Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 17 (2016) 685 – 692

Transportation Research Procedia

www.elsevier.com/locate/procedia

11th Transportation Planning and Implementation Methodologies for Developing Countries, TPMDC 2014, 10-12 December 2014, Mumbai, India

Critical Assessment of Road Capacities on Urban Roads – A Mumbai Case-Study

Rajesh Gajjar [a*] and Divya Mohandas [b]

[a] *Rajesh Gajjar – Managing Director, GMD Engineering Consultants Pvt Ltd, India*

[b] *Divya Mohandas - Traffic Engineer, GMD Engineering Consultants Pvt Ltd, India*

Abstract

Road capacity in general refers to the maximum traffic flow obtainable on a given roadway using all available lanes; usually expressed in vehicles per hour or vehicles per day. This depends upon several factors, mainly, traffic conditions, road geometry characteristics, environmental factors etc. The present study is a critical assessment of road capacities on major urban roads in Mumbai, Maharashtra. Field traffic surveys were carried out to capture the classified volume count for major arterial, sub-arterial and collector roads spread across Mumbai through manual as well as video graphic techniques. Based on the collected data, the existing traffic volume per lane was ascertained during peak morning and evening hours. This has been compared with the maximum Road capacity values specified as per IRC 106-1990 for urban roads to critically analyze the existing capacity potential of major roads in Mumbai. Based on our study, it was observed that volume per lane for several major roads in Mumbai are way beyond the capacity. However, interestingly, no major congestion issues were found in these roads notwithstanding the excessive volume.

Peer-review under responsibility of the Department of Civil Engineering, Indian Institute of Technology Bombay

Keywords: Road Capacity;Traffic Surveys;Mumbai.

1. Background

India has a vast road network of 33 million kilometres in 2014, making it the second largest road network in the world. However, in accord to its population, India has less than 3.8km road for every 1000 people including paved and

* Rajesh Gajjar Mob: 09920519933
E-mail address : rhgajjar@gmdconsultants.in

Peer-review under responsibility of the Department of Civil Engineering, Indian Institute of Technology Bombay
doi:10.1016/j.trpro.2016.11.124

unpaved roads. This is paltry, in comparison to USA (21 km) and France (15 km). However, vehicle growth in India has been unprecedented, increasing at 10% per annum over the last 5 years (Source:NHAI).

Capacity analysis is a fundamental component in design, planning, operation and maintenance of roads. It is the primary component which helps in ascertaining the efficiency of the existing roads as well as designing new roads. For existing roads, capacity analysis is helpful in determining the vehicular traffic carrying capacity of the roads and analyzing whether the accessible number of lanes would be sufficient to handle the traffic volume under the prevailing roadway conditions. Also, modifications in the existing geometry, traffic control devices and traffic management measures can be effectively planned if capacity studies are taken into consideration.

Owing to its role in road design several studies were conducted in India to fix capacity values for urban roads. The earliest study involved fixing tentative capacity values on junctions for Urban Roads in IRC 86:1983. However, this did not serve its purpose as it did not reflect ground reality and the need for a fresh and realistic study was stressed upon by traffic engineers across India. With advancement in the field of urban road design and traffic engineering, several studies were conducted and revised urban roadway capacity values were formulated. This was presented in IRC 106:1990.

Capacity standards were fixed in accordance to the Level of Service adopted for the design. Level of Service is a qualitative measure used for indicating the traffic conditions in terms of speed, travel time, freedom to maneuver, comfort, convenience, traffic interruptions, safety etc. Volume/Capacity Ratio (V/C ratio) is the strongest indicator of level of congestion and corresponding level of service. The more the ratio more is the congestion. A value of 1.0 indicates dense traffic. The V/C ratio and the corresponding Level of Service (LOS) indicator values for various scenarios are presented in the following table.

Table-1 Level of Service

Level of Service (LOS)	Volume/Capacity Ratio (V/C)	Level of Comfort	Nature of flow
A	<0.30	Highest	Free Flow
B	0.30 – 0.50		Reasonably free flow
C	0.50 – 0.70		Stable flow
D	**0.70 – 0.90**	**Threshold**	**Approaching unstable flow**
E	1.00		Unstable flow
F	>1.00	Lowest	Forced flow

The code specifies Design Service Volumes, i.e., the maximum hourly volume at which the vehicle can traverse through a point, or a certain distance under the prevailing conditions at a reasonable level of service. During design of roads, keeping in mind the need for smooth vehicle movement, a design service volume pertaining to Level of Service (LOS) C has been considered. At this level, volume of traffic will be 0.7 times the design capacity. Capacity values for different categories of urban roads (arterial, sub-arterial and collector roads) as prescribed by IRC 106:1990 has been specified below.

Table-2 Design Service Volume

Sr No.	Type of Carriageway	Total Design Service Volumes for Different Categories of Urban Roads		
		Arterial*	Sub-Arterial**	Collector***
1	2-Lane (One way)	2400	1900	1400
2	2-Lane (Two way)	1500	1200	900
3	3-Lane (One way)	3600	2900	2200
4	4 Lane Undivided (Two way)	3000	2400	1800
5	4 Lane Divided (Two way)	3600	2900	
6	6 Lane Undivided (Two way)	4800	3800	
7	6 Lane Divided (Two way)	5400	4300	
8	8 Lane Divided (Two way)	7200		

***** No frontage access, no standing vehicles and very little cross traffic

** Frontage development, side roads, bus stops, no standing vehicles, waiting restrictions

*** Roads with free frontage access, parked vehicles and cross traffic

Source: IRC 106:1990

The code also states that the classification of roads based on arterial sub-arterial and collector roads is based upon the access criteria as stated above. However, if the on-site conditions do not confirm with the stated assumptions, the prevailing conditions would be taken as a reference in ascertaining the capacity of a particular road. "**In other words, where a road is functionally arterial road, but prevailing fringe conditions correspond to sub-arterial, or collector, the values corresponding to the latter will apply and vice versa".**

The following study examines the roads of Mumbai. In most of the major roads, arterial and sub-arterial roads alike; on-street parking or standing vehicles is a common site. However, if we go by the code, and assess the degree of saturation (Volume / Capacity) values during peak hours, majority of the roads will have a value way exceeding 1 which would mean extremely congested and forced flow. However, this is not the case in Mumbai. The study analyzes the same.

2. Objectives of Analysis

The basic objectives of study include the following:

1. To conduct Volume Studies for several roads in Mumbai;
2. To compare the observed volumes with the capacity values given in IRC 106:1990 and evaluate the Level of Service; and
3. Explore the possible causes and reasons to attribute the gap between observed volumes and standard capacities.

In order to carry forward the same, following roads located in Mumbai city were selected.

Table 3 Roads selected for Study

Sr No	Name of road	Survey location	Date of Survey (day)	Description	Type of Road	Standing Vehicles
1	Lady Jamshedji Road	Near Mahim Dargah	17th,October 2012 (Wednesday)	4 Lane Divided Road	Sub -Arterial	Yes
2	Dubey Road	Universal High School, Dahisar	18th February, 2014 (Tuesday)	4 Lane Undivided Road	Sub -Arterial	Yes
3	MIDC Central Road	Near Seepz, Andheri	17th,October 2012 (Wednesday)	6 Lane Divided Road	Sub -Arterial	Yes
4	Sahar road	Near CSIA Airport, Vile Parle	17th,October 2012 (Wednesday)	6 Lane Divided Road	Sub -Arterial	No
5	S.V.Road	Near BEST Bus Depot,Borivali	18th February, 2014(Tuesday)	6 Lane Divided Road	Sub -Arterial	Yes
6	M.G.Road	Near Borivali Railway Station	27th March, 2014(Thursday)	6 Lane Divided Road	Sub -Arterial	Yes
7	Ghodbunder Road	Near T.G.Road Junction, Thane	2nd April, 2013(Tuesday)	8 Lane Divided Road	Arterial	No
8	Link Road	Near Sanghvi Industrial estate, Kandivali	7thAugust, 2013(Wednesday)	8 Lane Divided Road	Sub -Arterial	Yes
9	Dattapada Road	Near Rivali Park, Kandivali	12th February, 2010(Friday)	8 Lane Divided Road	Sub -Arterial	Yes
10	WEH	Near Rivali Park, Kandivali	12th February, 2010 (Friday)	8 Lane Divided Road	Arterial	No
11	Cheda Nagar Flyover	Cheda Nagar Flyover	21st March, 2014 (Thursday)	3 Lane One-Way	Arterial	No

3. Data Collection

For the study, 16 hour traffic counts were performed for several roads in Mumbai. Photographs of these roads are illustrated below.

4-Lane Roads

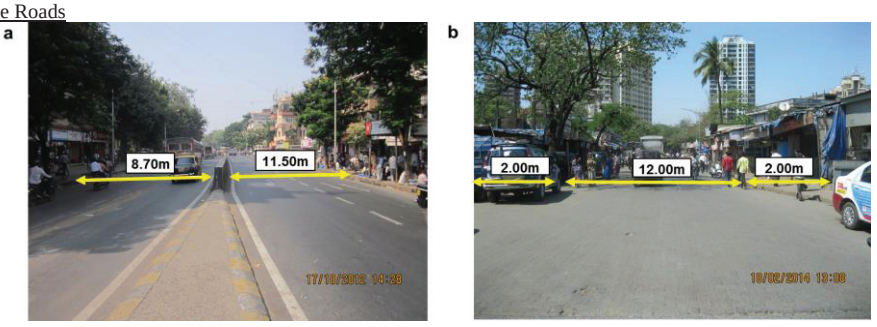

Fig. 1. (a) L.J. Road; (b) Dubey Road.

6 Lane Roads

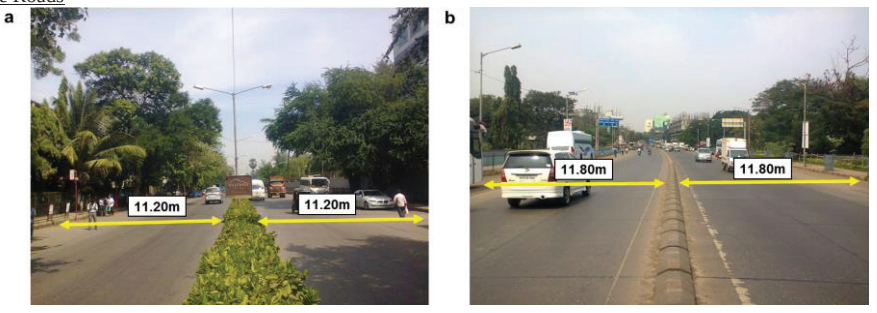

Fig. 2. (a) MIDC Road; (b) Sahar Road.

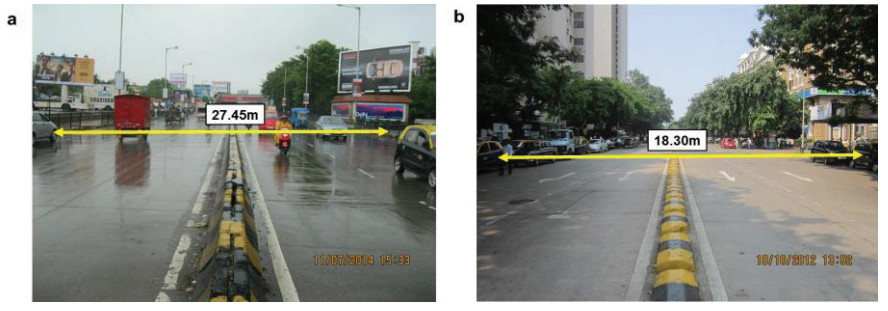

Fig. 3. (a) SV Road; (b) MG Road.

8 Lane Road

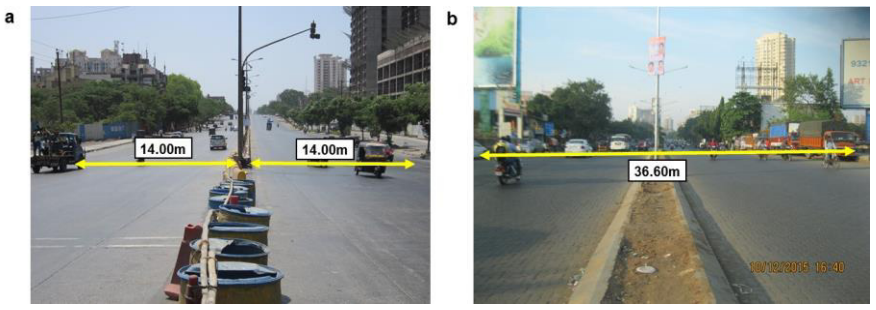

Fig. 4. (a) Ghodbander Road; (b) Link Road

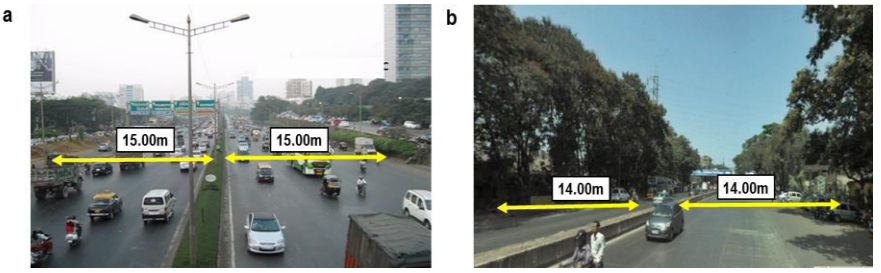

Fig. 5. (a) WEH Road; (b) Dattapada Road.

3 Lane- One Way – Cheda Nagar Flyover

Fig. 6 Cheda Nagar Flyover

4. Data Processing

For the study, 16 hour traffic counts were performed for several roads in Mumbai. For analysis purpose, the traffic volume was converted into equivalent passenger car units (PCU's) by using equivalency factors as specified by IRC 106:1990. This traffic volume is then expressed as PCU's per hour. IRC recommends conversion of different types of traffic into a common unit called Passenger Car Units (PCU) or Passenger Car Equivalents (PCE). Passenger car is

considered as the base unit and every other mode is expressed in a multiple of a passenger car unit. PCU values reflect the level of interference the vehicle can cause to the traffic flow. This has been specified below.

Table 4 Passenger Car Units (PCU)

Type of Vehicle	Composition Below 10%	Above 10%
Two Wheeler	0.5	0.75
Car	1	1
Three Wheelers	1.2	2
Light Commercial Vehicle	1.4	2
Bus	2.2	3.7
Tractor / Trailer	4	5

Based on the observed data, the peak hour data for morning as well as evening was identified. This was multiplied with the respective Passenger Car Units (PCU's) and the peak hour PCU'S were ascertained. Also, the modal mix type was identified for each road. This has been specified below.

Table 5 Peak hour volumes of selected roads

Sr No	Name of Road	Type	Observed Peak Volume in PCU(AM)	Observed Peak Volume in PCU (PM)	Major vehicle mode	Proportion of 2W+ 3W + Car
1	Lady Jamshedji Road	4-Lane Road	2897	3517	2W,3W,Cars	90%
2	Dubey Road	4-Lane Road	3909	4078	2W,3W,Cars	95%
3	MIDC Central road	6 Lane Road	4125	3675	2W,3W,Cars	84%
4	Sahar road	6 Lane Road	4628	4550	2W,3W,Cars	83%
5	S.V.Road	6 Lane Road	6884	6444	2W,3W,Cars	93%
6	M.G.Road	6 Lane Road	3762	4379	2W,3W,Cars	78%
7	Ghodbander Road	8 Lane Road	8483	5673	2W,3W,Cars	78%
8	Link Road	8 Lane Road	10062	8728	2W,3W,Cars	95%
9	Dattapada	8 Lane Road	6798	7651	2W,3W,Cars	90%
10	WEH	8 Lane Road	9853	7608	2W,3W,Cars	82%
11	Cheda Nagar Flyover	3 Lane 1 way	5513	4650	2W,3W,Cars	90%

As observed, the major modes of traffic in all these roads are Cars, Two Wheelers and Three wheelers which account to more than 80% of traffic.

5. Comparative Analysis

Based on the peak hour volume obtained for the roads and the capacity of the respective roads as mentioned in IRC 106:1990, Volume/ Capacity analysis was performed to ascertain the Level of Service of the Roads. This has been tabulated below:

Table 6 Level of Service or selected roads

Sr No	Name of Road	Description	Observed Peak Volume in PCU	Capacity (as per IRC 106:1990)	V/C	LOS
1	Lady Jamshedji Road	4-Lane Road	3517	2900	1.21	F
2	Dubey Road	4-Lane Road	4078	2400	1.69	F
3	MIDC Central Road	6 Lane Road	4125	4300	0.95	E
4	Sahar Road	6 Lane Road	4628	4300	1.07	F

5	S.V.Road	6 Lane Road	6884	4300	1.60	F
6	M.G.Road	6 Lane Road	4379	4300	1.01	F
7	Ghodbander Road	8 Lane Road	8483	7200	1.17	F
8	Link Road	8 Lane Road	10062	7200	1.39	F
9	Dattapada Road	8 Lane Road	7651	7200	1.06	F
10	WEH	8 Lane Road	9853	7200	1.36	F
11	Cheda Nagar Flyover	3 Lane 1 way	5513	3600	1.53	F

Most of the roads considered for the study are arterials and sub-arterial roads though in reality, they all function as collector roads. Standing vehicles or on-site parking is a common site along most of the arterial as well as sub-arterial roads in Mumbai. However, in spite of this, it was observed that for all the roads, existing peak hour volume exceeds IRC prescribed capacity. This has been tabulated below along with the percentage increase of existing peak hour volume as compared to capacity.

Table 7 Comparative study of Capacity values for selected roads

Sr. No.	Road Name	Observed Capacity	Functional Capacity (as per IRC 106:1990)	% Increase
1	Lady Jamshedji Road	3517	2900	20%
2	Dubey Road	4078	2400	70%
3	MIDC Central Road	4125	4300	5%
4	Sahar Road	4628	4300	10%
5	S.V.Road	6884	4300	60%
6	M.G.Road	4379	4300	5%
7	Ghodbander Road	8483	7200	20%
8	Link Road	10062	7200	40%
9	Dattapada Road	7651	7200	6%
10	WEH	9853	7200	38%
11	Cheda Nagar Flyover	5513	3600	45%

Many of the roads tabulated above are functioning with road volumes more than 30 % of the prescribed IRC Capacity. However, neither of these roads is heavily congested in a way which would result in long queues or result in a scenario where travel speed between 25 to 33 % of free speed.

6. Cause and Reasons for increased Road Capacity

An analysis of the cause and reasons for this increased capacity was undertaken. Various factors such as technology, road conditions, modal split and urban phenomenon could be factors affecting observed road capacities. These factors have been elaborated below:

1. Technology:

There has been a sea change in the vehicle technology over the last decade (*for e.g. Maruti 800 (800 cc) used*

to dominate car market then and now Dzire/Swift/I10 (1100 cc) have replaced Maruti 800). The engine, acceleration, speeds, brake, safety features, etc have manifested in a marked increase in mobility of vehicles. The new features such as satellite navigation, congestion / traffic indicators, FM radio traffic broadcasts are further helping in faster dispersal of traffic.

2. Better Roads

   Since 1990, the roads in India have undergone a sea of change. With the advent of cement concrete pavements, the quality of roads have increased manifold in the last two decades resulting in better ridership and faster vehicle speeds. Many junctions have been replaced by flyovers making the ride faster.

3. Familiarity of Roads

   Mumbai is the financial and commercial capital of India. Most of the ridership population of Mumbai comprises of work and education based traffic in the morning and home based return trips in the evening. Thus, familiarity of roads plays an important part in determining the capacity of roads as more familiar roads would mean higher speeds, lesser waiting time and better dispersion rate.

4. Urban traffic characteristics

   Cars, Two wheelers and three wheelers contribute about 80% of traffic in urban roads. This makes a marked difference in vehicle movement as traffic dispersion would be faster as compared to roads with a higher percentage of heavy vehicles. In the past two decades, roads in India have witnessed a sea change in modal split characteristics. Bullock carts, animal drawn vehicles and hand carts completely out of the picture and instead fast moving two wheelers and cars have increased their share. Therefore, this increased percentage of light vehicles is an important criterion in increasing the road capacity in urban areas.

7. Conclusions

Thus, a comparative study was performed for the maximum Road capacity values specified as per IRC 106-1990 to the practical capacity value on-site for urban roads to critically analyze the existing capacity potential of major roads in Mumbai. Based on our study, it was observed that volume per lane for several major roads in Mumbai are beyond the IRC prescribed capacities in range of 5% to 70%.

However, interestingly, no major congestion issues were found in these roads notwithstanding the excessive volume. Some of the reasons – which could be attributed to this increased capacity, are:

1. Technology
2. Better Roads
3. Familiarity of Roads
4. Urban traffic characteristics

8. Way Forward

Thus, keeping all these considerations in mind, it is suggested to update Urban Road capacities in order to bridge this gap between predicted capacities and observed volumes. Considering the changes which has occurred in the last 20 years terms in terms of vehicle technology, better roads, familiarity and urban characteristics, the need of the hour is to revise the road capacity values as in IRC 106:1990 and to propose new capacity standards in tune with current times.

9. References

IRC 86:1983 – Geometric Design Standards for Urban Roads in Plains

IRC 106:1990-Guidelines for Capacity of Urban Roads in Plain areas