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Estimation of Highway Capacity and LOS using LOSPLAN 2012 Software–A Case Study of NH 24

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Abstract—*Planning and management of Indian Transportation system particularly, National Highways has been a challenging prospect for civil engineers considering the heterogenous traffic conditions in India ever since the economic growth in India. In order to accommodate the growing needs and growth in economy of country, there is a need for a transportation which is not only quantitatively sufficient but qualitatively sound as well. For the purpose of providing a sound and quality transportation network, the subject of Transportation planning and management provides a useful and utterly important hand. Though national highways account for only 2% of the total road length, they carry nearly 1/3 of the total traffic. These highways measured over 92,851.05 km as of 2014, including over 1,000 km (620 mi) of limited-access Expressways are of huge financial as well as logistical importance for our country. This paper presents a case study of NH 24 which connects capital of Uttar Pradesh, Lucknow with the national capital Delhi. In this study, trafficflow.*

Keywords: *LOSPLAN 2012 , Classified Traffic Volume Study, Level of Service, National Highway 24*

1. INTRODUCTION

Traffic studies and continuous monitoring of traffic is necessary in order to facilitate the assessment of present and future traffic demands , for the development of need-based infrastructure. Accurate information from traffic surveys and studies is needed for necessary planning, design, construction and maintenance of the country's road network, which is aimed at meeting prevailing traffic flow, future trafficgrowth and loading without considerable deterioration in the quality of service. Traffic Data Collection and projections thereof traffic volumes are basic requirements for planning of road development and management schemes. Videography technique is one of the methods to monitor the characteristics of traffic.

Traffic study of National Highway 24 attempts to determine the traffic stream characteristics through classified traffic volume count and speed study using videography technique and Level of service of operation through LOSPLAN 2012 software which is developed by The Department of Transportation, State of Florida.

Level of Service (LOS) is a term that designates a range of operating conditions on a particular type of facility (HCM, 2010). Developing countries like India need to have a proper level of service (LOS) criteria for various traffic facilities asthis helps in planning, design of transportation projects and also allocating resources to the competing projects.

2. METHODOLOGY

The present study has been done on a four lane section of National Highway 24 connecting state capital of Uttar Pradesh, Lucknow with National capital Delhi via Sitapur, Bareilly, Moradabad and Ghaziabad. The section for videography was near a village BehraChakki**,** which was 18 kms from the city limits of Lucknow in order to avoid city traffic in the study. A 30m stretch of road was marked on both the sides of 4 lane highway. The videocam was mounted at a height of 50 ft (including stand used for videocam) and traffic video was obtained for a duration of 12 hours from 6am to 6pm.

2.1 Classified Traffic volume count

12 Hour video of 7 days was studied and traffic count for different categories of vehicles was tabulated in a spreadsheet. The volume count was converted into their respective passenger car units (PCUs) in order to determine average 12 hour daily traffic count from 7 days data.

This traffic volume count for 7 days gives us the peak hour volume as well as peak hour period under normal conditions of operation of traffic. The 12 hour traffic count was converted into **Average Daily Traffic (ADT)** by taking into account expansion factors obtained from a study on National Highway connecting Lucknow and Agra by Uttar Pradesh Expressways and Industrial Development Authority (UPEIDA). The

obtained ADT was then further converted into **Annual Average Daily Traffic (AADT)** by taking into account seasonal factors obtained from the study on National Highway 2 and a case study on Travel Demand Forecasting by Jahar R. Sarkar and Dr. BhargabMitra, IIT Kharagpur.

2.2 Speed Study

Speed indicates the quality of service experienced by the traffic stream. In this present study, space means speeds have been determined crossing the marked section of road through analysis of video obtained through videography survey. After obtaining the speeds, a frequency distribution table was prepared and plotted on the graph on MS Excel in order to obtain the frequency distribution curve and cumulative distribution curve. From the curves, 85^{th} and 98^{th} percentile speeds have been obtained as desired **design speed**and **maximum operating speed on the road.**

Flow was calculated as well for the period of speed study in order to obtain a speed-flow relationship and hence obtain a speed-flow equation through simple linear regression analysis and obtaining a best fit line on the scatter diagram representing flow and speed on horizontal and vertical axis respectively using MS Excel as done in Ref [5].

2.3 LOS And Estimation of Capacity

Capacity is definedas maximum hourly rate at which persons or vehicles can be expected to traverse a point or uniform section of a lane or roadway during a given time period under prevailing roadway traffic and control conditions, as defined by Highway Capacity Manual, US Transportation Research Board. Level of service (LOS) is a quality measure which is describing operational conditions within a trafficstream in terms of service measures such as speed and travel time, freedom to maneuver and traffic interruptions, comfort and control. Now six levels of service are recognized, it

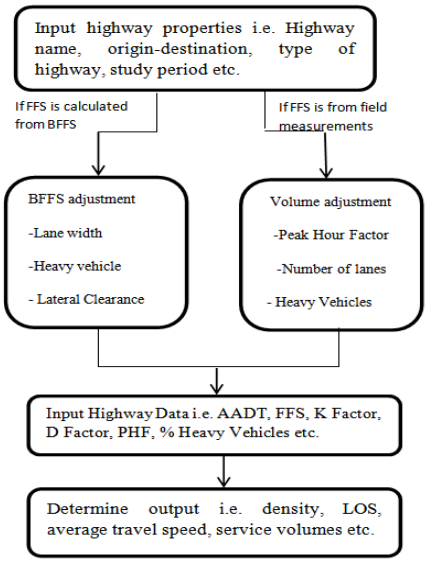

Fig. 1: Flow chart for LOS determination

is designated as from A to F so in short we say LOS A, LOS B and so on with LOS representing the best operating condition so now max freedom to maneuver is possible while it is a free flow condition so obviously LOS A is defined as free flowcondition and LOS F is defined for worst possible operating condition that is the breakdown flow condition.

3. LITERATURE REVIEW

The objective of this study is to determine the classified traffic volume and average speed of vehicles on the highway and calculate the PCU/hour/lane for the highway.National Highway 24 sections status as on 2014 :

- Delhi (UP Gate)–Moradabad Stretch–135km (4 lane toll free movement)
- Moradabad–Bareilly Stretch–121 km (4 lane toll taxed movement)
- Bareilly–Shahjahanpur–Sitapur - 161 km (2 lane, 4 lane widening work in process)
- Sitapur–Lucknow stretch–75 km (4 lane toll taxed movement)

*Velmurugan, S. et al (2011)*analysed vehicular speeds at a micro level and studied the relationship between Space Mean Speed (SMS) and Time Mean Speed (TMS) under heterogeneous traffic conditions.

*Chandra, S. (2004)*has done research on the effect of capacity of two lane roads under the influence of parameters like gradient, lane width, shoulder width, traffic composition, directional split, slow moving vehicles and pavement surface conditions. Dynamic PCU as ratio of speed ratios and space ratio was developed for analysing speed flow characteristics.

Conceptual planning is a type of application detailed enough to reach a decision on design concept and scope, applicable when there is a desire for a good determination of LOS of a facility without doing detailed operational analysis. FDOT's LOSPLAN software, which includes ARTPLAN, HIGHPLAN and FREEPLAN is a major tool in conducting this type of analysis. In general, the software is based on the HCM techniques and the Transit Capacity and Quality of Service Manual (TCQSM). It contains the core tools for site and project specific analysis in planning stages and conducting alternative analysis (eg, four through lanes undivided versus two through lanes with a two way left turn lane) .

Very few attempts are made in India to evaluate capacity standards for multilane highways under heterogeneous traffic and untidy behavior of drivers. IRC guidelines for rural roads (IRC: 64, 1994) were framed in 1990. The traffic characteristics have changed considerably during last two decades.Recognizing this need of having indigenous methods for capacity estimation for Indian highways, CSIR-CRRI initiated the efforts for the "Development of Indian Highway Capacity Manual (Indo-HCM)".

Quality level of service handbook(2013),State of Florida Department of Transportation has been referred for the use of LOSPLAN 2012 and guidelines regarding the Level of service. Also referred as *QLOS Handbook*, it gives generalized as well as conceptual planning for review of capacity and LOS determination.

4. DATA COLLECTION AND ANALYSIS

4.1 On Site Features

The land use near the area of study was agricultural and commercial upto the BakshikaTalab also called as BKT area of Lucknow. After crossing the BKT area, the land use was agricultural with just roadside shops of food etc. Apart from that most of the land was waste or under the residential plot schemes with different builders. The study was done outside the city area, i.e 18 kms outside the city limits near village Behra, Itaunja. However, the highway is flocked with numerous engineering colleges on both the sides of highways, thus contributing to the flow of buses and two-wheelers quite significantly to the traffic.

4.2 Road conditions

The present road width of NH 24 at the section was 25m. Lane width was 3.5m and shoulders provided were of 1.6m distance. Median was provided to provide for four lane divided carriageway. Access point density calculated for a period of 1km was 16 access points per km. There was sufficient lateral clearance, however there was no sufficient land on either side for future land widening, if any.

Earthquake zones demarcate different zones which depend upon the vulnerability of earthquake. Etawah lies in Uttar Pradesh state which lies in zone III which is moderate zone.

4.3 Classified Traffic Volume Count

The classified traffic volume count was obtained from the 12 hour traffic video done on the section. The classified average traffic volume count from the period of 7 days are as follows :

- Average vehicles count on Up side (towards Sitapur-Delhi) is 10476 veh/day or 12456 PCUs/day and on Down side (towards Lucknow) is 10417veh/day or 11667 PCUs/day.
- Average vehicles count on both sides was 20893 veh/day or 24075.5 PCUs/day
- The distribution of various modes of travel is given in Fig. 2.
- Peak Hour Volume is 2064 vehicles or 2310 PCUs during the evening time 5pm-6pm

Computation for ADT

ADT = 12 hr volume count * Expansion Factor (1)

Expansion Factor = 1.6 (...from a study of Uttar Pradesh Expressway AndInustrial Development Authority for Lucknow-Agra Highway Ref [1])

Hence ADT = 20893 * 1.6 = 33429 vehicles/day

Computation for AADT

Seasonal variation factors are determined from a case study on Travel Demand Forecasting by Jahar R. Sarkar and Dr. Bhargab Mitra, IIT Kharagpur.

Average Seasonal Index (Nov-Feb) = 100

Average Seasonal Index (Mar-June) = 88

Average Seasonal Index (July-Oct) = 77

Average Seasonal Index = 88.3

Traffic study conducted in the month of September hence average seasonal factor :

= 88.3–77 = 11.3

Hence ADT to be increased by 11.3% to obtain AADT

AADT = 33423 + (0.113*33423) = 37207 veh/day

The graphical distribution of traffic volume study is as follows

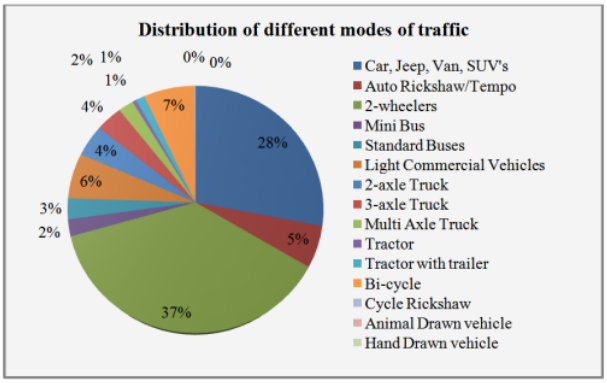

Fig. 2: Distribution of different modes of transportation from traffic study

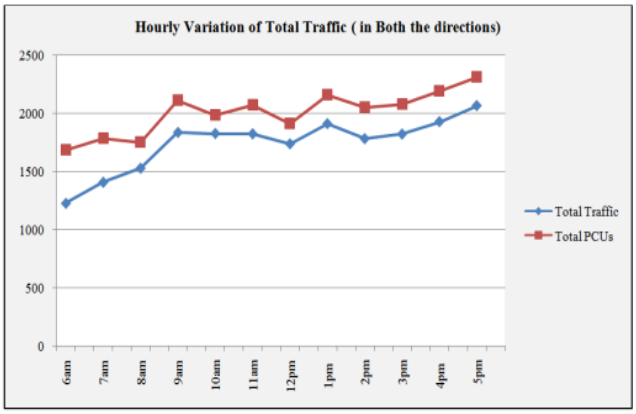

Fig. 3: Hourly Variation Distribution of Total Traffic

4.4 Speed Study

Speed Study is done in order to calculate the speed distribution of the vehicles passing through the section. A period of 1 min is selected randomly in every hour of study each day and analysed to calculate the time required for each vehicle to pass through the marking placed at 30m distance apart. Flow value for the period of speed study is also calculated in order to plot the speed-flow relationship.

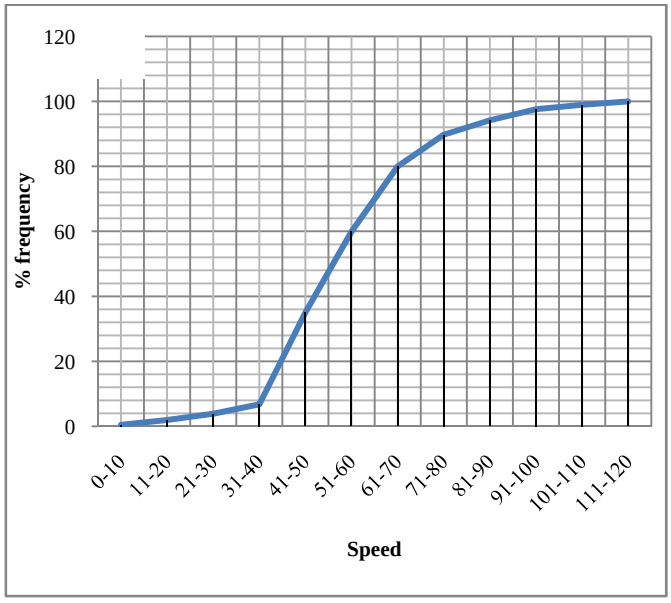

Fig. 4: Cumulative frequency distribution of speed

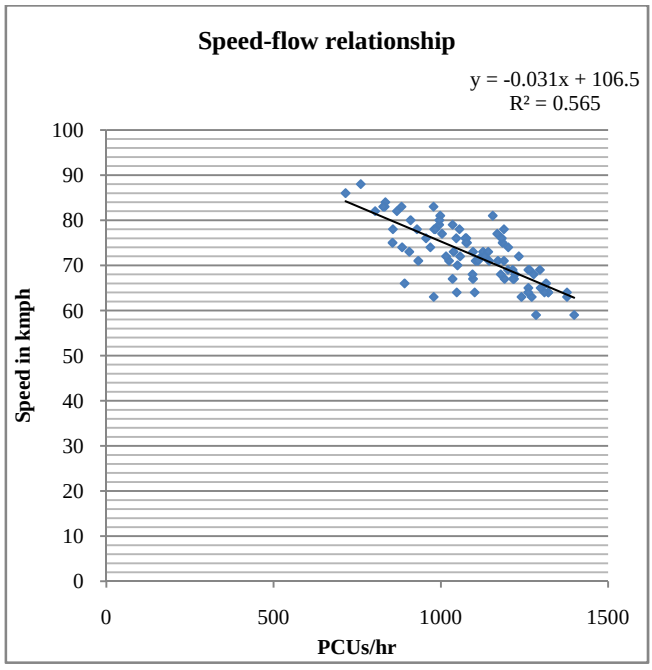

Fig. 5: Speed–Flow relationship

From the cumulative distribution curve we obtain

85^{th} percentile speed as the average speed of the highway = 75kmph

98^{th} percentile speed as the maximum speed of the highway = 103 kmph

Mode of frequency distribution curve of speed comes out to be at 50 kmph, hence the modal speed.

The speed flow graph is plotted as given below in Fig. 5 through scatter diagram and obtaining a best fit line representing the relationship between speedand flow.

The graph shows the usual trend of decreasing speed with increasing flow.

4.5 Capacity And LOS Calculation

Capacity and LOS of highway has been determined through LOSPLAN 2012 software developed by FDOT. LOSPLAN software contains three modules namely, HIGHPLAN, FREEPLAN and ARTPLAN. HIGHPLAN has been used for the determination of LOS and service volumes since the facility is a multi-lane highway. The software is based on the techniques of HCM 2010, Transportation Research Board as mentioned in section 3 of the paper. The methodology adopted as given in section 2.3 of this paper.

Geometric data

4-lane divided highway with median

Lane width 3.5m and level is terrain

Determination of free flow speed

FFS is the free flow speed for vehicles travelling in moderate to low conditions.

FFS = 80kmph (average speed of PCUs for flow less than 900PCus per hour in peak direction)

In absence of field values, take BFFS as 110kmph and apply in basic equation and adjusting it as per need :

$$FFS = BFFS - f_{LW} - f_{LC} - f_M - f_A \quad (2)$$

However, field values if present should be preferred.

Computation of K Factor

K Factor is the ratio of the traffic volume in the study period or peak hour period to the annual average daily traffic indicated as percent. The range of acceptable values depends on the type of analysis performed and the area of analysis which is as follows :

Standard K

Two-Lane Segment

9.0 for Large/Other Urbanized and Transitioning/Urban

9.5 for Rural Developed and Rural Undeveloped

Multilane Segment

9.0 for Large/Other Urbanized and Transitioning/Urban 9.5 for Rural Developed and Rural Undeveloped

Two-Lane Facility: 9.0 - 15.0 (all area types)

Kother
Two-Lane Segment: 1.0 - 20.0 (all area types)

Multilane Segment: 1.0 - 20.0 (all area types)

Two-Lane Facility: 9.0 - 15.0 (all area types)

DirHr Demand Vol
Two-Lane Segment

9.0 for Large/Other Urbanized and Transitioning/Urban

9.5 for Rural Developed and Rural Undeveloped

Multilane Segment:

9.0 for Large/Other Urbanized and Transitioning/Urban

9.5 for Rural Developed and Rural Undeveloped

Two-Lane Facility: 9.0 - 15.0 (all area types)

K Factor = Peak Hour Volume/AADT * 100
= 2064/37207 * 100 = 5.6% (rounded to 1stdp)

Determination of D Factor

The proportion of traffic during the study period travelling in the predominant or peak direction indicated as a percent. For example, a D Factor of 50% indicates equal traffic in both the directions, a D Factor of 95% indicates 95% traffic in peak direction whereas a D Factor of 100% indicates a one-way street.

D Factor = 10476/20893 * 100
= 50.2 % (rounded off to 1stdp)

Determination of PHF Factor

Peak hour factor or PHF Factor is the ratio of the hourly volume to the peak 15-min flow rate within the hour times four. The range of acceptable value is between 0.75-1.00.

PHF = 0.88 (default value for multi-lane highways as per HCM 2010)

Fig. 6: Window for inputting properties of highway

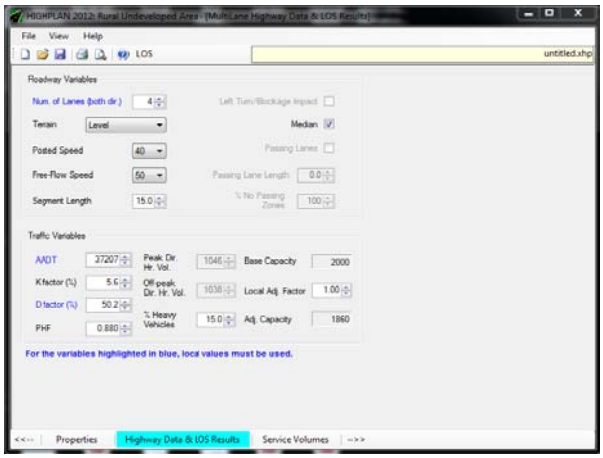

Fig. 7: Window for inputting Highway Data

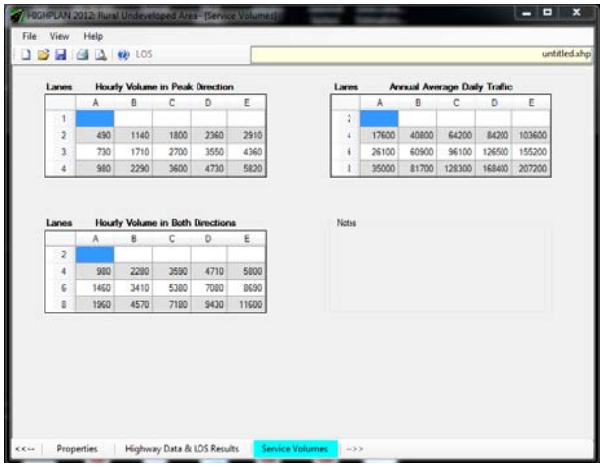

Fig. 8: Output window for service volumes

LOS report is as follows :

HIGHPLAN 2012 Conceptual Planning Analysis

Project Information

Analyst	Rishi	Highway Name	NH 24	Study Period	Kother
Date Prepared	14-Jan-15 3:16:13 AM	From	Lucknow	Analysis Type	Multilane Segment
Agency		To	Delhi	Program	HIGHPLAN 2012
Area Type	Rural Developed	Peak Direction	Westbound	Version Date	12/12/2012
File Name	untitled.xhp				
User Notes					

Highway Data

Roadway Variables				Traffic Variables			
Segment Length	1.000	Median	Yes	AADT	37207	PHF	0.880
# Thru Lanes	4	Left Turn Impact	No	K	0.056	% Heavy Vehicles	15.0
Terrain	Level	Pass Lane Length	N/A	D	0.502	Base Capacity	2000
Posted Speed	40	% NPZ	N/A	Peak Dir. Hrly. Vol.	1046	Local Adj. Factor	1.00
Free Flow Speed	50	Class	3	Off Peak Dir. Hrly. Vol.	1038	Adjusted Capacity	1860

LOS Results

v/c Ratio	0.32	Density	12.8	PTSF	N/A	ATS	50.0	% FFS	100.0
FFS Delay	0.0	LOS Thresh. Delay	12.0	Service Measure	Density	LOS	B		

Service Volumes

Note: The maximum normally acceptable directional service volume for LOS E in Florida for this facility type and area type is 0 veh/h/ln.

	A	B	C	D	E
Lanes	Hourly Volume In Peak Direction				
1					
2	490	1140	1800	2360	2910
3	730	1710	2700	3550	4360
4	980	2290	3600	4730	5820
Lanes	Hourly Volume In Both Directions				
2					
4	980	2280	3590	4710	5800
6	1460	3410	5380	7080	8690
8	1960	4570	7180	9430	11600
Lanes	Annual Average Daily Traffic				
2					
4	17600	40800	64200	84200	103600
6	26100	60900	96100	126500	155200
8	35000	81700	128300	168400	207200

* Cannot be achieved based on input data provided.
# Performance measure results are no longer applicable with the presence of passing lanes. Refer to the service volume tables to obtain the LOS.

5. CALCULATIONS BASED ON HCM 2010

Firstly FFS is determined either from field observations or using the basic equation relating BFFS and FFS. FFS is the free flow of speed in low to moderate conditions.

$$BFFS = FFS + f_{LW} + f_{LC} + f_M + f_A$$

In presence of field observations, they should be preferred over BFFS equation. FFS from field observations for low to moderate conditions of flow (taken as less than 900PCUs/hr in peak direction) comes out to be 80kmph i.e. 50mph.

Flow rate = $(AADT * K * D)/(N*PHF*f_{HV}*f_p)$

Where N is the number of lanes in peak direction

f_{HV}= adjustment due to heavy vehicles

$$=1/ (1+ P_T (E_T - 1) + P_R(E_R-1) = 0.93$$

$P_T$and P_R are percentage of trucks, buses and recreational vehicles respectively.

$E_T$and E_R are equivalents depending upon grade.

f_p= 1.0 (for commuter traffic varies on nature of traffic)

Flow rate = 640 PCUs/hr/lane

		LOS				
Free-Flow Speed	Criteria	A	B	C	D	E
100 km/h	Maximum density (pc/km/ln)	7	11	16	22	25
	Average speed (km/h)	100.0	100.0	98.4	91.5	88.0
	Maximum volume to capacity ratio (v/c)	0.32	0.50	0.72	0.92	1.00
	Maximum service flow rate (pc/h/ln)	700	1100	1575	2015	2200
90 km/h	Maximum density (pc/km/ln)	7	11	16	22	26
	Average speed (km/h)	90.0	90.0	89.8	84.7	80.8
	Maximum v/c	0.30	0.47	0.68	0.89	1.00
	Maximum service flow rate (pc/h/ln)	630	990	1435	1860	2100
80 km/h	Maximum density (pc/km/ln)	7	11	16	22	27
	Average speed (km/h)	80.0	80.0	80.0	77.6	74.1
	Maximum v/c	0.28	0.44	0.64	0.85	1.00
	Maximum service flow rate (pc/h/ln)	560	880	1280	1705	2000
70 km/h	Maximum density (pc/km/ln)	7	11	16	22	28
	Average speed (km/h)	70.0	70.0	70.0	69.6	67.9
	Maximum v/c	0.26	0.41	0.59	0.81	1.00
	Maximum service flow rate (pc/h/ln)	490	770	1120	1530	1900

Fig. 9: LOS criteria for multi-lane highways

Now average speed (S) for flow rate less than 1400PCUs/hr/lane is same as FFS, i.e. 50mph

Density = Flow rate/S

= 640/50

= 12.8 PCUs/mile/lane or 8 PCUs/km/lane

Determining LOS from LOS criteria given in HCM.

Basic Capacity = 2200–20(60-FFS) , FFS in mph

= 2000 veh/hr

Peak Capacity (C) = Base Capacity*PHF*N*f_{HV}*f_p

= 2000*0.88*2*0.93*1.00

= 3273.6 veh/hr

Hence v/c ratio comes out to be :

V = DDHV = AADT*K*D

= 1046 veh/hr

V/C = 1046/3273.6 = 0.32

6. CONCLUSION

The study concludes that the peak direction hourly volume (DDHV) of the highway is 1046 PCU/hr and has ADT of 33429 veh/day and AADT of 37207 veh/day. The average travel speed from the speed study comes out to be 75kmph while LOS results give average speed as 80kmph based upon the free flow speed. LOS of the given highway facility NH 24 comes out to be LOS B as density comes out to be 12.8 veh/miles while density of 18veh/mile at free flow speed of 80kmph will pass it into LOS C. Traffic can be easily forecasted based on different methods of traffic demand forecasting to forecast the time required for highway to attain subsequent levels of service and hence accordingly maintenance or widening work can be planned out.

LOSPLAN 2012 thus helps in calculating the LOS and helps in planning of transportation facilities. HCM 2010, the manual on which the software is based is the most widely used manual for determination of LOS and other traffic characteristics as well. LOSPLAN software not only determines primary outputs such as number of lanes required, operational LOS and maximum flow rate achievable but also secondary output values such as maximum hourly volume in peak and both the directions, maximum AADT for different combinations of LOS and number of lanes.

Performance measures such as density, speed, v/c ratio and PTSF (percent time spent following) wherever applicable can be easily determined using the software.

REFERENCES

[1] UPEIDA, "A Traffic Report on Agra-Lucknow Green Field Project" , 2013
[2] TRB, HCM(2000) ,*National Research Council, Highway Capacity Manual.*: Washington D.C.
[3] HCM(2010), Highway Capacity Manual. TRB.www.hcm.trb.org/
[4] Highway Performance Monitoring System Field Maual, FHA, (2010) US Department of Transportation, http://www.fhwa.dot.gov/policyinformation/hpms/fieldmanual
[5] Chandra S. (2004) , " Capacity Estimation Procedure for two lane roads under mixed traffic conditions*", Journals of Indian Road Congress*, New Delhi 165-170.
[6] Quality Level of Service Handbook(2013), Department of Transportation, Florida, US.