PM	474	118.5	502	251	65	65	0	0	434.5
18:00PM- 19:00PM	536	134	132	66	63	63	6	0.6	263.6
19:00PM- 20:00PM	402	100.5	104	52	54	54	7	0.7	207.2
20:00PM- 21:00PM	315	78.75	9	4.5	20	20	0	0	103.25
21:00PM- 22:00PM	105	26.25	2	1	8	8	0	0	35.25

Table 4: Ghanta Ghar OUT vehicle count survey

TIME (IN HOURS)	BIKES	ECU (BIKE=0.25)	AUTOS	ECU (AUTO=0.50)	CARS	ECU (CAR=1.00)	BI-CYCLES	ECU (BICYCLE=0 .10)	TOTAL
10:00AM-11:00AM	470	117.5	1200	600	45	45	7	0.7	763.2
11:00AM-12:00PM	414	103.5	1100	550	60	60	7	0.7	714.2
12:00PM-13:00PM	580	145	1100	550	42	42	8	0.8	737.8
13:00PM-14:00PM	579	144.75	844	422	43	43	5	0.5	610.25
14:00PM-15:00PM	500	125	830	415	45	45	6	0.6	585.6
15:00PM-16:00PM	417	104.25	798	399	51	51	6	0.6	554.85
16:00PM-17:00PM	440	110	842	421	59	59	2	0.2	590.2
17:00PM-18:00PM	435	108.75	455	227.5	60	60	0	0	396.25
18:00PM-19:00PM	489	122.25	118	59	47	47	3	0.3	228.55
19:00PM-20:00PM	392	98	99	49.5	52	52	2	0.2	199.7
20:00PM-21:00PM	303	75.75	9	4.5	18	18	0	0	98.25
21:00PM-22:00PM	101	25.25	2	1	8	8	0	0	34.25

Table 5: Hope Circus IN vehicle count survey

TIME (IN HOURS)	BIKES	ECU (BIKE=0.25)	AUTOS	ECU (AUTO=0.50)	CARS	ECU (CAR=1.00)	BI-CYCLES	ECU (BICYCLE=0.10)	TOTAL
10:00AM-11:00AM	2750	687.5	317	158.5	38	38	8	0.8	884.8
11:00AM-12:00PM	2016	504	297	148.5	49	49	9	0.9	702.4
12:00PM-13:00PM	2416	604	322	161	27	27	6	0.6	792.6
13:00PM-14:00PM	2597	649.25	299	149.5	42	42	7	0.7	841.45
14:00PM-15:00PM	2003	500.75	307	153.5	40	40	8	0.8	695.05
15:00PM-16:00PM	1982	495.5	318	159	35	35	12	1.2	690.7
16:00PM-17:00PM	2196	549	277	138.5	27	27	14	1.4	715.9
17:00PM-18:00PM	2569	642.25	301	150.5	39	39	2	0.2	831.95
18:00PM-19:00PM	2400	600	255	127.5	43	43	5	0.5	771
19:00PM-20:00PM	1776	444	177	88.5	19	19	0	0	551.5
20:00PM-21:00PM	800	200	56	28	8	8	0	0	236
21:00PM-22:00PM	216	54	5	2.5	5	5	0	0	61.5

Table 6: Hope Circus OUT vehicle count survey

TIME (IN HOURS)	BIKES	ECU (BIKE=0.25)	AUTOS	ECU (AUTO=0.50)	CARS	ECU (CAR=1.00)	BI-CYCLES	ECU (BICYCLE=0.10)	TOTAL
10:00AM-11:00AM	2678	669.5	300	150	36	36	5	0.5	856
11:00AM-12:00PM	1979	494.75	254	127	45	45	8	0.8	667.55
12:00PM-13:00PM	2301	575.25	302	151	27	27	6	0.6	753.85
13:00PM-14:00PM	2500	625	285	142.5	38	38	3	0.3	805.8
14:00PM-15:00PM	1997	499.25	291	145.5	36	36	5	0.5	681.25
15:00PM-16:00PM	1930	475	310	155	33	33	9	0.9	663.9
16:00PM-17:00PM	2094	523.5	256	128	24	24	14	1.4	676.5
17:00PM-18:00PM	2476	619	284	142	33	33	0	0	794
18:00PM-19:00PM	2300	575	241	120.5	38	38	1	0.1	733.6
19:00PM-20:00PM	1766	441.5	170	85	17	17	0	0	543.5
20:00PM-21:00PM	780	195	55	27.5	8	8	0	0	230.5
21:00PM-22:00PM	204	51	4	2	5	5	0	0	58

Table 7: Parking demand from Hope Circus and Ghanta Ghar

TIME (HOUR)	Ghanta Ghar			Hope Circus			
	IN (ECU)	OUT (ECU)	Parking Demand	IN (ECU)	OUT (ECU)	Parking Demand	Total demand
10:00AM-11:00AM	814	763	51	885	856	29	80
11:00AM-12:00PM	774	714	60	702	668	34	94
12:00PM-13:00PM	772	738	34	793	754	39	73
13:00PM-14:00PM	632	610	22	841	806	35	57
14:00PM-15:00PM	607	586	21	695	681	14	35
15:00PM-16:00PM	567	555	12	691	664	27	39
16:00PM-17:00PM	617	590	27	716	677	39	66
17:00PM-18:00PM	435	396	39	832	794	38	77
18:00PM-19:00PM	264	229	35	771	734	37	72
19:00PM-20:00PM	207	200	7	552	544	8	15
20:00PM-21:00PM	103	98	5	236	231	5	10
21:00PM-22:00PM	35	34	1	62	58	4	5
TOTAL							623

From table 7, the parking demand in the area of study was calculated as 623 ECU.

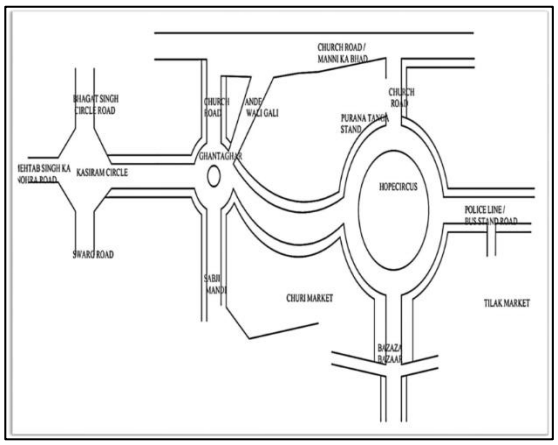

Figure 2: Line diagram of study area

Parking Capacity

The parking capacity assessment entails a methodical analysis aimed at evaluating the available parking spaces within a specific area. This study identified five locations within the market area suitable for arranging paid parking. The space required for parking bays aligns with the guidelines outlined in IRC: SP:12-2015, as depicted below-

Two wheelers- 2m x 1m (6'6" x 3'3")
Four wheelers- 5m x 2.5m (car) (16'5" x 8'2")
Those five places shown below:

Slot 1 parking (Kashi Ram auto stand)

This space designated for an auto stand is currently encroached upon by illegal parking, occupying a significant portion of the parking area. This illegal parking must be cleared to establish an configuration being the most beneficial. The size of this slot is:-

N= 49'
S= 49'
E= 17'
W= 17' Auto/car stand alongside the parking lot, where on-street parking for four-wheelers can be facilitated optimally with a 90-degree parking arrangement. Size of this slot:-
N= 49'
S= 49'
E= 18'
W= 18'

According to this dimension, 6 cars can be parked in that slot. The figure showing the market area and parking layout is shown in Fig. 3.

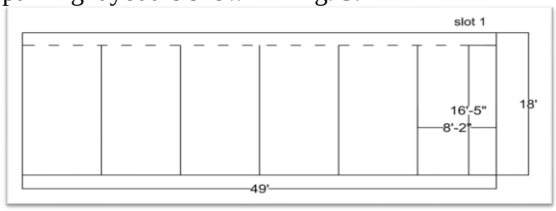

Figure 3: 90^0 parking bays layout at Kashiram auto stand

Slot 2 parking (Sabji Mandi paid parking)

The parking slot is currently obscured by fruit carts around it, making it difficult for drivers to locate. To ensure the provision of parking facilities in an organized manner, the fruit carts must be properly arranged to maximize the utilization of parking spaces. This will enable efficient on- street four-wheeler parking, with a 90-degree parking

According to these dimensions, 6 cars can be parked in that slot. The figure showing the market area and parking layout is shown in Fig. 4.

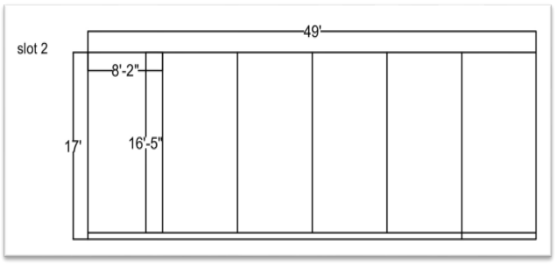

Figure 4: 90^0 Parking bays layout at the Sabji mandi area

Slot 3 parking (Church Road)

Despite the lack of designated parking space, vehicles are often parked haphazardly in this area. Implementing proper parking facilities at this location is crucial. On-street parking would be a suitable solution, with a 90-degree angular parking arrangement being the most feasible option. The size of this slot is:-

N= 25’
S= 22’
E= 33’
W= 33’

According to these dimensions, 4 cars can be accommodated in this slot. The figure showing the parking layout is shown in Fig. 5.

Slot 4 parking (Bazaza Bazaar)

Improper parking persists on both sides of the road, posing a challenge. To address this issue effectively, designated parking slots can be established to encourage proper parking facilities. On-street four-wheeler parking can be facilitated, ideally with a 180-degree angular parking configuration. 180-degree parking is adopted due to the insufficient width of the road. This will allow parking and movement of vehicles simultaneously. The size of this slot is:-

N= 84’
S= 84’
E= 11’
W= 11’

According to these dimensions, this area can be used to park 10 cars (5 cars on each side). The picture shown in Fig. 6 shows the parking layout.

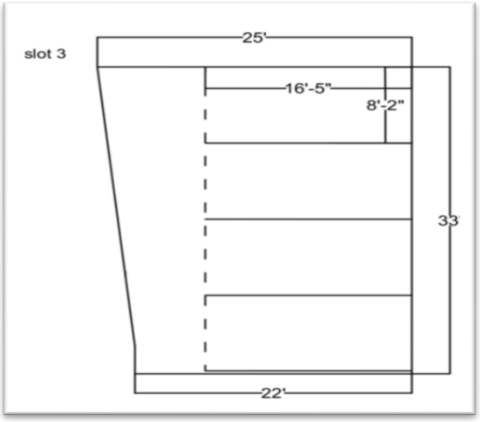

Figure: 5: 90^0 parking bays at Church Road

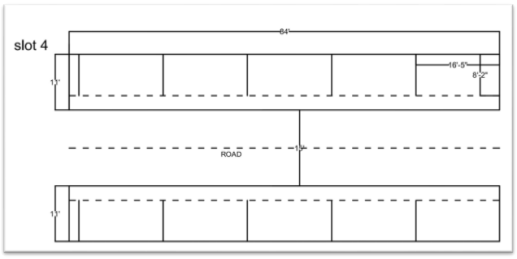

Figure 6::180^0 parking bays at Bazaza bazaar

Slot 5 parking (Old tanga stand)

This area is under the jurisdiction of the city council and could be enhanced to offer improved parking amenities. With ample space available, it's ideal for accommodating both four-wheeler and two-wheeler parking. Recommending it for off-street parking is prudent. An automated underground parking system would be the most suitable solution for maximizing parking capacity and efficiency in this location. The size of this slot is:-

N= 115’
S= 115’
E= 50’
W= 50’

This lot can meet the parking requirement of 14 cars. The parking area is shown in Figure 7and the parking layout is demonstrated in Figure 8.

In these five parking lots, a total of 40 car bays are available for parking. However, these lots fall short of meeting the parking demand. Based on this calculation, it is evident that additional parking spaces are needed to fulfill the requirement.

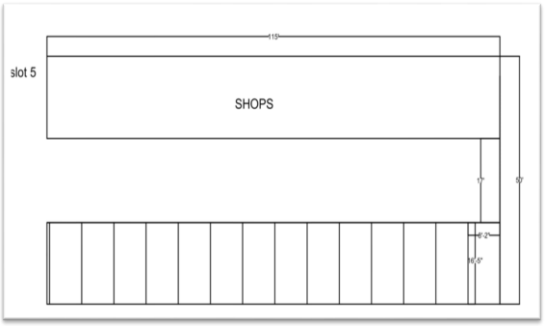

Figure 7: 90^0 parking bays layout at Old Tanga Stand

4.4. Parking Accumulation and Occupancy

From an IN-OUT survey conducted in the parking area, which consists of 40 bays, the initial count recorded was 27 vehicles. This initial count was for the vehicles which were already parked in the parking lots. These vehicles were of shopkeepers and shop workers. The total accumulation is determined by adding the parking demand to the initially counted vehicles within a specific time interval. Parking occupancy refers to this formula:

$$\textbf{Parking occupancy} = \frac{Parking\ demand}{Parking\ capacity} X100$$

From this formula, the occupancy is shown in Table 8.

Table 8: Ghanta Ghar and Hope Circus Parking Survey

TIME (HOUR)	Ghanta Ghar and Hope Circus		
	Parking Demand	Accumulation	Occupancy (%)
10:00AM-11:00AM	80	107	267.5
11:00AM-12:00PM	94	121	302.5
12:00PM-13:00PM	73	100	250
13:00PM-14:00PM	57	84	210
14:00PM-15:00PM	35	62	155
15:00PM-16:00PM	39	66	165
16:00PM-17:00PM	66	93	232.5
17:00PM-18:00PM	77	104	260
18:00PM-19:00PM	72	99	247.5
19:00PM-20:00PM	15	42	105
20:00PM-21:00PM	10	37	92.5
21:00PM-22:00PM	5	32	80
TOTAL	623	947/12=78.91	2367.5/12= 197.29%

From the above calculation, a graph was drawn to determine the peak hour occupancy. This graph is shown in Fig. 4.10. This graph shows the highest occupancy at 11:00 A.M. to 12:00 A.M. and 17:00 P.M. to 18:00 P.M. From the above graph, it can be observed that the parking occupancy gradually increased from 10 A.M. to 12 P.M. The parking demand is on the lower side from 01:00 P.M. to 04:00 P.M. but it is still above the parking capacity. The demand again increases in the evening time from 04:00 P.M. to 07:00 P.M. As the people from nearby towns and villages visit this marketplace for shopping purposes, they arrive at the market at day time and depart from the market at the evening time. Hence, the occupancy of the market area is highest at these periods. Apart from this, major office timings are also scheduled between these time slots, they also contribute to more traffic density and parking occupancy in this area.

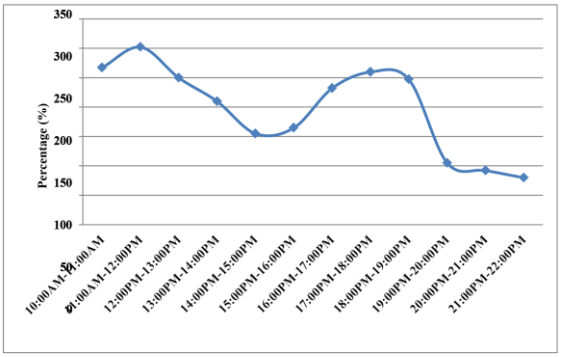

Figure 8: Parking occupancy at Ghanta Ghar and Hope Circus

4.5. Parking Space Inventory

This refers to the development of new spaces to meet the demand for parking in the study area. Since the market area can accommodate only 40 ECU, but the demand is to accommodate 121 ECU, there is a need to develop a new parking facility to provide parking facilities to the other vehicles. In this study, a new area is identified near the marketplace. This place is named as Company Garden, which comes under the jurisdiction of the Alwar UIT (Urban Improvement Trust). A portion of this place can be used to develop the paid parking facility. A 188' X 155' garden area, allowing 45° angular parking, can be developed with a capacity of 164 vehicles, which can fulfill the present and future demands of the marketplace. The company garden has very good connectivity with the marketplace. E-rickshaws can be used as a mode of connectivity to the marketplace. This parking area can also act as a sole parking space and the parking can be restricted in the marketplace. The design of the parking lot in the Company garden is shown in Figure 9. Due to parking in the company garden, there will be a reduction in the movement of vehicles coming and going from Church Road. Vehicles going to Hope Circus can also park their vehicles in the Company garden. An e-rickshaw facility can be provided to move people from the parking area to the market area.

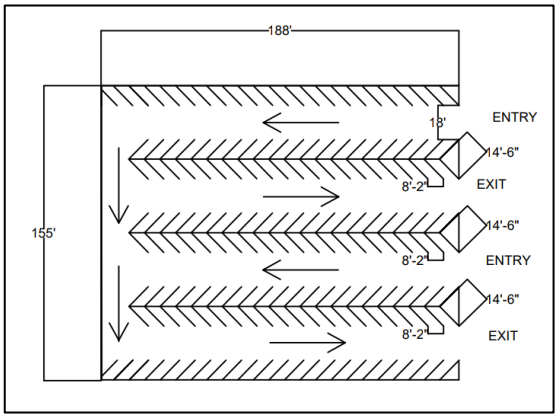

Figure 9: Company Garden parking layout

3. CONCLUSIONS & RECOMMENDATIONS

The following conclusions were drawn from this study:

- The average parking occupancy at Ghanta Ghar and Hope Circus for 4-wheelers was found to be 197.29%, indicating insufficient parking space.
- Peak occupancy reached 302.5% between 11:00 AM and 12:00 PM, with a demand of 94 vehicles. In contrast, off-peak hours (9:00 PM - 10:00 PM) saw an 80% occupancy rate.
- A second peak (260%) occurred from 5:00 PM to 6:00 PM, with a demand of 77 vehicles.
- The study highlighted that parking challenges are influenced by individuals' behaviors, income, and living standards, impacting parking characteristics in the area.
- Parking bay markings were poorly visible, and better marking is recommended to maximize space utilization.
- Illegal on-road parking was observed, causing congestion. It is advised to deploy traffic police and implement paid parking.
- Current parking facilities and congestion do not meet standards.
- A 600' x 244' area in the Company Garden can accommodate 776 bays, addressing the parking shortfall, as only 40 bays currently serve a demand of 623 vehicles.
- Effective parking management through better communication, law enforcement, and signage is essential for improving both on-street and off-street parking.

Parking plays a vital role in ensuring the efficiency of the road network and accessibility to different land uses in the market area. However, inadequate or improper management of parking spaces and ineffective law enforcement. Such behaviour causes the above- mentioned traffic problems. The study area should adopt tactics like clear communication, parking regulation enforcement, operational streamlining, and installation of parking signs to enhance the management of both off-street and on-street parking.

4. REFERENCES

[1] Economic Times. *Strong sales growth for entry-level two-wheelers in H2 of FY24; big relief for automakers*. Economic Times. Retrieved from https://www.economictimes.indiatimes.com

[2] **The Hindu Business Line.** Indian automobile industry records 12.5% growth in FY24. *The Hindu BusinessLine*. https://www.thehindubusinessline.com

[3] IRC SP:12-2015, "Guidelines for parking facilities in Urban Roads", Indian Road Congress, New Delhi.

[4] Central Pollution Control Board. (n.d.). *Action plan on Non-Attainment City – Alwar*. https://www.cpcb.nic.in/Actionplan/Alwar.pdf

[5] Wikipedia. (n.d.). *Alwar*. https://en.wikipedia.org/wiki/Alwar

[6] Transport Department, Government of Rajasthan. *Comparative chart of road, vehicle & population*. https://www.tourism.rajasthan.gov.in/content/dam/transport/transport-dept/pdf/statistical2016-17/2.1.pdf

[7] Basri Said, L., & Syafey, I. (2021). The scenario of reducing congestion and resolving parking issues in Makassar City, Indonesia. Case Studies on Transport Policy, 9 (4), 1849–1859.

[8] Parmar, J., Das, P., & Dave, S. M. (2020). Study on demand and characteristics of parking system in urban areas: A review. *Journal of Traffic and Transportation Engineering (English Edition)*, *7*(1), 111-124.

[9] Biswas, S., Chandra, S., & Ghosh, I. (2017). Effects of on-street parking in urban context: A critical review. *Transportation in developing economies*, *3*, 1-14.

[10] Chen, J., & Zhang, H. (2011). Coordinated Layout Programming of Urban On-Street and Off-Street Parking Facilities. In *ICCTP 2011: Towards Sustainable Transportation Systems* (pp. 337-345).

[11] Chowdhury, I. R. (2016). Scenario of on street parking demand: A case study of Kolkata City, India. *Research Journal of Recent Sciences, E-ISSN*, *2277*, 2502.

[12] Arjun, C. A., & Nagakumar, M. S. (2014). Studies on on-street parking using license plate method in Basavangudi Bangalore. *International Journal of Emerging Technologies and Engineering*, 72-84.

[13] Aliedani, A., Loke, S. W., Desai, A., & Desai, P. (2016, September). Investigating vehicle-to-vehicle communication for cooperative car parking: The copark approach. In *2016 IEEE international smart cities conference (ISC2)* (pp. 1-8). IEEE.

[14] Boro, D., & Goswami, A. (2015). Impact of On Street Parking on Traffic Flow Characteristics. *Journal of Civil Engineering and Environmental Technology (JCEET)*, *2*(7), 555-559.

[15] Stark, J., & Klementschitz, R. (2008). Off-street parking regulations for shopping facilities: Potential impacts and scope of implementation. *Journal of urban planning and development*, *134*(4), 173-179.

[16] Yousif, S. (1999). A study into on-street parking: Effects on traffic congestion. *Traffic Engineering and Control*, *40*, 424-427.

[17] *IRC SP19: 2001 Manual for Survey, Investigation and Preparation of Road Projects*. Indian Roads Congress.

[18] *IRC SP012: 2015 Guidelines for Parking Facilities in Urban Roads (First Revision)*. Indian Roads Congress.