FSI as a Development Control Tool in Indian Cities-Analysing the Case of Vijayawada, India

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***Abstract*—FSI (Floor space index- the ratio of the built-up space on a plot to the area of the plot) is a regulation followed in the development control norms of many cities. Cities are known for their complexity and dynamic growth patterns. Often cities have differential growth patterns, density patterns and differential levels of infrastructure. In many Indian cities, the FSI distribution is independent of land availability and densities. In recent news, it was revealed that 33% of Indians occupy living space that is less than that of the prisoners of United States. This was found from the recent National Sample Survey. FSI values of Indian cities are low compared to other cities in the world, which keeps the per capita built space low.**

The paper analyses and compares the various factors considered by some of the Indian cities in their building regulations with respect to the FSI for residential and related categories. A study of Vijayawada city is undertaken to analyze the impact of plot regulations and to find out various parameters affecting the same. Further the study can carry forward to examine selected planned and unplanned areas with respect to FSI, density and infrastructure.

***Keywords*— Floor space index, per capita space, density, infrastructure, urban sprawl**

I. INTRODUCTION

In India urban area is defined in terms of population, density and work composition. A minimum population of 5000 with 75% of male population engaged in non-agricultural work with a density of at least 400 persons/ Sq.Km. (Census India, 2011). There are three main levels of regulating the urban development.

a) Policy level controls which intend to regulate the type and use i.e. zoning regulations, density allocation, right of way and transfer of development rights.

b) Implementation level controls, which intend to regulate the intensity of built form, e.g. controls on FSI, Ground coverage, building height restriction, setbacks etc.

c) Execution level Controls that are preconceived e.g. urban design controls, control on façade, color, form etc.

The revised common building rules in 2006 and Andhra Pradesh building rules in 2012 has taken out the component of FAR and gave regulation for heights and setbacks as per road widths, now common for entire Andhra Pradesh (A.P.) Now the Municipal administration and Urban development of AP is planning to reintroduce the FAR norm for high rise buildings in the state. The present proposal is to study the existing building rules, its impact on urban infrastructure, comparison of earlier rules, FAR norms in different states, study the density aspects resulting out of present rules in relation to available infrastructure and shall suggest modifications. (Article in Times of India, 2013).

A Case area to be selected is Vijayawada city (the new capital city of Andhra Pradesh). Sample surveys shall be conducted in the selected case area. Vijayawada city, is a new growth potential area, is taken into consideration for the research. The outcome of the research will be a model demonstrating the appropriate FSI for the city.

The question of the economic efficiency of city size had been discussed extensively in the 'optimum city' size debates of the 1970s (Richardson, 1972, 1977; Segal, 1976). In some cases, planning controls have resulted in high densities; for example, Seoul's greenbelt (in place since 1971) has reduced the supply of land available for urban use, raised land prices and increased densities (Kim, 1994; Bae, 1998).

Wackernagel and Rees (1995) pointed out that the denser settlements make more efficient use of land and other resources. Mike Jencks and Rod Burgess (2000) concluded that denser environments are more social and convivial but on the other side they are associated with pollution, congestion, noise, unhealthy environment, poor sanitation and inadequate infrastructure. It is also learnt that India would be the most populated country by 2030.

Recently it is also found that there is strong relation between density, design and residential development. Height, plot coverage and communal open spaces play a key role in the evolution of development patterns. (Chan and Lee, 2009, Churchman 1999, Forsyth et al 2007, Jabareen 2006, Paunt and Hopt 2007). Parker (2004) stated that mixed use allows compatible land uses, which can shorten the travel distance between activities.

Jabareen (2006) conducted an in depth research in understanding sustainable urban forms through a matrix to assess the same through parameters like density, diversity, mixed-land use, compactness, sustainable transportation, passive solar design and ecological design. He concluded that "the ideal sustainable urban form according to the design concepts of sustainable urban form is that which has a high density and adequate diversity, compact with mixed land uses and based on sustainable transportation, greening and passive solar energy." It is also pointed out that "the key objectives to achieve sustainable urban forms are decreased energy use,

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reduced waste and pollution, reduced automobile uses, preservation of open space and sensitive eco-systems and liveable and community oriented human environments" (Jabareen, 2006). Jabareen (2006) stresses that there is an urgent need not only in our behaviour but also in the design of the built form.

Higher household density in Mumbai (Dave 2010) has indicated that Density has mixed perceived impacts. A positive impact on the access to facilities and amenities, no impact on the sense of safety and negative impact on the amount of living space.

Another recent research explores the possibility of high density with good living conditions focussing on quality and character of new developments and modifying old ones (Shirish B. Patel, 2011). FAR norms were introduced as an analytical tool to make projections of development intensity in a given plot.

Shirish Patel states that the proportion of buildable plots to street area is not considered for the comparision, as Manhattan has 1.7 plot factor (plot area/street area) which means area under roads is more as compared to buildable area and for Mumbai C ward plot factor is 2.4 which means area under roads is less and buildable area is more. There is less street crowding in Manhattan as compared to Mumbai c Ward. On the other hand, Bertauad argues that FSI values have little to do with densities and contradicted the presumed theory that low FSI would result in lowering the densities or at least keep it constant. However, lower FSI in Mumbai resulted in scarcer floor space and eventually making it expensive, also resulting in lesser open space.

Manish Shirgaokar (2013) stresses that the urban peripheral nodes and sub-centres, where there is higher potential for managing land uses and supplying infrastructure, should be included in the development focus which shall encourage balance between housing and jobs and will tend to make efficient use of expensive transportation infrastructure. He suggests that increasing FSI (say 2 to 4) will work if it is linked to mix of uses like housing, retail, offices,recreational etc. He also points out that there is limited understating if there is limited data. Also Brueckner and Sridhar (2012) rely on aggregate (city/regional level) data to model the effects of higher FSI. Neither Mumbai nor Bangalore are similar to other cities that may have different population, mix of housing, employment, infrastructure etc.

There is a need to critically understand the growth variables in the cities and regulate the urban form carefully to avoid unintended pattern of development. The co-relation between the FSI and the Urban form has not been explored much through strategic models. FSI is a common variable in cities and results in varying Urban form and space. For example, in Mumbai typical middle-class family occupies 5sqm per capita whereas in Manhattan it is 55sqm per capita (Shirish Patel, 2011).

Indian cities are thriving for better infrastructure to augment space. The form of the cities is becoming uncontrollable with pressure of population and urban development. Also it is projected that 70 % net new employment will be generated in cities by 2030. (Mc.Kinsey & Company, 2010). Total Urban population of India in 2011 is 377.2 million i.e. 31.16 % of the total. By 2050, India's Urban population will be more than 50% of the total. India represents almost 17.31% of the world's population, which means one out of six people on this planet live in India (Census, 2011).

II. FSI AND BUILDING REGULATIONS FOR RESIDENTIAL BUILDINGS IN INDIA

A. Delhi

In Delhi (as per 4.4.3-A page 43 of Delhi Master plan, 2021), the FSI norms are as per the size of the plot, building activity or the use of land but not dependent on the road width and FSI decreases as the plot size increases (varying from 1.2 to 3.5 maximum). For residential plotted development the ground coverage varies from 40% to 90% and also there are setbacks and height regulations on each plot. There is a stipulation of maximum number of dwelling units on the plot regulating the density. The parking is regulated at 2 ECS for 250 to 300 sqm. plot and 1 ECS thereof for every 100 sqm. built-up area in plots exceeding 300 sqm. For group housing (as per 4.4.3-B page 47 of Delhi Master plan, 2021) there is a standard FSI of 2 allowed on a minimum plot area of 3000 sqm. There is no setback and height restriction under group housing category. Plots in the influence zone of MRTS/Major transport corridor are given higher FSI along 500m on both sides of the corridor. Delhi also promotes redevelopment strategies in a minimum area of 4 hectares with enhanced FSI subject to a maximum of 4, is allowed for planned and unplanned areas through a process of reorganization and optimum utilization of land.

B. Bangalore

In Bangalore (as per Table-10 page 27, Zoning of land use and regulations 2004, Bangalore Revised Master plan 2015) all the factors like building activity, road width, plot size, ground coverage, heights, setbacks are considered for residential plotted development category. The city is zoned specifically into three zones- intensely developed, moderately developed and sparsely developed areas for allocating FSI (known as FAR in Bangalore). Along MRTS, 150 m from the transit hub additional 0.5 FSI is allowed for plots abutting 60m or more on payment of fees. Unlike Delhi the FSI increases from smaller plots i.e. 1.75 to 3.25 for larger plots. There are no density regulations or dwelling unit restriction on the residential plots. Bangalore also has regulations for integrated tonwships (as per Table-22 page 47, Zoning of landuse and regulations 2004, Bangalore Revised Master plan 2015) for which 40 % has to be under residential use and the minimum area for the same is 40 hectares. The rest of the 55% may be Hi-tech category with IT/BT related areas. The FSI for the same varies from 2.5 for road width above 18m up to 24m to 3.25 for roads wider than 30m.

C. Calcutta

In Calcutta, (as per Table-IV, page 16,New Town Kolkata Building rules 2009) the FSI for the residential plots under 1500sqm. have a blanket FSI of 2.5 and further as the plot size increases, the FSI reduces to 1.5 as in the case of Delhi. The building regulations specify norms as per the building use or use of land, road width as means of access, setbacks but do not specify density. However there is no height restriction for buildings abutting more than 40 m of means of access.

D. Mumbai

In Mumbai for residential development (Table 14, Page 75, DCR Municipal Corporation of Greater Mumbai, 1991 and notifications thereof) the FSI is uniform over entire zone. The FSI varies from 0.5 in the suburbs to 1.33 in the Island city. The density in the Island city is stipulated at a minimum of 600 dwelling units per hectare and also maximum density of 267 dwelling units for plots above 1 hectare. Additional FSI is allowed where road widening or construction of new roads are proposed will be utilizable on remaining plot up to a limit of 40% of the area of the plot in Mumbai city and up to 80 % in the suburbs. Mumbai's regulations are unique from any other city in India. Mumbai also offers higher FSI for development and redevelopment of Maharashtra Housing Area Development Authority (Section 33, Page 87, DCR Municipal Corporation of Greater Mumbai, 1991 and notifications thereof). It allows for 2.5 FSI on vacant lands under MHADA and 2.5 plus incentives for redevelopment.

E. Chennai

In Chennai for residential plotted development mentioned as ordinary residential buildings (Table -I page 22, Chennai Second Masterplan 2026 Chennai Metropolitan Area,Vol-II, Development regulations, May 2013), the maximum FSI is fixed at 1.5 for any given plot size and location. Ordinary residential buildings include residential buildings, clinics, dispensaries, nursing homes, working women hostels, Guest houses, small cottage industries, reading rooms, libraries, post office, EB office, telegraph office, nursery schools and primary schools not exceeding a stipulated plot area and height.

Minimum plot frontage and plot coverage are stipulated in each case. Also like other cities the building setbacks have been defined with respect to the abutting road widths. Residential buildings with more than two floors and more than 6 dwelling units are categorized as under special buildings and is allowed on a minimum road width of 10m or the access road through which the plot is gained access. Another category is the Group developments having two blocks or more than two blocks with residential or commercial or combination of such activities.

However, the maximum FSI is 1.5 under these categories too. Only in the high rise category the FSI goes upto 2.

F. Vijayawada

The study has been taken up in the city of Vijayawada, recently notified capital of the newly formed state of Andhra Pradesh. Vijayawada is flanked by Krishna river on the west and Budameru river on the north. The region is covered by rich and fertile agricultural lands. The city is spread on an area of 61.88 sq.km. with a population of 10, 48, 240 (Census of India, 2011) and the density is of population is 16,939 persons per sq.km. The landmark of the city is the Vijaya durga temple along Krishna River on Indra kiladri hill. Construction of Prakasam barrage was commenced in 1852 and completed in 1855 and later the construction of three irrigation canals- Ryves canal, Eluru canal and Bandar canal were marked by the initial growth of the city.

The existing building rules of Andhra Pradesh G.O.168 which has no FAR norm and allows maximum built-up area in a given plot with respect to the abutting road without height constraints is resulting in varying per capita space, density distribution and pressure on civic infrastructure like roads, sanitation etc.

The FSI component was removed from the Andhra Pradesh building regulations since 2006. Maximum height and setbacks are stipulated as per the abutting road width for the plot sizes. Also there is no variation with resect to the use of land or building activity on a certain plot which means the regulations are even for residential and commercial typology of buildings. As there is no FSI component the author made the assumptions as below based on the plot categories (as per Clause 5, Table-III page 9, GO 168, Govt of Andhra Pradesh, April 07, 2012) and calculated the achievable FSI for plots under non-high rise category.

TABLE – III

Sl. No.	Plot Size (in Sq. m) Above – Up to	Parking provision	Height (in m) Permissible Up to	Building Line or Minimum Front Setback to be left (in m) Abutting Road Width					Minimum setbacks on remaining sides (in m)
				Up to 12 m	Above 12m & up to 18m	Above 18m & up to 24 m	Above 24m & up to 30m	Above 30m	
1	2	3	4	5	6	7	8	9	10
1	Less than 50		7	1.5	1.5	3	3	3	-
2	50-100	-	7	1.5	1.5	3	3	3	-
			10	1.5	1.5	3	3	3	0.5
3	100 - 200	-	10	1.5	1.5	3	3	3	1.0
4	200 - 300	Stilt floor	7	2	3	3	4	5	1.0
			10	2	3	3	5	6	1.5
5	300 - 400	Stilt floor	7	3	4	5	6	7.5	1.5
			12	3	4	5	6	7.5	2.0
6	400 - 500	Stilt floor	7	3	4	5	6	7.5	2.0
			12	3	4	5	6	7.5	2.5
7	* 500 - 750	Stilt floor	7	3	4	5	6	7.5	2.5
			12	3	4	5	6	7.5	3.0
			15	3	4	5	6	7.5	3.5
8	750 - 1000	Stilt + One Cellar floor	7	3	4	5	6	7.5	3.0
			12	3	4	5	6	7.5	3.5
			15	3	4	5	6	7.5	4.0
9	1000 - 1500	Stilt + 2 Cellar floors	7	3	4	5	6	7.5	3.5
			12	3	4	5	6	7.5	4.0
			15	3	4	5	6	7.5	5.0
			18**	3	4	5	6	7.5	6.0
10	1500 - 2500	Stilt + 2 Cellar floors	7	3	4	5	6	7.5	4.0
			15	3	4	5	6	7.5	5.0
			18**	3	4	5	6	7.5	6.0
11	Above 2500	Stilt + 2 or more Cellar floors	7	3	4	5	6	7.5	5.0
			15	3	4	5	6	7.5	6.0
			18**	3	4	5	6	7.5	7.0

Fig. 1. Setback regulations for Non high-rise buildings, G.O. 168, Table III, page no.9

TABLE I: DERIVATION OF FSI BASED ON G.O. 168, TABLE 3 PAGE NO.9 BUILDING RULES- NON HIGH-RISE CATEGORY

ASSUMPTIONS			*Considering maximum Height permissible*	*Building line or Front minimum setback*		*Minimum Setbacks on remaining sides*	*Total built up Area (Max GC x number of floors)*	*FSI achieved on minimum road width (12m wide road)*	*FSI achieved on road width (above 30m wide road)*
Plot size taken in sqm.	*Plot dimensions*			*Abutting road widths*					
	Width	Length		Upto 12m	Above 30m				
80	8	10	10 (3floors)	1.5	3	0.5	168	**2.10**	**1.71**
150	10	15	10 (3floors)	1.5	3	1	300	**2.00**	**1.76**
240	12	20	10 (3floors)	2	6	1.5	446	**1.86**	**1.41**
375	15	25	12 (4floors)	3	7.5	2	880	**2.35**	**1.82**
475	19	25	12 (4floors)	3	7.5	2.5	1092	**2.30**	**1.77**
600	20	30	15 (5floors)	3	7.5	3.5	1528	**2.55**	**2.06**
900	25	36	15 (5floors)	3	7.5	4	2465	**2.74**	**2.31**
1200	30	40	18 (6floors)	3	7.5	5	3840	**3.20**	**2.75**
2400	40	60	18 (6floors)	3	7.5	6	8568	**3.57**	**3.26**
2600	40	65	18 (6floors)	3	7.5	7	8580	**3.30**	**3.03**
3000	50	60	18 (6floors)	3	7.5	7	10800	**3.60**	**3.28**

One interesting observation is that the FSI achieved on minimum road width is always greater than the FSI achieved on the maximum road width for the same given plot. Whereas, the plots adjacent to wider roads can always have higher FSI as in the case of other cities as wider roads can support better infrastructure and higher densities.

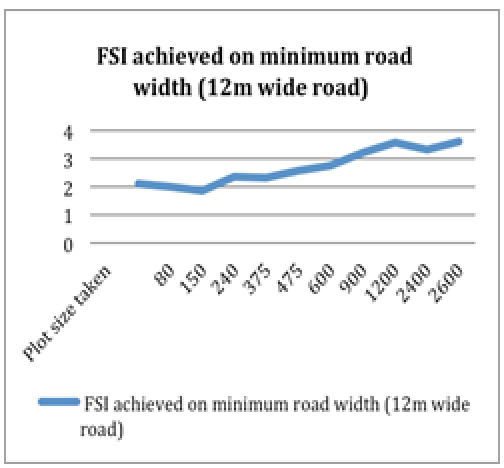

Fig. 2. FSI achievable on 12m wide road

The above figure shows that the range of FSI achievable on plots abutting 12m wide road ranges from 2.1 to 3.6 for varying plot as per Table I.

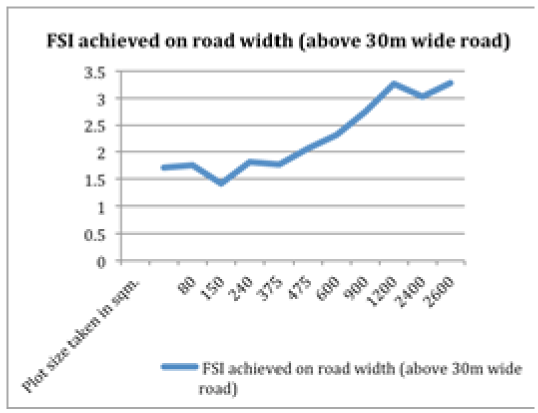

Fig. 3. FSI achievable on 30m wide road

The above Figure 3 shows that the range of FSI achievable on plots abutting 30m wide road ranges from 1.71 to 3.28 for varying plot as per Table I.

The analysis was also done in the High Rise category.

TABLE – IV

Height of building (in meters)		Minimum abutting road width required (in meters)	Minimum all-round open space on remaining sides (in meters) *
above	**Up to**		
1	**2**	**3**	**4**
-	21	12	7
21	24	12	8
24	27	18	9
27	30	18	10
30	35	24	11
35	40	24	12
40	45	24	13
45	50	30	14
50	55	30	16
After 55m 0.5m additional setback for every 5m of height shall be insisted			

Fig. 4. Setback regulations for high-rise buildings, G.O. 168, Table IV, page no.13

The plot sizes above 2000 sqm. and certain plot dimensions were considered as shown in the below Table II. The setbacks as mentioned in the G.O. 168 and 10% mandatory open space were deducted for calculating the maximum ground coverage (building footprint). In this case the size of plots was increased from 2600 sqm. to 6500 sqm. along with the number of floors from 7 to 18 respectively.

The building footprint multiplied by the number of floors allowed, gave the total built-up area achieved and FSI. It was observed that the FSI increased from 2.87 to 3.34 as the plot sizes and floor heights were increased as per the abutting road width. Hence bigger the plot and increase in height, we get higher FSI unlike other cities.

TABLE II: Derivation Of FSI Based On G.O. 168, Table IV Page No.13 Building Rules- High-Rise Category For Varying Floors

In the other case, with the same plot dimensions the number of floors was kept constant.

Plot size taken in sqm.	*Plot dimensions*		*Remaining area after setbacks in sqm.*	*Deducting 10% mandatory Open space in sqm.*	*Building footprint in Sqm.*	*No. of floors*	*Total built up area achieved in Sqm.*	*FSI achieved*
	Width	*Length*						
2600	***40***	***65***	***1326***	***260***	***1066***	***7***	***7462***	***2.87***
3000	***30***	***100***	***1176***	***300***	***876***	8	***7008***	***2.34***
3500	***35***	***100***	***1394***	***350***	***1044***	9	***9396***	***2.68***
4000	***40***	***100***	***1600***	***400***	***1200***	10	***12000***	***3.00***
4500	***45***	***100***	***1794***	***450***	***1344***	11	***14784***	***3.29***
5000	***50***	***100***	***1976***	***500***	***1476***	12	***17712***	***3.54***
5500	***55***	***100***	***1750***	***550***	***1200***	15	***18000***	***3.27***
6000	***60***	***100***	***1904***	***600***	***1304***	16	***20864***	***3.48***
6500	***65***	***100***	***1856***	***650***	***1206***	18	***21708***	***3.34***

TABLE III: Derivation of FSI based on G.O. 168, Table IV page No.13 Building Rules- High-rise category for constant floor height

In this case it was found that the FSI variation was from 2.87 to 4.02, which means larger the plot higher is the FSI allowed on the same abutting road width i.e. 12m minimum and also the FSI was more than the earlier case for the same plot sizes. That means one could get higher built up area by going only up to 7 floors height as compared to going up to 18 floors height on an abutting road width of 30m. Even in the high-rise category, going high may not be beneficial rather it will only allow more open space within the plot.

Plot size taken in sqm.	*Plot dimensions*		*Remaining area after setbacks in sqm.*	*Deducting 10% mandatory Open space in sqm.*	*Building footprint in sqm.*	*No. of floors*	*Total built up area achieved*	*FSI achieved*
	Width	*Length*						
2600	***40***	***65***	***1326***	***260***	***1066***	***7***	***7462***	***2.87***
3000	***30***	***100***	***1376***	***300***	***1076***	7	***7532***	***2.51***
3500	***35***	***100***	***1806***	***350***	***1456***	7	***10192***	***2.91***
4000	***40***	***100***	***2236***	***400***	***1836***	7	***12852***	***3.21***
4500	***45***	***100***	***2666***	***450***	***2216***	7	***15512***	***3.45***
5000	***50***	***100***	***3096***	***500***	***2596***	7	***18172***	***3.63***
5500	***55***	***100***	***3526***	***550***	***2976***	7	***20832***	***3.79***
6000	***60***	***100***	***3956***	***600***	***3356***	7	***23492***	***3.92***
6500	***65***	***100***	***4386***	***650***	***3736***	7	***26152***	***4.02***

III.Conclusion

The FSI variation in Vijayawada was unlike Delhi where FSI decreases by the increase in plot size and similar to Bangalore where FSI increases with the increase in plot size. There are no other parameters considered unlike few other cities where density, location and proximity to MRTS/major roads were considered. The FSI achieved on minimum road width is always greater than the FSI achieved on 30m and above roads for the same plot sizes. Hence owners having plots on 12m roads shall benefit more than the owners having plots on 30m or wider roads in terms of the total built up area that they could achieve.

Also in Vijayawada as per the G.O. 168 there is no differentiation with respect to the use of land, which is vital. The end result if the same kind of stereotype boxes found monotonously spread across the city, which were built after 2006. One more reason for that is, there is no freedom for the Architect or the builder to play with the massing for smaller or mid sized plots, as there are no projections or balconies allowed beyond the stipulated setbacks and heights regulated. The variations can be seen on bigger plots.

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