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## Development of Residential Parking Regulations for Navi Mumbai

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### Abstract

Building bye-laws play an important role in residential parking management. Navi Mumbai is one of the largest planned cities in India and it is also the satellite city to the financial capital of India, Mumbai. Due to the rapid development and lack of adequate parking norms, Navi Mumbai is facing a transportation crisis regarding parking management. Hence, the main objective of this study is to recommend new parking norms considering current and future vehicle ownership. It was found that the existing parking norms were devised in 1994 and they are not adequate for current vehicle ownership. The result of scientific residential parking demand survey shows that only approximately 40 % of vehicles have residential parking space available. This is paper recommends parking requirements based on plot area rather than carpet area. The recommended option- II gives flexibility to developers as parking requirement is in common unit called Equivalent Car Space (ECS).

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### 1. Introduction

Cities are the centers of dense habitation and high concentration of economic activities. The complex social interaction and economic activities pertaining to the vitality of the cities are supported by the transportation system. Hence the efficiency of the transportation infrastructure and management are crucial to the proper functioning of any city. However, often such a complex system faces a supply-demand imbalance when the ever-increasing demand cannot be met due to a variety of reasons. One of the major problems associated with the current transportation

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scenario, which is often overlooked, is that of parking. ‘Building bye-laws’ implemented by local or state government manages the infrastructure development and parking provisions. These ‘bye-laws’ varies across municipalities and cities. However, the scientific backgrounds on which these provisions are laid are often questioned. In most of the cases, these provisions are generally imbibed or partially adopted from other municipalities of different city or cities. As a matter of fact, the provisions laid down in the municipal guidelines regarding parking are often argued upon. These provisions need to be updated by time to time due to a general rise in affluence and an increase in vehicle ownership. It must be kept in mind that either a too parsimonious or a too liberal parking space provision may prove to compound the existing transportation problems. Hence, the governing body, in deciding such critical regulations, must be careful and must undertake a scientific approach to have a sustainable solution to the parking problems. Thus, the focus of this study is to understand and analyze the residential parking requirements for different house types in Navi Mumbai through household survey and propose suitable parking requirement norms which can be implemented by Navi Mumbai Municipal Corporation in its jurisdiction.

Navi Mumbai is one of the largest planned cities in India. It is also considered as the satellite city to the financial capital of India, Mumbai. Due to the rapid development, Navi Mumbai is facing a transportation crisis regarding parking management. This is due to more and more private vehicles are finding their ways to the streets which pose a serious problem to the transport planners regarding parking management. Moreover, any vehicle in their lifetime spends the majority of the time parked than on the streets. Inadequate and inefficient parking leads to congestion along streets (as cars are parked unscientifically), pollution (as a vehicle spends more time searching for a parking space), accidents (due to improper parking) and safety issues (theft). Delving deeper into this problem reveals that the parking problems relating to residential parking are precarious, especially in a developing economy such as India. Though the country has witnessed high growth in private vehicles, parking norms of many Indian cities are based on older vehicle ownership patterns and did not consider the recent rapid growth.

### *1.1. Objectives of the Study*

The overall objectives of this study can be broken into three major points.

- To study residential parking provisions in other Indian cities and compare it with existing Navi Mumbai parking provisions
- To design and conduct a scientific survey for residential parking demand in the jurisdiction under Navi Mumbai Municipal Corporation (NMMC)
- Analyze parking requirement and parking space availability in the jurisdiction under NMMC
- Recommend new residential parking norms considering current and future growth in vehicle ownership

### *1.2. Demographics of Navi Mumbai*

Navi Mumbai—the largest planned city in India—is also considered as the satellite city to the financial capital of India, Mumbai. The city is spread over 108.6 sqkm and has seven jurisdiction nodes: Airoli, Ghansoli, Sanpada/Turbhe, Kopar Khairane, Vashi, Nerul and Belapur. It was planned to deflect the pressure from the city of Mumbai and to create an alternate development center in the Mumbai Metropolitan Region (MMR). From census data a sharp rise in the curve was observed since 1981 to the current decade. The population of the city increased from 6.91 lakh in 2001 to 11.19 lakh in 2011; the population estimate in 2017 is 14.69 lakh. The prediction (Revised City Development Plan 2012, Navi Mumbai) is that the population would be around 25 lakhs by 2031. Therefore, it is imperative that proper management of the land resource is implemented to sustain the population. The number of vehicles in 2010-11 was 2.31 lakh which increased to 4.25 lakh in 2016-17. From data, a constant increase in vehicular population in Navi Mumbai can be observed with the current number of vehicles in the road a little less than half a million. Such an increase in vehicles calls for continuous improvement or addition of infrastructure. Since the current focus of this study is on residential parking improvements, the focus is mainly given to the two-wheelers and four-wheelers vehicle population and growth. From the Environmental Status Report of NMMC (2017), one interesting observation is that the sale of cars has decreased in the last two years (2015 - 2017). This could be due to better public transportation and increased used taxi aggregators such as Uber and Ola. The City and Industrial Development Corporation (CIDCO) developed mainly affordable housing with reasonable facilities in Navi Mumbai. By the end of

2010, in Navi Mumbai, 93,485 household were developed by CIDCO. With the estimated population of 25 lakhs in 2031, it can be reasonably assumed that the housing stock requirement would cross 6 lakhs by 2031. The provision for parking spaces in a household is a vital aspect in the management and control of parking issues. The existing parking regulation of Navi Mumbai Municipal Corporation, which was devised in 1994, suggest following regulations. The parking related issues observed in the city (discussed in Section 2) clearly indicates that provisions made in Table 1 are not adequate and there a need to study the current parking demand and revise the parking space norms in residential buildings.

Table 1: Off Street residential parking regulations of NMMC

Sl. no	Land Use	One Parking space for every
1.	Residential	a) 4 tenements having carpet area up to 35 sq.mt each. b) 2 tenements with carpet area exceeding 35 sq.mt each. c) 1 tenement with built-up area exceeding 45 sq.mt. but not exceeding 60 sq.mt. each. d) ½ tenement with built-up area exceeding 60 sq.mt. In addition to the parking spaces specified in (a, b, c & d) above, parking shall be provided to the extent of 10 per cent of the number stipulated above, subject to a minimum of one.

## 2. Actual Parking Space Requirement & Current Residential Parking Issues in Navi Mumbai

This section talks about the requirement of parking space mainly for a car parking. It can be inferred that without fulfilling these requirements it is difficult to provide adequate parking. Moreover, this section also discusses about the various problems of Navi Mumbai city, which resulted in the critical paucity of parking spaces.

### 2.1. Residential Building Minimum Requirement for Parking Facility

To enter car inside residential area entry width needed is 3m. Therefore, for one parking facility, the minimum width of the plot along the access road should be calculated considering this minimum width, the passageway width, the appropriate setbacks (depending on the means of access) and other structural and functional considerations. For example, inadequate access width leads to insufficient space and turning radius for a car to manoeuvre and park within the residential plot; hence, providing a parking space at such residential plot is redundant. Some specific requirements are listed as below:

- Access road a dwelling unit should be at least 3 m wide
- If parking is to be provided perpendicular to the road ground level, the width of the building should be minimum of 5.1 m just to accommodate an entrance door; more than 6 m is needed to create a room adjacent to the parking space. The case wherein the parking bay is required to be parallel to the means of access requires greater consideration for sufficient manoeuvring space for the vehicle. Considering the length of the parking bay (5.0 m), the typical minimum width of column (0.3m) and typical passageway width (2.0 m), the typical minimum width of the plot required along the means of access is 7.3 m in addition to the offsets on either side. Length of the building needs to be more than 10 m to construct a small 1BHK dwelling unit. This results in a building area of more than 60 sqm. There are thousands of dwelling units in Navi Mumbai with a plot area of about 25 sqm (see Fig. 1).
- There is also need of space for turning radius when vehicles enter/exit a dwelling out from/to road.
- The space requirement is even more if parking is to be provided at basement level or first floor level. About 30 m length is needed to move a vehicle from one floor to another with a straight ram. A circular ramp requires about 12 m x 12 m space.

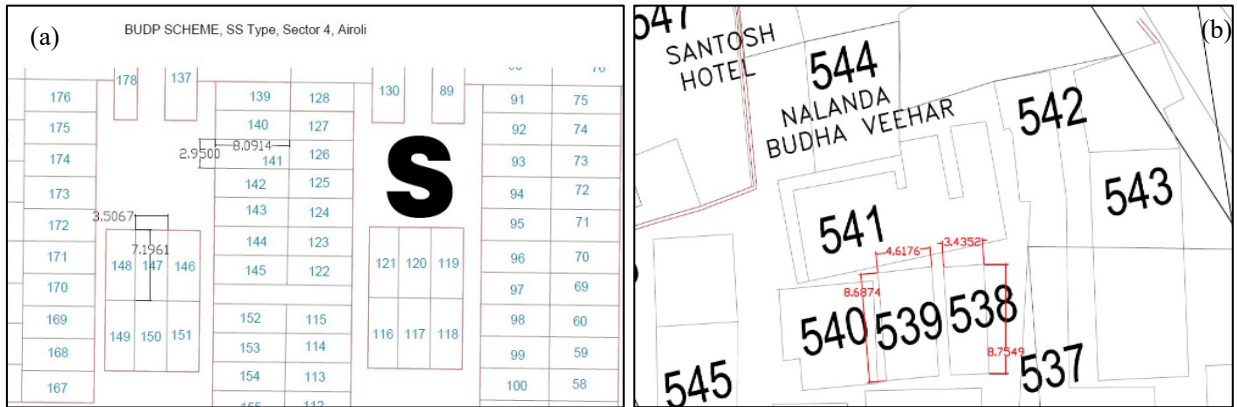


Fig. 1. (a) SS Type CIDCO housing plots in Navi Mumbai (Sector 4, Airoli) (b) Gaathan in Sector 29A, Ghansoli

## 2.2. Vehicular Access width

The issues related to residential parking are most of the times due to the unavailability of adequate means of access to the residential plots. Inadequate access width leads to insufficient space and turning radius for a car to maneuver and park within the residential plot. The mean of vehicular access inadequacy can be classified into two categories as follows.

- Vehicular Access width less than 3 m

In cases where the access width is less than 3 meters, there is no enough space for a typical car to access the plot. Therefore, there is no question of providing car parking spaces at such residential plots. In the case of Navi Mumbai, all of the nodes have vehicular access width less than 3 m. Fig. 2 shows the example for this type of houses.



Fig. 2. Houses with very less approach width (Location - (a) AL/H type, Sector 6, Airoli, (b) Diwale Gaathan Area (Belapur CBD))

- Vehicular access width greater than equal to 3 m but insufficient road space

Sometimes, the vehicular access width to the residential plot may be greater than 3 m. However, the space for proper maneuvering of cars is insufficient keeping in mind the offsets of the building, proper turning radius or space for other vehicles to maneuver. In such cases, even if a car is able to access the residential plot, providing a parking space for the same becomes problematic as it obstructs the smooth functioning of other movements. Fig. 3 shows the example for this type of problem.

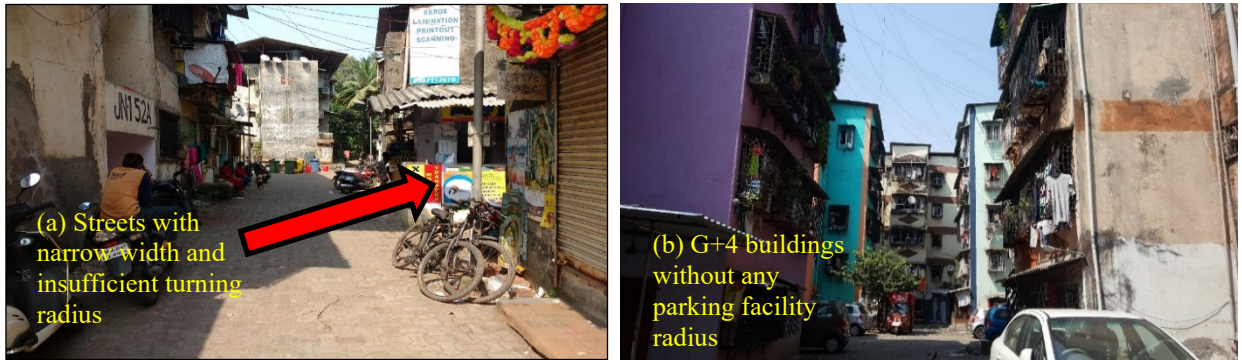


Fig. 3. Building with narrow parking space and without parking facility (a) JN-1, A Type in sector 9, Vashi; (b) Sector 4, B type, Belapur CBD)

The common problem observed in all nodes is unviability of open space and house or apartment construction without any provision of the parking facility. Houses in all nodes of Navi Mumbai are densely packed and constructed without any open spaces around the building or house, now it is very difficult to provide separate or common parking facility as free space is not available.

### 3. State-of-the-art policies Regarding Residential Parking in other Major Cities of India

Before recommending new regulations and policies, it is important to know and understand the state-of-the-art policies regarding the residential parking spaces that are adopted by various municipal corporations and development authorities in other regions of the country. The development control regulations laid down for the Mumbai Metropolitan Region (MMR) applies to the lands within the jurisdiction of Municipal Corporations in the Mumbai Metropolitan Region except Municipal Corporation of Greater Mumbai, Navi Mumbai and erstwhile areas of CIDCO included in Panvel Municipal Corporation. The residential parking policies are as under.

Table 2: Off Street residential parking regulations of MMR (2017)

Sl no.	Occupancy	Parking Space Requirement (in nos.)	Parking Space Requirement (in nos.)		
			Car	Scooter	Cycle
1	Plots more than 250 sqm.	For a Single Dwelling unit	2	2	2
2	Plots up to 250 sqm but more than 100 sqm	For a Single Dwelling unit	1	2	2
3	Plots less than = 100 sqm	For Single Dwelling unit	0	2	2
		For every tenement having carpet area above 80 sqm	2	2	2
4	Multi-Family	For every tenement having carpet area equal to or above 40 sqm. but less than 80 sqm.	1	2	2
		For every 2 tenements having carpet area up to 40 sqm.	1	2	2

Other than this, parking regulations of many major cities were studied, and major points can be summarised as follow:

- Municipal Corporation of Greater Mumbai (MCGM) in their recently developed DCR2034 mandated one parking space for four tenements of carpet area up to 45 sqm and for two tenement of carpet area between 45 to 60 sqm. The requirement is further reduced for projects under slum rehabilitation.
- Kolkata Municipal Corporation (year 2009) is among the agencies requiring least parking spaces. There is no parking needed for five tenements of floor area up to 50 sqm each. For a single dwelling unit, there is no need to provide parking for floor area up to 100 sqm.

- Chennai Metropolitan Development Authority's parking regulation (2013) suggest that 1 car space for every 2 dwelling units and 1 two-wheeler space for every dwelling unit having floor area between 50 to 75 sq. m. Only one two-wheeler space is needed for floor area between 25 to 50 sqm.
- Municipal Corporation of Delhi (MCD), the New Delhi Municipal Council (NDMC) as well as the Delhi Development Authority (DDA), governing various regions and districts of the national capital region do not differentiate between two-wheeler and car parking; they use Equivalent Car Space (ECS). For plotted houses 2 ECS for plots of 250 to 300 sqm.
- The residential parking regulations in Bangalore (2003) mandate one car for one dwelling unit of the area between 50 to 150 sq. m and dwelling units with an area less than 50 sqm. in multifamily buildings. No parking is needed in a single-family unit with an area less than 100 sqm
- Pune Municipal Corporation regulations (2016) require one car four two-wheelers and four bicycle parking spaces for every two tenements with each tenement having carpet area less than 40 sq.

In addition to these parking requirements, many regulations suggest the provision of 5% to 10 % visitor parking. It can be observed that Kolkata mandates least parking space requirement and Pune's recent norms mandate the highest parking spaces. Mumbai and Chennai are also lenient on parking requirements. Almost all cities require the least parking for smaller individual dwelling units. Although different cities in the country have different economies and land use-transportation nuances, this section mainly presents the state-of-the-art parking policies adopted by municipalities and development authorities in various cities. It must be kept in mind that providing insufficient residential parking causes several urban difficulties such as congestion, accidents and theft apart from inconveniencing the users; on the other hand, providing excessive residential parking spaces causes under-utilization of valuable land in a demanding and congested urban environment that may further cause resentment among builders and developers. Hence, a scientific survey is the need of the hour for deciding a reasonable parking recommendation for the region.

#### **4. Scientific Survey for Residential Parking Demand Analysis**

##### *4.1. Design of Questioner*

To analyze the prevailing parking related problems, it is imperative to understand the parking demand, the current socio-economic characteristics and sensitivities of the region. This can be achieved by designing and performing a scientific survey in the region concerned. A questionnaire was designed for the purpose of conducting a Revealed Preference (RP) survey at a household level. The survey aims to discern the parking requirements based on the household type and household socioeconomic characteristics. The questionnaire contains several sections; each section tries to capture information regarding a particular aspect that may be used to identify the factors influencing the parking requirements. The questions pertaining to each section are described below.

- Household related information
- Family Head personal and travel details
- Parking related information
- Apartment Building Details, if applicable
- Previous day trips information

The volunteers appointed by NMMC Corporation visited households filled the questionnaire in a paper format based on the information provided the household members. After assessing the completeness, 5447 questionnaire forms were selected for further analysis. The descriptive statistics from these samples are given in the following subsection. Following Fig. 7 shows the nodewise distribution of the collected sample.



#### 4.2. Descriptive Analysis of Survey

Descriptive statistics show the socioeconomic characteristics and sensitivities of the region which may influence the parking requirement. It helps to understand the sample collected from the survey. The questionnaire contains several sections, as discussed above. Based on the 5447 sample size, some descriptive statistics of the various questions asked are presented below.

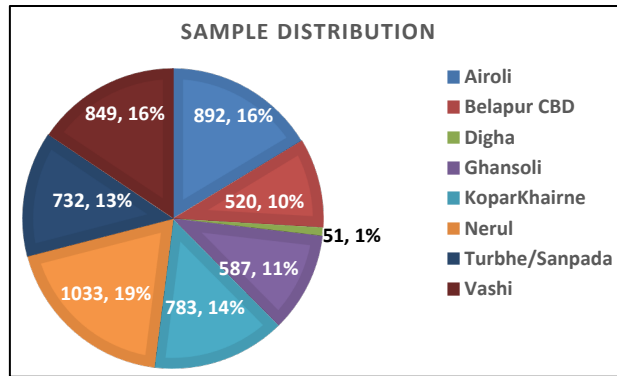


Fig. 4. Nodewise Distribution of Collected Sample

- **Dwelling type:** Classification of the sample has been done considering node, area type (developed by CIDCO or privately developed) and dwelling type (apartment, bungalow or single house) and can be inferred that CIDCO has constructed most of the single houses and row houses where private builders have constructed more apartment and bungalow. Out of total recorded samples, 57% samples were of the apartment, 41% samples were of a single house, and 2% of the sample has dwelling type as a bungalow.
- **Family Monthly Income:** 47.5% of the total sample households have monthly family income less than Rs.30,000 while 38.6% of the total sample households have monthly family income in the range between Rs.30,000-Rs.80,000.
- **Satisfaction about the accessibility of the house with respect to public transport:** Survey shows almost 90% of the total households are satisfied with their current accessibility of house with respect to public transport. This shows good coverage of public transport in Navi Mumbai.
- **Vehicle Ownership:** It is found that 82% of the household own two-wheeler and 57% own cars.
- **Accessibility of a car up to the entrance of a building:** Almost 34% of households sampled do not have access road wide enough for a car to reach their houses.
- **The primary mode of travel to the office:** It can be inferred that the majority of the people (more than 55%) are using private vehicles (2W or car) for their work trip. Close to 30% people are using public transport (Local Train or Bus) for their work trip.
- **Characteristics of Male Adults:** This survey shows that around 68% of male adults are working. The percentage of male adults with a two-wheeler and car driving license respectively are 58% and 46%.
- **Characteristics of Female Adults:** The percentage of working female adult is found to be 15% which is significantly less than male adults. Similarly, only 12% and 10% female adults have 2W and car driving license respectively.

#### 5. Parking Analysis for Navi Mumbai

This section shows an in-depth analysis of parking demand and supply for Navi Mumbai city. To incorporate the difference of physical parking characteristics and for in ease in analysis household samples were only classified into the single house (Single house and Bungalow) and Apartment.

### 5.1. Parking Analysis for Single Houses

Out of total 5447 households used in analysis 2280 are single dwelling units. Questions were asked to check the parking requirements and availability inside and outside the premises dwelling units. It is found that 86% (1963 out of 2280) dwelling units do not have parking space. The households who do not have parking space inside their premises were asked if they have designated on-street parking; only 15% answered 'yes'. Thus 1667 households out of 2280 (73%) neither have parking space available within the premises of dwelling unit nor on-street in the locality. The question on vehicles ownership revealed that the total number of two-wheelers and cars respectively are 1839 and 1089. This corresponds to two-wheeler ownership of 0.8 per household and car ownership of 0.48 per household. Table 3 shows the designated parking space available for different dwelling unit types and the number of vehicles owned for single dwelling units surveyed in Navi Mumbai. Out of 2280 questionnaire for single dwelling units, 237 did not have clear information about sub-classification of single dwelling units. Thus the table is based on 2043 questionnaire. As expected the car ownership increased from one-room-kitchen (1 RK) to 2+BHK household types. Form the table below it can be inferred that there is a significant deficiency of space for parking owned vehicles. The situation is critical for 1 RK and 1 BHK dwelling type where car ownership respectively is 0.15 and 0.32

Table 3: Parking Demand and Available Parking Space in Single House for Navi Mumbai

Classification	parking space inside compound?	no. of samples	2W own	Car own	Available car parking bay	Available 2w parking bay
RK	Yes	11			0	22
	No	382	252 (0.64)	59 (0.15)	0	0
	Total	393				
1 BHK	Yes	11			68	90
	No	382	754 (0.80)	303 (0.32)	0	0
	Total	940				
2 BHK	Yes	68			143	181
	No	366	399 (0.92)	292 (0.67)	0	0
	Total	434				
2+ BHK	Yes	124			143	181
	No	152	258 (0.935)	378 (1.37)	0	0
	Total	276				

### 5.2. Parking Demand & Supply Analysis for Apartment

For family units living in apartments, sample data has been broken down into those who are privately developed and those which are developed by CIDCO. (CIDCO constructed majority of the apartments before 2007 and after that most of the apartments were developed privately.) Further, their parking demand and parking space availability have been compared in Fig. 5. For apartments it the information on parking available for the surveyed households was not obvious. Parking information was available for the entire apartment complex as a whole. Thus, here the vehicle ownership is expanded for all the dwelling units in the apartment complex and the demand-supply analysis carried out. The figure indicates that the parking availability is slightly better than the single dwelling units but still highly deficient. The privately developed apartments with 35% car parking availability are slightly better than the CIDCO developed apartments.



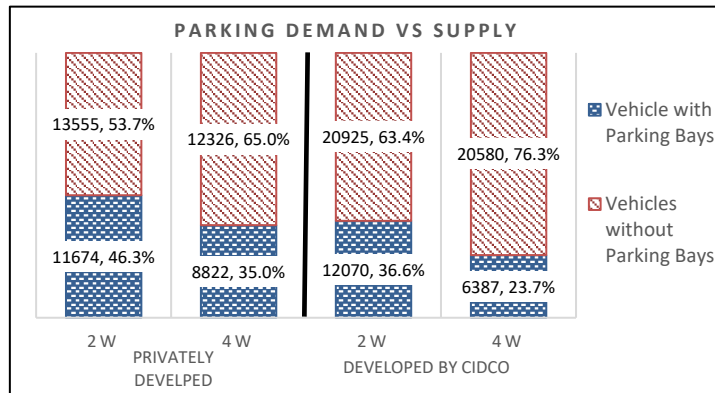


Fig. 5 Parking Demand vs Parking Supply for Apartments

### 5.3. Available Parking Space Analysis with respect to No. of Bedrooms in Apartment

In the case of apartments, the number of bedrooms can be considered as a proxy of the prosperity of the household. This may also be the representation of the vehicle ownership of the household. So, the household with a greater number of bedrooms will require more space for parking compared to the household with a lower number of bedrooms. So, this analysis shows available parking bays for both vehicles types the apartments having various types of flats in that. Table 4 presents the availability of parking spaces in different types of apartment buildings. Since the parking spaces in an apartment complex serve all dwelling units, we have considered all dwelling units for the calculations in the table. Some apartments have only one type of dwelling unit (such as 1RK or 1BHK) where as some have mixed have mixed types. The bracket value shows the parking space as a percentage of total flats for that type of apartment. For example, for 1 RK type apartments, only 9 Car parking bays available for every 100 flats. Hence, from the table given below, it can be inferred that the scarcity of parking is at a critical level in 1 RK and 1 BHK type of apartments.

Table 4: Available Parking Space Vs Number of Flats

Type of Apartments	Sum of Flats	Sum of Car Parking Available	Sum of 2W Parking Available
1 RK	11629	1040 (8.9%)	2098 (24.9%)
1 BHK	2031	372 (21.3%)	785 (41.4 %)
2 BHK	5980	3178 (53.1 %)	4169 (69.7 %)
3 BHK	299	321 (107.4 %)	224 (74.9 %)
1 RK + 1 BHK	674	149 (22.1 %)	418 (62.0 %)
1 BHK + 2 BHK	3332	863 (25.9 %)	1320 (39.6 %)
1 BHK + 2 BHK + 3 BHK	980	621 (63.8 %)	667 (68.0 %)
2 BHK + 3 BHK	280	217 (77.5%)	106 (37.9 %)

### 5.4. Projection of Current Situation in Navi Mumbai

The survey conducted for the parking demand and supply doesn't show the prevailing condition for parking bays and vehicle ownership in Navi Mumbai. To get the real sense of the actual situation in the city this sample is extrapolated to the city level. For the estimation of a number of houses in 2017, the sample data collected and house stocks available till 2007 (Revised city development plan 2012) were considered. Here, in privately developed houses yearly 2% growth in the household is assumed, and the extrapolation is done till the year 2017 (After 2007, CIDCO stopped constructing houses in Navi Mumbai.). The nodewise house projection was also carried out using sample collected and using Revised city development plan 2012. Considering the projected houses in 2017 and the vehicle

ownership available in the sample, the nodewise vehicle ownership was extrapolated. For the same, the ratio of projected households in 2017 to the available household in the sample is taken as an expansion factor for both 2W and Cars available in the sample. The same technique was also applied for the extrapolation of off-street parking available for both 2W and Cars. Hence, the ratio of extrapolated households in 2017 to the available household in the sample is taken as an expansion factor. Table 5 shows the extrapolated values for a number of houses, vehicle ownership and off-street parking bays available in Navi Mumbai.

Table 5: Dwelling Type wise Projected/Extrapolated Values

	Single house	Bungalow	Apartment	Total
Projected Houses in 2017	1,24,891	5,748	1,67,129	2,97,768
Extrapolated 2W	96,782	4,806	1,40,288	2,41,876
Extrapolated Car	46,453	8,934	1,06,528	1,61,915
Extrapolated off-street 2W Parking Bays	39,038	11,706	22,621	73,365
Extrapolated off-street Car Parking Bays	26,907	10,656	14,624	52,187

Table 6 shows the nodewise public parking available for 2W and Cars. This table is directly obtained from the Parking Supply and Demand Analysis, Navi Mumbai Municipal Corporation (KPMG), 2014 report. As shown in the following table, this report also doesn't have public parking space information for Ghansoli node.

Table 6: Nodewise Public Parking Available (Source: KPMG Report, 2014)

Node	Car parking spaces	2W Parking spaces
Airoli	807	478
Belapur	1161	1215
Koparkhairane	730	630
Nerul	822	960
Turbhe	625	305
Vashi	1900	1050

### 5.5. Nodewise Parking Supply vs Demand

Considering the extracted nodewise values of vehicle ownership and parking bays available nodewise supply (Residential parking, Public parking and on-street) and demand analysis was carried out. Table 7 shows the supply and demand analysis for parking bays and vehicle own. Here, supply is parking bays available, and demand is no. of vehicles own. From the following table, it can be inferred that in Airoli node very fewer parking bays available for both 2W and Car compared to the vehicle ownership available in that node. Moreover, the following analysis was not carried out for Ghansoli node because of unavailability of data related public parking.

Table 7: Parking Supply vs Parking Demand Analysis

Node Name	Supply	Demand	Supply/Demand	Supply	Demand	Supply/Demand
	For Car			For 2W		
Airoli	2,529	18,399	14%	4,065	36,175	11%
Belapur CBD	9,176	17,839	51%	9,943	21,515	46%
Koparkhairane	9,861	14,870	66%	15,500	30,104	51%
Nerul	9,781	29,452	33%	13,986	52,586	27%
Turbhe/Sanpada	11,720	29,403	40%	21,656	33,577	64%
Vashi	15,165	28,561	53%	12,853	25,176	51%
Navi Mumbai	58,232	1,38,524	42%	78,003	1,99,133	39%

From supply and demand analysis it can be clearly observed that, the parking space available in Navi Mumbai is too low compared to the city's vehicle ownership. Hence, the current parking regulations are not fulfilling its purpose and amendment in existing parking bye-laws is required to tackle current residential parking space deficiency. Table

3 shows the vehicle ownership and parking bays available in single house and it was used to calculate following table, which clearly indicates the lack of off-street parking bays in single houses. Consider the vehicle ownership recorded in the survey and as mentioned in Table 3 the equivalent car space is calculated. Here, it is assumed that 1 car park space is approximately equal to 4 two-wheeler park spaces. Hence, Table 8 shows the equivalent car parking space required for current vehicle ownership in various type of single dwelling unit. Though the vehicle ownership per household is quite high, available parking bay is too less.

Table 8: Equivalent Car Space Required for Current Vehicle Ownership

Classification	Single Houses Recorded	2W owned	Car owned	Equivalent car space required
RK	393	252 (0.64)	59 (0.15)	0.3
1 BHK	940	754 (0.80)	303 (0.32)	0.5
2 BHK	434	399 (0.92)	292 (0.67)	0.9
2+ BHK	276	258 (0.935)	378 (1.37)	1.6

It is noted that the earlier NMMC required only one car space for every four tenements of carpet area up to 35 sqm (see Table 1) and for every two tenements of carpet area more than 35 sqm. By comparing Table 8 and Table 1, it can be inferred that the existing norms are not adequate for the current vehicle ownership of the city. Hence, there is a need of new parking norms.

## 6. Norms Recommendation

Based on the vehicle ownership for different dwelling units and also considering the current practices in other cities, in this study two options for the parking norms are proposed for residential buildings in Navi Mumbai. For the first time, multi-dwelling units have been divided into two types for parking norms: the ones with up to 8 units and the other more than 8 units. The former case is mostly when a group of persons coming together for constructing a small building. This is possible at some CIDCO developed multi-dwelling units and row houses. Moreover, this is useful in gaothans where very tiny dwelling units without any circulation space. Such cases need encouragement and may have somewhat lenient parking requirements compared to the multi-dwelling units developed by registered builders. While suggesting norms a base case is taken as the registered builders who typically build multi-storey multi-unit buildings. The parking requirement for them is kept a bit higher side compared to the single dwelling units and multi-dwelling units up to 8 units. The recommendations are given in Table 9 and Table 10. Both are similar as for as the requirement of overall parking space.

### 6.1. Option 1

Table 9: Norms Recommendation (Option 1)

Sr no.	Occupancy	Parking Space Requirement (in nos.)		
		Car	2W	
1	Multi-dwelling units (up to 8 units)	For each 100 sqm of carpet area	1	2
2	Multi-dwelling units (more than 8 units)	For each 100 sqm of carpet area	2	0
3	For Single Dwelling unit	Carpet area below 35 sqm	0	1
		Carpet area above 35 sqm but less than 60 sqm	0	2
		Carpet area greater than 60 sqm and less than 100 sqm	1	0
		Carpet area greater than 100 sqm	2	0

Notes:

- 1) For a single dwelling unit or a multi-dwelling unit with less than 8 units, if access road to the dwelling unit is less than 3 m, no car parking is insisted.
- 2) For multi-dwelling units (with more than 8 units), 10% parking space is reserved for visitors with minimum one car parking space.

## 6.2. Option 2

Here, 1 car park space (ECS) is assumed to be equal to 4 two-wheeler park spaces. The space requirement is similar to the option 1, but gives more flexibility to builders to distribute overall space between car bays and two-wheeler bays.

Table 10: Norms Recommendation (Option 2)

Sr no.	Occupancy	Parking Space Requirement (in nos.)	ECS
1	Multi-dwelling units (up to 8 units)	For each 100 sqm of carpet area or a part of it	1.5
2	Multi-dwelling units (more than 8 units)	For each 100 sqm of carpet area or a part of it	2
3	For Single Dwelling unit	Carpet area below 35 sqm	0.25
		Carpet area above 35 sqm but less than 60 sqm	0.5
		Carpet area greater than 60 sqm and less than 100 sqm	1
		Carpet area greater than 100 sqm	2

Notes:

- 1) For a single dwelling unit or a multi-dwelling unit with less than 8 units, if access road to the dwelling unit is less than 3 m, no car parking is insisted.
- 2) For multi-dwelling units (with more than 8 units), 10% parking space is reserved for visitors with minimum one car parking space.

## 6.3. Highlights of the Proposed Norms

As per earlier norms, a builder can construct four dwelling units of 35 sqm carpet area which and provide only one car parking space. This is equal to one parking space for 140 sqm carpet area. The proposed norms require 2 spaces for 100 sqm; this requirement is almost thrice the earlier one. For single dwelling units, cities usually specify the parking requirements based on plot area and most cities do not require car parking space for plot area of less than 100 sqm. Here again, we are deviating general practice by other cities and proposing norms based on carpet area of the dwelling unit. A person may own a bigger plot and might decide to construct only a small dwelling unit for some reason. In another case, an owner of a small plot might construct a multi-storey building which actually increases the parking requirements. Thus, parking requirement-based carpet area is more logical than based on plot area. In low-income group row houses constructed by CIDCO and in gaothan areas, plot areas are small and entire plot area is used for construction. Not only cars cannot access those houses because very narrow roads, but there will also hardly be any space left if they are forced to make a provision for car parking. Most of them do not own a car either. Thus, only two-wheeler provision is recommended for carpet area less than 60 sqm. One car space is recommended for dwelling unit of carpet area 60 sqm to 100 sqm. Both options (section 6.1 and 6.2) delineate the same amount of parking space requirement, but they are in different units. The key features of the proposed norms are:

- Simple norms, easy to verify
- Gives flexibility to developers (car spaces and two-wheelers spaces in one common unit) – Option 2
- Avoids development of rigid threshold on dwelling unit carpet area in multi-dwelling unit buildings

Moreover, the proposed norms have considered the following characteristics of the Navi Mumbai.

- The car sales in Navi Mumbai in general is decreasing
- Further reduction in car/TW usage is possible due to
  - Planned Metro and suburban rail networks
  - Increased usage of online taxi services like Ola and Uber

It is advisable that the parking space norms may be assessed after 5 years and revised within 10 years to accommodate the vehicle growth of the city.

## 7. Conclusions and Other Suggestions to Meet the Demand

The official record of the current number of dwelling units in Navi Mumbai is not available. Based on earlier

record we projected the number to 2,97,756 for the year 2017. Moreover, using the two-wheeler and car ownership rates from the household survey and the projected dwelling unit the number of two-wheelers and cars are estimated to be 2,41,876 and 1,61,915 respectively for the year 2017. Table 7 shows that considering both on-street and off-street parking the supply to demand ratio is 0.39 for two-wheelers and 0.42 for cars. Recently NMMC approved additional 3256 two-wheeler and 5620 car off-street parking spaces. Thus, the supply to demand ratio for two-wheelers and cars is slightly improved to 0.41 and 0.46 respectively. Clearly, there is a significant shortage of parking spaces even after considering the existing on-street parking. Although it is expected that the proposed norms will take care of the demand of the new residential buildings, the current deficient is so high that the parking issues will not disappear immediately.

It is observed that NMMC and CIDCO have earmarked many plots for public parking, but are not developed. Based on the records provided, it is noticed that CIDCO has transferred plots in different nodes of total area around 2,000 sqm. Additionally, CIDCO's plan has a provision of plots totalling more than 20 hectares for parking. CIDCO and NMMC may coordinate and construct multi-storey public parking on these plots. It is to be noted that the multi-story parking facilities will serve only the nearby dwelling units. A part of the parking spaces will be used by users to fulfil their non-home end parking needs. On-street parking can be a good option to meet a part of deficiency. It is suggested that NMMC explore the availability of additional on-street parking areas. A detailed study may be initiated with objectives to

- 1) identify additional available on-street areas,
- 2) identify locations where on-street parking space can be created by either clearing obstructions or widening roads
- 3) suggest a suitable approach to operate on-street parking spaces.

Navi Mumbai is changing very rapidly with many projects being implemented and planned to be implemented. Additionally, the life style of people is also changing very rapidly. On one side there is a comfort and flexibility of a personal car, but on the side, there are externalities such as cost, emissions, congestion associated with personalized cars. Moreover, increased awareness about health and environment is making people shift to bicycle and walk mode wherever possible. To conclude it is very difficult to paint a picture of 10 years from now. Thus, it is advised that the parking space norms may be assessed after 5 years and revised within 10 years to accommodate the change in the dynamics of the city and its citizen.

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