

# A Study of Open Air and Underground Parking Lot in Commercial Buildings of Greater Noida, India.

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**Abstract** - In a commercial building, the need for a parking lot is of utmost importance, and the priority in its design gives a phenomenal impact on the growth of the commercial activities. However, most of the commercial buildings with parking lot problems experience a downfall in the business which affect the tenants and the landlord income. This paper aims to study the comparison between the open-air parking lot and underground parking lot in terms of the efficiency and flexibility of use in commercial buildings of Greater Noida. The paper argues that the underground parking lot is not well, efficient and flexible like an open-air parking lot; which is ascertained through the relevant works of literature and public perceptions survey. This research employs thorough reconnaissance of the four landmark commercial buildings in Greater Noida (Grand Venice, Ansal Plaza, Krishna Tower, and Sunrise Tower) chosen from judgmental sampling, to gauge the efficiency and comfortability of these parking types in an attempt to obtain a robust and reliable result. One-hundred and twenty-four questionnaires were distributed equally across the identified buildings to collect the public perceptions between open-air and underground parking lot concerning the efficiency and flexibility of usage. Findings reveal that open-air parking lot is more comfortable, efficient, and more flexible in space usage, it gives direct entry and exit without difficulty based on the respondents result.

**Keywords:** Parking Space, Underground Parking lot, Open Parking lot, Commercial Buildings in India.

## 1.0 INTRODUCTION

Parking lot design focuses to significantly accommodate a reasonable number of cars within the space provided, this aids to control the flow of the traffic and proper utilization of the open spaces about the social and ecological condition of the immediate environment, [1]. The parking lot is among the keys aspect of commercial buildings in urban

and suburban areas, although some architects and other allied professionals underrate the impact of the parking lot in commercial buildings. However, customers always look for parking spaces that are flexible enough and closer to the building to access and exit without any difficulty, and it is understood that those spaces wanted by the shoppers are utilized for other purposes, [2]. The underground parking lot provides a perennial gain to the development of the project; it is deemed to improve the surrounding atmosphere, enhance the safety of the vehicles and maximize the effective use of the open spaces in urban areas, [3]. The fundamental concept of the parking lot is pivoted on the drivers' way of parking, and superlative design parking which is done with prime parking access elaborated signage, and information distribution, [4]. Car parking guide in Greater Noida is regulated by Greater Noida industrial development authority (GNIDA); all areas that are within the territory of Greater Noida are under the control of these norms. GNIDA provides all the requirements and the guide of any parking lot type such as multi-story, basement (underground), and open-air parking lots with the minimum and maximum requirements of width, length, driveways, entrance, and exit, etc. [5]. Commercial building's parking lot faces challenges and pressure of the space devoted to parking primarily at the peak time of the shoppers; this makes other spaces vulnerable for use as parking informally, as well as shared parking within the same premises. As the city grows, the density increases and the rate of space used for parking in commercial buildings also increases, these cause forceful disintegration of public spaces, to maximize the spaces available and improve the flow of activities and the ecological sense of the city, [6].

## 1.1 GENESIS OF THE STUDY

The evolutionary idea of the present Noida came up in 1972 when the Government of Uttar Pradesh realized the dissemination of land in the region. There was a lot of pressure and the massive increase in population density of Delhi NCT because of the urban opportunities present, due to that, some population relocated to the nearby Delhi NCR like Greater Noida, Ghaziabad, and Faridabad, etc. to reduce the density of the city fabric and improve the development of the new city. (See fig. 1). However, the population density creates a downfall in the developing character of the city. The master plan of Noida 2031 vision reveals some temporal ideas that contribute to the conducive and livelihood of the inhabitants. They include: the achievement of diversified opportunities in Noida, Greater Noida, and their surroundings, support future development, and improve more employment through institutional, commercial, and office development. [7]. Therefore, the sense of development possessed by this developing city, especially on the phase of commercial activities remains untampered due to the progressive influx of residents and workers. [8]. Taking off the above analysis of Greater Noida, it brought an idea of a comparative analysis between the underground parking lot and open-air parking to ascertain their impact on the commercial context of this region. This will provide a helping hand to the professionals and the clients to have a clear insight into the preparable parking type while designing a commercial development.

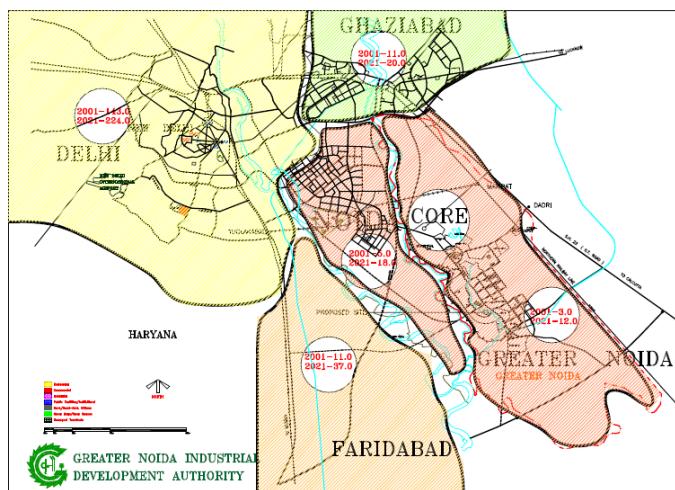


Figure 1. Regional Setting Map. [9]

## 1.2 OPEN-AIR PARKING LOT

Open-air parking lot serving commercial buildings could be regarded as one parking area, because of its free from demarcations and different accesses and exits spread around the parking area to improve and maintain the

traffic flux within the staunch spaces. Even in some parking spaces that are alphabetically labelled, the scenario of naming goes the same; it gives an easy hint for the parking lot users to locate their vehicles especially in a crowded parking zone as well as signage for U-turn, exits, entrance, etc. [10]. The open-air parking lot does not buttress enclave; the spaces provided a stand for a finite time located on an open-air space covering a reasonable amount of space. Furthermore, this system of parking gives vulnerability to further research as there are still some lacuna and void that need to be covered to improve the entire system and maximize the outdoor open spaces for other functions. [11].

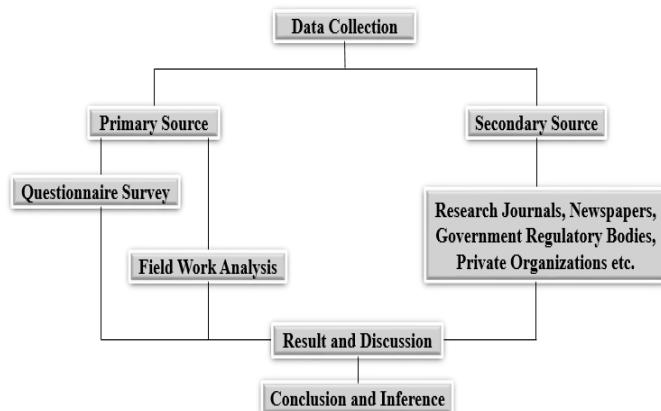
## 1.3 UNDERGROUND PARKING LOT

The underground parking lot is planned below the ground level of the building structure, or at the separate non constructed area, this kind of parking lot is more exorbitant than the open air, and it has some awkwardness in its operation and function about some building services. The modern underground parking lot is designed with an approximate capacity of 250-300, which spans up to 7 floors below the ground level and the shape comes from either circle or rectangle depending on the design and the space availability, [12]. The development of the underground parking lot determined the continuity of public space or an urban space, although to maintain a comfortable environment in this respect, it requires a lot of energy and special equipment for regular maintenance. Moreover, it is identified that most public buildings in urban areas are facing the issue of the parking lot, which is why underground parking lot adaptation remains mandatory. [13].

## 1.4 METHODOLOGY

Purposive sampling was employed for this research in selecting the buildings to study, the four landmark commercial buildings were identified in Greater Noida that use open-air and underground parking lots for proper comparative study. The plan to have reliable data from the selected buildings remain the prime priority; this research employs an in-depth assessment of the parking lots in the study area coupled with the public perceptions survey results obtained from the administered questionnaire. A comprehensive questionnaire was designed for this research to collect the public perceptions; it entails section one, which collects the details of the respondent (age, gender, and driving experience). The second section asks about the parking lot problems encountered, the easiest and flexible, and the safest between open-air and underground. One-hundred and twenty-four

questionnaire were distributed equally across the four selected commercial buildings in Greater Noida, and the responses from the respondents were analyzed in Microsoft Excel and SPSS software for the comparative analysis between open-air and underground parking lot. The inferences obtained from the analysis were represented in tabular form (see table 6, 7, and 8) and graphically (See fig. 19) for proper comprehension of the findings.



## 2.0 CONCEPTUAL FRAMEWORK

The Literature review of the parameters listed below was based on the relevant works of the scholars and researchers on this topic. They include research articles, journals, government regulatory bodies, etc. The analysis of the parking lot was done with the aid of the above data, and the inferences from them lead to the pinpointing of the vital result through which this study is bonded.

### 2.1 Planning of Parking Lot

A parking lot is a tedious approach made up of enough planning component and their interconnectedness; it is of utmost importance to consider the parking lot regulations and regularities to meet up the demand that brings out a phenomenal delivery. Taking cognizance of the area, the space, and the degree of stochasticity, different routes as well as circumnavigating spaces for flexibility and anticipation in the entrance and exit within, the number of vehicles expected with their approximate dimensions are equally considered concerning the planning area. [14]. Parking lot design needs in-depth analysis to align with the behaviour and the demand of the users. Indian cities are lagged in recognizing the core impact of high motorization; this uses the parking lot planning approach to meet up their need for personal motorized travel. The MOUD looks forward to providing protective guideline tools to surpass the efficiency of the parking lot practices status quo. Planning urban parking policies requires an exquisite equilibrium of the city focus and goal to be achieved, to design and control convenient and effective parking lot.

The description of different parking zone both at the central business district and the residential areas concerning their high demand of parking lot at the peak point is of utmost importance. Inventory of the existing areas which comprises all the parking patterns, recognizes the need for parking in each zone. [15]. The increasing number of privately owned vehicles needs to be controlled, as it contributes to creating the pressure of parking space in the affected zone. People do park their vehicles anyhow on the roadside, footpath, and other spaces not devoted to parking.

It should be noted that car uses three different parking lot which is the owner's residence, office, and recreational or commercial facility, the belief that says the provision of parking is the solution to parking problem should be wiped from people's minds. However, rather appropriate policies and control of the cars should be adequately adopted. [16]. Parking lot guidance system is shared among drivers to help educate them on the specific number of vehicles needed to be parked in a spot. However, the information given can even gauge the parking space status of a user positioned in the parking area with the aid of electronic maps and signage for smooth flow and understanding of the system. [17]

### 2.2 Parking Lot Planning Problem

Parking lot in urban areas is affected by the progressive influx of the people which happens to increase the density of the city fabrics and catalysis the pressure of traffic jams. This scenario raised the alarm of various parking lot pressure within the city, which blocks the flow of the road network, causing many dilemmas to the community. The implication of the parking lot problem does not stop only on public and city comfort amenities but also affects the commercial flow of the city especially in urban areas where good parking spaces integration triggers the sales of the product in a commercial building. In most of the developing cities, about 90% of parking lot facility is own by the state, 9% goes to private organization and partnership, and 1% is own by the social forces. [18]. The issue of hold-up and difficulties in the traffic flow has forced people with vehicles to be time selective on when to travel mostly around the central business district. Parking lot in this respect happens to be among the causative agent of his problem, which lead to the need for improving the number of parking lot to reduce this pressure. It is noted that land in the CBD areas land is costly and due to this reason, most of the developers do not incorporate an efficient number of the parking lot in urban planning and cities as well. Vehicles' consideration is part of the relevant aspect to be given the needed justice in planning their ignorance causes many issues in the success of any city. [19]. In most of the cities and communities, assessment of parking lot problem is one of the leading aspects that is considered to be improved in

an attempt to push the city development forward. The impact of mixed-use spaces with a convenient parking lot is recognized especially in retail in most communities aiming to develop, the need for parking in a mixed-use building varies significantly with the expected number of shoppers and staffs depending on the location of the facility. In some instances sidelining the conventional vehicles in designing a parking lot creates another challenge, the inflexibility of the provided parking area gives the problem of redesigning which might include additional spaces to make it universal and accommodate everybody. Moreover, in this case, resources are wasted, which could have been used for further development. [20]. Car parking lot problem is a significant cause traffic hold up and has been the scratching issue affecting the flow of vehicles both in small communities and urban cities. [21].

### 2.3 Patterns of Parking Lot

The design of parking space is vital for a sound system, lack of a parking lot in any facility is detrimental, and it will be a disorderly condition for everyone. The design of the parking lot happens to be a difficult task which constitutes the incorporation of different determinants that needs to be comprehensively integrated while designing. The parking lot pattern is categorized into (a) On-street parking lot and (b) Off-street parking lot, their design and analysis take a dynamic phase to achieve a convenient flow of parking activity. [22].

**i. On-street parking lot:** Vehicles require a parking space to park, lack of a proper parking lot mostly in commercial areas or central business districts affects the traffic flow of the area which makes the place vulnerable to accidents and other unwanted happenings. Parking of vehicles on the road body disrupts the accessibility of the road, and this is caused due to inadequate provision of parking lot requirements to accommodate the expected number of cars. It is therefore imperative to consider the volume, efficiency, and duration to avoid on-street parking and enhance the effectiveness of the recommended space. [23]. Well-planned on-street parking gives clear access for the traffic flow without any hindrance; this parking type in some instances is considered to be advantageous to the local business (See fig. 1). Today most of the on-street parking lot are not formally approved spaces, the unavailability and the cost of land make the developers not to give parking lot the needed priority resulting in on-street parking. This poses the life of pedestrians in danger as their spaces are occupied by vehicles (See fig. 2).



Figure 2. Semi-formal on-street parking zone [24]



Figure 3. Parking on the pedestrian walkway [24]

**ii. Off-Street Parking Lot:** The majority of the off-street parking requirement focuses on capacity giving less concern to the quality of the parking lot. This type of parking stresses more on the ratio of parking space to floor area for quantity determining structure, regardless of the repercussions that might come up from urban design. Parking lot tend to intersperse the streetscape. Off-street parking happens to intercede the quality delivery of architecture by limiting the design freedom to architects and designers. [25]. Off-street parking in a small or a large city environment provides a reasonable number of parking spaces used by the public. It could be a basement parking, open surface parking, etc. (See fig. 3 & 4). In the sense of local authorities, the need for capital in the off-street parking design is the challenging part of this development, and the potential users are the general public, especially in commercial zones. [26].

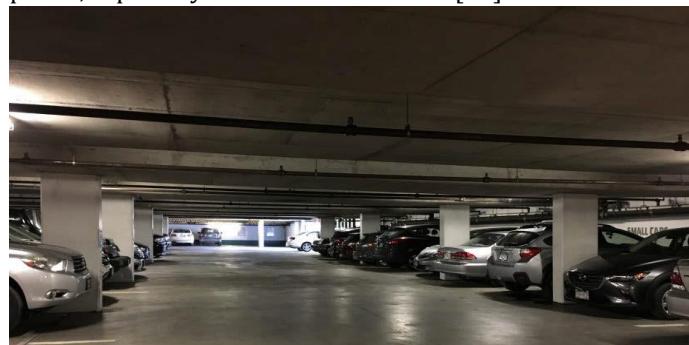


Figure 4. Underground parking lot [27]



Figure 5. Surface parking lot [28]

## 2.4 Importance of Parking Lot in Commercial Building

Professionals and other stakeholders need to increase the capacity of the parking layout to cater for the anticipated users. The parking lot is essential in a commercial building; it promotes the flow, reduction of the noise, pollution and also reduces the chance of criminal attack caused by the massive traffic jam. Each parking lot has varying ability; for example, in automated parking, it requires less construction cost and space than a conventional parking lot. However, each parking lot type has its impact on the safety of the roads, pedestrians, and the area itself—a conventional parking lot. Construction of parking facilities like underground parking has an incredible cost-benefit and efficiency than an automated parking lot in commercial buildings (See table 1).

Table. 1 Construction of cost comparison between the conventional & automated parking lot [29]

Configuration	Type	Unit Cost/SF	Efficiency SF/Stall	Building Cost per Stall	Automated Machinery Cost, \$/Stall	Total Cost per Stall
Stand-alone, Above Grade	Conventional	\$50	320	\$16,000	\$0	\$16,000
	Automated	\$45	225	\$10,125	\$16,000	\$26,125
Below building, above grade	Conventional	\$75	450	\$33,750	\$0	\$33,750
	Automated	\$65	225	\$14,625	\$16,000	\$30,625
Below building, below grade	Conventional	\$105	450	\$47,250	\$0	\$47,250
	Automated	\$85	225	\$19,125	\$16,000	\$35,125

Effective control in the parking lot design is equally vital especially when there is an involvement of the legal municipalities, the enacted rules and policies are duly followed, they substantially create centre-piece that gives a dynamic approach to the system. [30].

## 3.0 EVALUATION OF THE BUILDINGS

The four elegant commercial buildings are identified in Greater Noida with an underground and open-air parking lot for proper analysis. (See fig. 6). Grand Venice Mall and Ansal plaza mall use underground parking lot while Krishna Tower and Sunrise Tower use the open-air parking lot in their respective building designs. They are located along the commercial belt in Greater Noida, making them vulnerable to the progressive movement of vehicles creating much pressure of space used for a parking lot in this region.



Figure 6. Satellite image of the building's location in Greater Noida.

### 3.1 Grand Venice

This is a landmark project in Greater Noida with an outstanding business standard in providing a world-class product for the satisfaction of its customers. (See fig. 7). The mall is built over 11 acres of land with an approximate built-up area of 3,000,000 square feet on the land. There is also functional planning of the retail spaces which cover around 1,200,000 square feet of land with entertainment and aquarium inclusive covering precisely 100,000 square feet of area with 22 tank. Due to the magnitude of the project, the Grand Venice mall offers a magnificent underground parking lot with a total capacity of 5000 cars. [31]. The parking lot is arranged in an orderly manner to give a comprehensive view and easy accessibility. (See fig. 9).



Figure 7. Grand Venice mall Greater Noida. (Source: Fieldwork, 2020).



Figure 8. Satellite image of Grand Venice mall Pari Chowk.



Figure 9. Grand Venice Mall Underground Parking Lot. (Source: Fieldwork, 2020).

Table 2: Sizes and Quantities of Parking Lot in Grand Venice Mall Pari Chowk.

S/N	Name of Item	Figures
1	Number of Parking Lot	5000
2	Number of Stores & Services	258
3	Area of Parking Lot in Square meter	947,000
4	Estimated Number of Shoppers Daily	6000
5	Number of Floors	4

### 3.2 Ansal Plaza

This is another commercial building located at Pari Chowk in Greater Noida completed in 2009. (See fig. 10). The mall provides an internal and external aesthetic wonder of functional activities to attract more customers and potential tenants. Ansal Plaza Pari chowk is designed to redefine the shopping complex destination coupled with the entertainment centre to complement the desire of the entertainment enthusiast. However, this mall houses some vital amenities that improve the quality condition of the place as well as the commercial flow of the activities they include; Atrium, power back-up, food court, kid entertainment zone, sprawling Shopping arcade, parking spaces etc. [32]. This building possesses two separate basement parking lot LG and UG which accommodate a total of approximately 1100 cars of the staffs and shoppers altogether. (See fig. 12).

Table 3: Sizes and Quantities of Parking Lot in Ansal Plaza Pari Chowk.

S/N	Name of Item	Figures
1	Number of Parking Lot	1100
2	Number of Stores & Services	410
3	Area of Parking Lot in Square meter	13750
4	Estimated Number of Shoppers Daily	2500
5	Number of Floors	4



Figure 10. Ansal Plaza Pari Chowk (Source: Fieldwork, 2020)



Figure 13. Krishna Tower Alpha 1 (Source: Field Work, 2020)



Figure 11. Satellite image of Ansal Plaza Pari Chowk.



Figure 14. Side view of the Parking Lot (Source: Field Work, 2020)



Figure 12. Underground Parking Lot in Ansal Plaza Pari Chowk (Source: Field Work, 2020).



Figure 15. Satellite Image of Krishan Tower Alpha 1 Greater Noida

Table 4: Sizes and Quantities of Parking Lot in Krishna Tower Alpha 1 Pari Chowk.

S/N	Name of Item	Figures
1	Number of Parking Lot	52
2	Number of Stores & Services	42

3	Area of Parking Lot in Square meter	960
4	Estimated Number of Shoppers Daily	1470
5	Number of Floors	4

### 3.4 Sunrise Tower

This commercial complex is also located at Alpha commercial belt in Greater Noida, with a total number of eight floors housing a series of activities in it, (See fig. 16). The building uses an open parking lot for the staffs and shoppers which summed up to be forty-eight with a single entry and exit, (See fig. 17). The complete number of one-hundred and sixty-two shops with a progressive commercial happenings makes the complicated busy as well as increases the usability of the parking lot provided.



Figure 16. Sunrise Tower (Source: Field Work, 2020)



Figure 17. Rear View of the Parking Lot (Source: Field Work, 2020)



Figure 18. Satellite Image of Sunrise Tower Alpha 1 Greater Noida.

Table 5: Sizes and Quantities of Parking Lot in Sunrise Tower Alpha 1 Pari Chowk.

S/N	Name of Item	Figures
1	Number of Parking Lot	48
2	Number of Stores & Services	168
3	Area of Parking Lot in Square meter	1620
4	Estimated Number of Shoppers Daily	2520
5	Number of Floors	8

## 4.0 RESULT AND DISCUSSION

### 4.1 Summary of the Results

From the fieldwork analysis of the case studies identified in Greater Noida and their delineation of the parking lot capacity, sizes, the number of building's floors as well as the number of shops in each building is recorded. (See table 6).

Table 6: Cumulative Sizes and Quantities of the Parking Lot in the selected buildings.

<b><i>Underground Parking Lot</i></b>					
Selected Building s	No of Parkin g Lot	No of Shop s	Parkin g Lot Area (m <sup>2</sup> )	Est. No of Shopper s	No of Floor s
<b>Underground Parking Lot</b>					
1. Grand Venice Mall	5000	258	94700 0	6000	4
2. Ansal Plaza Mall	1100	410	13750	2500	4

<b>Open Air Parking Lot</b>						
1.	Krishna Tower	52	42	960	1470	4
2.	Sunrise Tower	48	168	1620	2520	8

From table 6 above, buildings with underground parking lot like Grand Venice mall has 5000 total number of parking lots for 258 shops; however, Ansal Plaza owned 1100 and 410 total number of the parking lot and shops respectively. Likewise, in the buildings with an open-air parking lot, Krishna Tower possessed a total number of 52 parking lots for 42 number of shops and Sunrise Tower provides 48 number of parking lots for 168 shops which happen to exceed the number of parking lot significantly. Therefore, it could be inferred that an in-depth thought of efficiency was not given in the design of the open-air parking lot to accommodate the number of shoppers' vehicles.

#### 4.2 Public Perceptions Result

After the buildings reconnaissance and the collection of the primary data. The public perceptions were captured through the medium of a questionnaire distributed across the four selected buildings in Greater Noida. The questionnaire collected information about the respondents' gender, age and driving experience to have a comparative result across the varying set of people. Taking the overall responses, 85.5% of males responded to the questions and 14.5% females.

The percentages of the respondents with driving experience are 35.3%, 39.5%, and 22.7% with a year of experience between 1-5, 5-10, and 10 to above respectively, only 2.5% reveals no driving experience which means they do not drive. Based on this, it is recorded that the respondents with the years of experience between 5-10 responded the most to this questionnaire with 39.5% giving a clear picture of the type of people's response this paper is dealing with for certainty and reliability.

Table 7: Public Response to the problems encountered in Open Air and Underground Parking Lots

Selected Buildings	Yes (%)	No (%)	Partially (%)
<b>Underground Parking Lot</b>			
1. Grand Venice Mall	37	29	34
2. Ansal Plaza Mall	21	21	58
<b>Open Air Parking Lot</b>			

1. Krishna Tower	21	47	32
2. Sunrise Tower	15	23	63

The table above shows the public response on the problems encountered in each building both the open air and underground parking lot. In Grand Venice mall, 37% of the respondents declared Yes, and 29% said No problem while 34% partially have issues. However, 21% of the respondents reveal Yes and No, while 58% partially face problems in Ansal Plaza. In the open-air parking lot, 21% of the respondents' encountered problems and 47% of them declared no issues while 32% partially face problems in Krishna Tower. Lastly, in Sunrise Tower, 15% of respondents experience the parking problem, and 23% confront no parking issue while 63% partially come across problems of parking in this building.

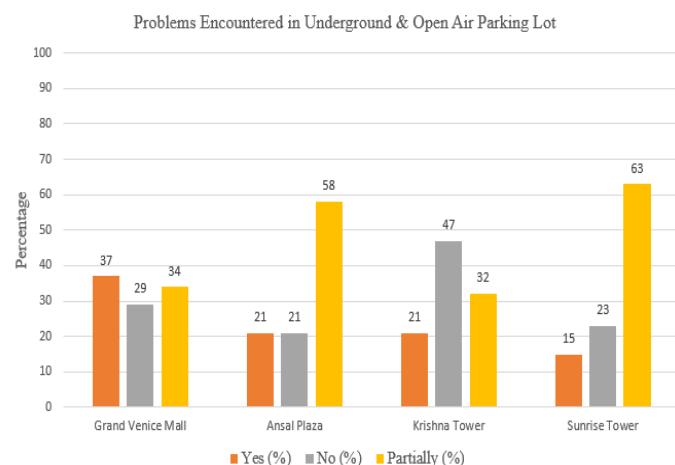


Figure 19. Result of the Problems Encountered in Underground and Open-Air Parking Lot According to the Respondents.

Taking the analysis of the four sets of data (See fig. 19), Grand Venice mall and Ansal Plaza mall are the two selected underground parking lot, while Krishna and Sunrise Tower are the open-air parking lot. The bar chart reveals that respondents face a problem in the underground parking lot as seen from the two selected buildings above. However, the graph gives a clear picture that the open-air parking lot does not give users problems according to the respondents.

Table 8: Respondents Feedback on Parking Lot Flexibility of use across the Selected Buildings

Questions	O.A Parking Lot (%)	U.G Parking Lot (%)	None of the Above (%)	All of the Above (%)
Efficient				

circulation area, turning radius, and space between each parking lot is effectively provided in?	56.90	36.60	4.10	2.40
Which parking lot do you find more secure for the safety of your vehicle?	30.90	65.90	2.40	0.80
Which parking lot do you think is more preferable in a commercial building?	43.10	52.80	2.40	1.60
The parking lot that gives exact entry and exit with or without signage are?	49.60	46.30	2.40	1.60
In the case of emergency, which parking lot will be easy for the vehicles to be evacuated?	52.00	43.90	2.40	1.60

Table 8 above shows that circulation spaces are efficiently defined in the open-air parking lot, and the safety of vehicles among the parking lot types is more emphasized in the underground parking lot. Furthermore, a parking lot that is more functionally flexible in commercial buildings is underground parking according to the public perception responses. However, a parking lot that gives exact entry and exit, as well as the ease of vehicles evacuation in case of emergency, is open-air parking lot based on the respondent's result.

## 5.0 CONCLUSION

Today the impact of parking space in commercial buildings has a direct effect on the sales and the commercial flow of that region accordingly. However, the functional design of parking lot is the key to the efficiency, flexibility, and the safety of vehicles for the users. Taking the Results conclusively, it is inferred that open-air parking lot is more circulatory efficient concerning the turning radius, space

margin between each vehicle, and the easy flow of the vehicles for entry and exit. Similarly, in the case of the emergency, open-air parking lot is more comfortable for the vehicles to be evacuated than underground parking lot according to the respondents. Therefore, considering all the results obtained in this research, the future of successful parking lot in commercial buildings is lying toward the open-air parking lot. However, commercial buildings in Greater Noida employ the use of different parking lot types including open-air and underground parking lot to accommodate customers for convenient drive-in and out, as part of this research's contribution to academia, building professionals and stakeholders. It gives an insight of how people in Greater Noida perceive open-air and underground parking lot, and from the findings obtained it shows that open-air parking lot is more comfortable, efficient, and flexible than underground parking lot based on the public perception responses collected from the four selected case studies in Greater Noida.

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