IMPACT OF GEOMETRIC CHARACTERISTICS ON CAPACITY OF HILL ROADS

ACHYUT DAS

DEPARTMENT OF CIVIL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

OCTOBER-2018

IMPACT OF GEOMETRIC CHARACTERISTICS ON CAPACITY OF HILL ROADS

by

ACHYUT DAS

Civil Engineering department

Submitted

in fulfillment of the requirements of the degree of Doctor of Philosophy

to the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

OCTOBER-2018

CERTIFICATE

This is to certify the thesis titled "**Impact of geometric characteristics on capacity of hill roads**" being submitted by **Mr. Achyut Das** to the Indian Institute of Technology, Delhi, India, for the award of the degree of **DOCTOR OF PHILOSOPHY**, is a record of original bona-fide research work carried out by him. Mr. Achyut Das has worked under our guidance and supervision. To the best of our knowledge, the thesis has reached the requisite standard. The material contained in this thesis has not been submitted, in part or in full to any other University or Institute for the award of any degree or diploma.

(Dr. Kalaga Ramachandra Rao)
Professor
Department of Civil Engineering
and Transportation Research and Injury
Prevention Programme
Indian Institute of Technology Delhi
New Delhi, India

(Dr.Geetam Tiwari)
Professor
Department of Civil Engineering
and Transportation Research and Injury
Prevention Programme
Indian Institute of Technology Delhi
New Delhi, India

ACKNOWLEDGEMENTS

I would like to express my sincere thanks and deep sense of gratefulness to my thesis supervisors, Dr. Kalaga Ramachandra Rao, Professor, and Dr. Geetam Tiwari, Professor Department of Civil Engineering for their inspiring guidance and constant encouragement without which this thesis could not have been completed. Their critical reviews, constructive comments and motivating discussions improved my grasp on the subject and steered to the fruitful completion of the work. They provided excellent help and understanding in every step of my work right from day one. In spite of their hectic and busy schedule they made it a point to spare time for me for valuable discussions and sharing wealth of their knowledge and expertise on the subject. Their dedication, punctuality, and elegant presentations motivated me to carry out my research work in a systematic way. My gratitude towards them is also for allowing me to use the computing and other facilities in Transportation lab. Moreover, I must acknowledge that they always stood behind me during this Ph.D. periods and provided strong moral support.I also take this opportunity to express my heartfelt thanks to the SRC members for their useful suggestions. I would like to express my thanks to my fellow research scholars Mr. Hassan, Mr. A.M.Rao, Mr.Gaurav Pandey,Mr. Hari, Ms.Laxmi, Mr. Amit, Mr.Mandal, Mr. Mohit and Ms. Abhari for their co-operation and excellent company, though they were themselves busy with their thesis activities. My thanks are also to all the office staff of the department for their kind support and co-operation. I also thank to Dr. Atul Bora, D.T.E. of Assam who helped me providing survey instrument in measuring gradient at my data collection site. In this connection I also like to offer thanks to Assistant engineer of P.W.D. office, Cherapunjee branch, Meghalaya and Mr. Astu Gautam, M.Tech.Student of IITDelhi.

Last but not the least; I convey my thanks to one and all who have contributed to the realization of this thesis.

Achyut Das

ABSTRACT

The majority of National and State Highways of India is two-way two-lane undivided highway. These two-lane two-way highway reach its maximum capacity very soon and so it needs constant up gradation from two lane to four or six lanes because of the fact that there is a steady increase in the growth of vehicles in India by approximately 7.5% to 8%.To accommodate such growth of vehicular traffic, the existing highways need to be improved and new highways need to be proposed and constructed. Hence traffic forecasts and capacity estimation of a highway is crucial for the development of highways and also safety movement of people and goods on inland modes. Being heterogeneous traffic, Passenger car unit (P.C.U.) was determined by three methods; namely Modified density method (M.D.M.), Area occupancy method (A.O.M.) and Speed Area Ratio method. The road traffic in India is highly heterogeneous comprising vehicles of wide ranging physical dimensions, weight, power and dynamic characteristics. Hence, to understand the implications of capacity augmentation, traditional method is used to establish the speed-flow relationship for the two lane two-way roads in India. However considering limitations of the traditional method, efforts were made to develop microscopic traffic simulation model for establishing speed-flow relationship and roadway capacity for the two-lane two-way roads. The heterogeneous traffic conditions witnessed even on the hill roads is hampered due to the presence of motorized two wheelers, slow moving commercial heavy vehicles. This in turn contributes to the changing speed characteristics on the two lane two-way roads. Capacity and level of service (L.O.S.) were also calculated by different methods. As the estimated capacity was below than expected capacity value so simulation was done with the help of VISSIM.The different percentage of traffic are combined and traffic were plied on the road with changing simulation time, volume input and speeds. The simulation was also run with changing the gradient. It means the effect of influencing parameter gradient, lane width, shoulder width, traffic composition, directional split, slow moving vehicles, rate of vertical curvature for SSD and OSD for crest and sag curves on capacity of two-lane two-way roads under mixed traffic conditions are studied in this thesis. . The passenger car equivalent value for plain road was found as 4.49, 3.88 and 2.79 for truck, 5.36, 3.6 and 2.21 for buses, 0.24, 0.69 and 0.89 for two-wheeler by speed area, area occupancy and modified density method

respectively. But according to IRC:64-1990 for hill road and IRC:73-1980 for rural road , for truck and bus the PCE value is 3 and for two wheeler it is 0.50 for both hill and plain road.

सार

भारत के राष्ट्रीय और राज्य राजमार्गों का बहुमत दो-तरफा दो-लेन अविभाजित राजमार्ग है। ये दो लेन दो-तरफा राजमार्ग अपनी अधिकतम क्षमता तक पहुंच जाता है और इसलिए इसे दो लेन से चार या छह लेन तक निरंतर अपग्रेड की आवश्यकता होती है क्योंकि इस तथ्य के चलते कि भारत में वाहनों के विकास में लगातार 7.5% 8% तक। वाहन यातायात के इस तरह के विकास को समायोजित करने के लिए, मौजूदा राजमार्गों में सुधार की जरूरत है और नए राजमार्गों को प्रस्तावित और निर्माण करने की आवश्यकता है। इसलिए राजमार्गों के विकास के लिए यातायात पूर्वानुमान और राजमार्ग की क्षमता अनुमान महत्वपूर्ण है और अंतर्देशीय तरीकों पर लोगों और वस्तुओं की सुरक्षा आंदोलन भी महत्वपूर्ण है। विषम यातायात होने के नाते, यात्री कार इकाई (पी.सी.यू.) तीन तरीकों से निर्धारित की गई थी; अर्थात् संशोधित घनत्व विधि (एमडीएम), क्षेत्र अधिभोग विधि (एओएम) और स्पीड एरिया अनुपात विधि। भारत में सड़क यातायात अत्यधिक विविध भौतिक आयामों, वजन, शक्ति और गतिशील विशेषताओं के वाहनों सहित अत्यधिक विषम है। इसलिए, क्षमता वृद्धि के प्रभाव को समझने के लिए, पारंपरिक विधि का उपयोग भारत में दो लेन दो-तरफा सड़कों के लिए गति प्रवाह संबंध स्थापित करने के लिए किया जाता है। हालांकि पारंपरिक पद्धति की सीमाओं पर विचार करते हुए, दो लेन वाली दो-तरफा सड़कों के लिए स्पीड फ्लो रिलेशनशिप और रोडवे क्षमता स्थापित करने के लिए माइक्रोस्कोपिक ट्रैफिक सिमुलेशन मॉडल विकसित करने के प्रयास किए गए। मोटरसाइकिल दो व्हीलर्स, धीमी चलती वाणिज्यिक भारी वाहनों की उपस्थिति के कारण पहाड़ी सड़कों पर भी देखी गई विषम यातायात की स्थिति में बाधा आ गई है। यह बदले में दो लेन दो-तरफा सड़कों पर बदलती गति विशेषताओं में योगदान देता है। क्षमता और स्तर के स्तर (एलओएस) की भी विभिन्न विधियों द्वारा गणना की गई थी। चूंकि अनुमानित क्षमता अपेक्षित क्षमता मूल्य से कम थी, इसलिए VISSIM की सहायता से सिमुलेशन किया गया था। यातायात के विभिन्न प्रतिशत संयुक्त होते हैं और सिमुलेशन समय, वॉल्यूम इनपुट और गति को बदलने के साथ सड़क पर यातायात लगाया जाता है। अनुकरण को ढाल बदलने के साथ भी चलाया गया था। इसका मतलब है कि पैरामीटर ढाल, लेन चौड़ाई, कंधे की चौड़ाई, यातायात संरचना, दिशात्मक विभाजन, धीमी गति से चलने वाले वाहनों, एसएसडी के लिए लंबवत वक्रता की दर और मिश्रित के तहत दो-लेन दो-तरफा सड़कों की क्षमता पर क्रिस्ट और साग वक्र के लिए ओएसडी को प्रभावित करने का प्रभाव इस थीसिस में यातायात की स्थिति का अध्ययन किया जाता है। । सादे सड़क के लिए यात्री कार समकक्ष मूल्य क्रमश: स्पीड एरिया, क्षेत्र अधिभोग और संशोधित घनत्व विधि द्वारा दोपहिया के लिए बसों, 0.24, 0.6 9 और 0.8

9 के लिए ट्रक, 5.36, 3.6 और 2.21 के लिए 4.4 9, 3.88 और 2.79 के रूप में पाया गया था। लेकिन आईआरसी के अनुसार: पहाड़ी सड़क और आईआरसी के लिए 64-19 0 9: ग्रामीण सड़क के लिए 73-1980, ट्रक और बस के लिए पीसीई मूल्य 3 है और दो पहिया के लिए यह पहाड़ी और सादे सड़क दोनों के लिए 0.50 है।

List of Contents

List of Tables

List of Figures

NOTATIONS

A.O.M. – Area occupancy method

Acptpkm-Access point per kilometer

Critical density **(**k_c) **-** The maximum density achievable under free flow is $k_{c.}$

FFS- Free flow speed

H.C.M. – Highway capacity manual

Jam density **(**k_j)- The maximum density achieved under congestion is k_j. In general, jam density is seven times the critical density.

KSSDcrest- Radius of curvature (K) value for stopping sight distance in crest vertical curve, m

KSSDsag - Radius of curvature (K) value for stopping sight distance in sag vertical curve, m

KOSDcrest - Radius of curvature (K) value for overtaking sight distance in crest vertical curve

KOSDsag - Radius of curvature (K) value for overtaking sight distance in sag vertical curve

L.O.S. – Level of service

M.D.M. – Modified density method

MTW - motorized two-wheeler

Optimum density- It is defined as the density level that exists when the traffic in the lane is flowing at capacity. Optimum density is normally around 36 to 48 vehicles per lane-mile, which corresponds to average distance headway of 110 to 147 feet.

P.C.U.-Passenger car unit

PCE- Passenger car equivalent

q_{b-} Base flow in vehicles/hour

q_{m-} Mixed flow

RTA-Road traffic accidents

S.A.M.- Speed area method

S.D.-Standard deviation

$\rho_{(A)}$- Area occupancy measured over space and time

%H.V.-Percentage of Heavy vehicles