APPLICABILITY OF HCM 2000 TO DETERMINE THE LEVEL OF SERVICE IN URBAN ARTERIAL ROADS, SRI LANKA

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Abstract: The objective of this research is to identify the applicability of Highway Capacity Manual (HCM) to determine the Level of service in urban minor arterial roads in Sri Lanka.
HCM has been developed by the transport research board, USA. Currently most of the local road development agencies use HCM for capacity analysis of roads. There have been no researches carried out to identify the applicability of HCM to the Sri Lankan condition. To depict the quality of service of the roads quantitative measures of a traffic stream are required. Level of Service (LOS) is a quality measure describing operational conditions within a traffic stream, generally in terms of service measures such as speed and travel time, freedom to maneuver, traffic interruptions and comfort.
Six LOS are defined based on service flow rates of roads. Letters designate each level from A to F with LOS A representing the best operating conditions and LOS F the worst. Though the local roads have acceptable LOS, the results obtained from both HCM 2000 and1986 have not reflected it.
It is required to identify the factors which affect the LOS. For that a sample of two way - two lane roads were selected. For the selected sample flow vs. density curves have been developed by considering traffic data and speed survey data. Based on the literature findings and data collected from the field, six LOS for the urban minor arterial roads have been defined.

Keywords: Highway Capacity Manual, Level Of Service, Two way two lane highways

1. Introduction

The **Highway Capacity Manual** (HCM) is a publication of the Transportation Research Board (TRB) in the United States. It contains concepts, guidelines, and computational procedures for computing the capacity and quality of service of various highway facilities, including freeways, highways, arterial roads, roundabouts, signalized and unsignalized intersections, rural highways, and the effects of mass transit, pedestrians, and bicycles on the performance of these systems. There have been five editions with improved and updated procedures from 1950 to 2010. The HCM has been a worldwide reference for transportation and traffic engineering scholars and practitioners, and also the base of several country specific capacity manuals.
Level of service (LOS) is a measure used by traffic engineers to determine the effectiveness of elements of transportation infrastructure. LOS is most commonly used to analyse highways by categorizing traffic flow with corresponding safe driving conditions.

Although speed is a major concern of drivers as related to service quality, freedom to maneuver with in the traffic stream and proximity to other vehicles are equally noticeable concerns.
These qualities are related to the density of the traffic stream
The LOS are defined to represent reasonable ranges in the three critical flow variable

- → Speed
- → Density
- → Flow rate

Level-of-Service A :(Figure 1(a)) Describes free-flow operations. Traffic flows at or above the posted speed limit and all motorists have complete mobility between lanes. The average spacing between vehicles is about 550 ft (167m) or 27 car lengths. Motorist has a high level of physical and psychological comfort. The effects of incidents or point breakdowns are easily absorbed. An example of LOS A occurs late at night in urban areas, frequently in rural areas, and generally in car advertisements.

Level-of-Service B:(Figure 1(b))Describes reasonable free-flow operations. Free-flow (LOS A) speeds are maintained, maneuverability within the traffic stream is slightly restricted. The lowest average vehicle spacing is about 330 ft(100m) or 16 car lengths. Motorist still have a high level of physical and psychological comfort.

Level-of-Service C:(Figure 1(c))Describes at or near free-flow operations. Ability to maneuver through lanes is noticeably restricted and lane changes require more driver awareness. Minimum vehicle spacing is about 220 ft(67m) or 11 car lengths. At LOS C most experienced drivers are comfortable, roads remain safely below but efficiently close to capacity, and posted speed is maintained. Minor incidents may still have no effect but localized service will have noticeable effects and traffic delays will form behind the incident. This is the targeted LOS for some urban and most rural highways.

Level-of-Service D: Figure 1(d) Describes decreasing free-flow levels. Speeds slightly decrease as the traffic volume slightly increases. Freedom to maneuver within the traffic stream is much more limited and driver comfort levels decrease. Vehicles are spaced about 160 ft(50m) or 8 car lengths. Minor incidents are expected to create delays. Example of LOS D is perhaps the level of service of a busy shopping corridor in the middle of a weekday, or a functional urban highway during commuting hours. It is a common goal for urban streets during peak hours, as attaining LOS C would require a prohibitive cost and societal impact in bypass roads and lane additions.

Level-of-Service E: (Figure 1(e) Describes operations at capacity. Flow becomes irregular and speed varies rapidly because there are virtually no usable gaps to manoeuvre in the traffic stream and speeds rarely reach the posted limit. Vehicle spacing is about 6 car lengths, however speeds are still at or above 50 mi/h(80 km/h). Any disruption to traffic flow, such as merging ramp traffic or lane changes, will create a shock wave affecting traffic upstream. Any incident will create serious delays. Driver's level of comfort becomes poor. LOS E is a common standard in larger urban areas, where some roadway congestion is inevitable.

Level-of-Service F : (Figure 1(f)) Describes a breakdown in vehicular flow. Flow is forced; every vehicle moves in lockstep with the vehicle in front of it, with frequent slowing required. Technically, a road in a constant traffic jam would be at LOS F. This is because LOS does not describe an instant state, but rather an average or typical service. For example, a highway might operate at LOS D for the AM peak hour, but have traffic consistent with LOS C some days, LOS E or F others, and come to a halt once every few weeks. However, LOS F describes a road for which the travel time cannot be predicted. Facilities operating at LOS F generally have more demand than capacity.

Figure 1(a)

Figure 1(b)

Figure 1(c)

Figure 1(d)

Figure 1(e)

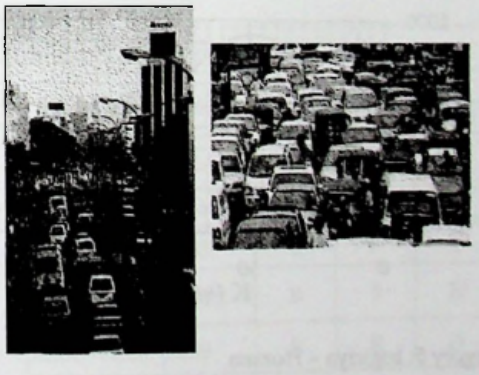
Figure 1(f)

There are several issues regarding the LOS obtaining from the both Highway capacity manual 1986 & 2000. The road conditions in the USA (which is highway capacity manual developed for) is different from the conditions of local roads (Figure 2). Main variations identified are

- Road side environment
- Vehicle Mix
- Jam densities

(a) (b)

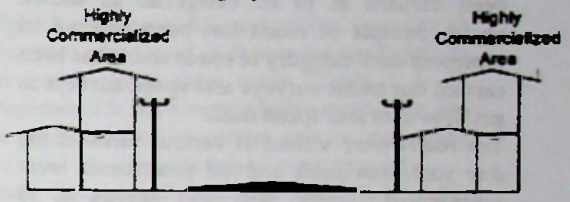
Figure 2 : USA Roads
(a) - Road Side Environment
(b) - Vehicle Mix



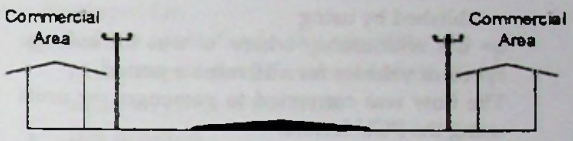
2. Methodology

The method to determine the LOS as given in the Highway Capacity Manual takes into consideration only the flow characteristics of traffic. However, the jam densities and general vehicle densities of Sri Lankan roads are very different from that of US conditions which the methods have been developed for. Therefore the method we propose is to obtain the flow density curves for a sample of urban roads with various roadway and roadside characteristics

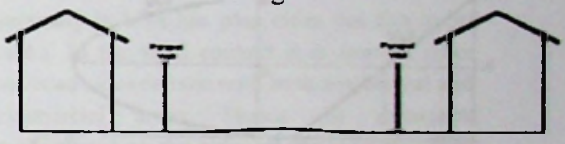
Category 1: Highly Commercialized area



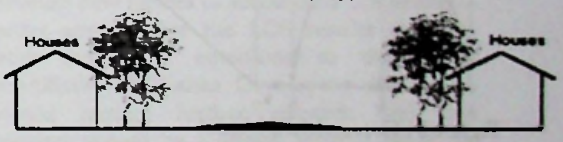
Category 2: Moderately Commercialized area



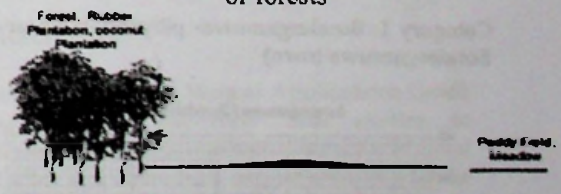
Category 3: residential area with tall parapet wall along road



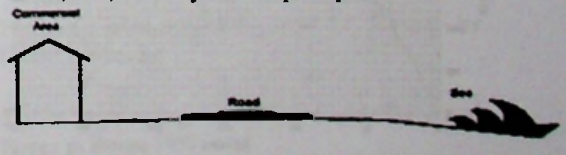
Category 4: Residence area with houses and trees close to the road



Category 5: Roads across paddy fields, Plantations or forests



Category 6: One side of the road is river, stream, drain, sea, railway or steep slope.



and then define levels of service using those curves. The levels of service obtained by this method are considered the true level of service for Sri Lankan urban roads.

All urban arterial two-way two lane roads have been divided in to six categories as shown above. Sample of roads has been selected to represent each category of roads and it has been carried out traffic surveys and speed surveys to get flow data and speed data.

The roads were visited at various times of the day such that peak and off peak times were represented. Traffic flow and speeds at 15 minute intervals at various times of the day were recorded and the densities were established by using

q= u k relationship where 'u' was the average speed of vehicles for a 10 minute period.

The flow was converted to passenger car units using the PCU factors.

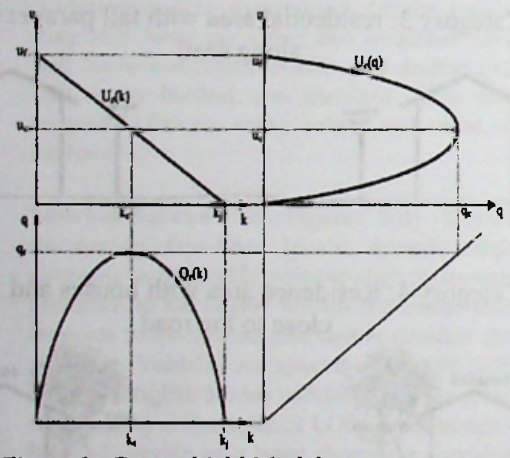
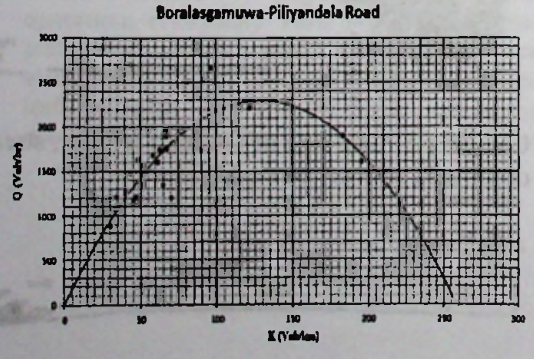


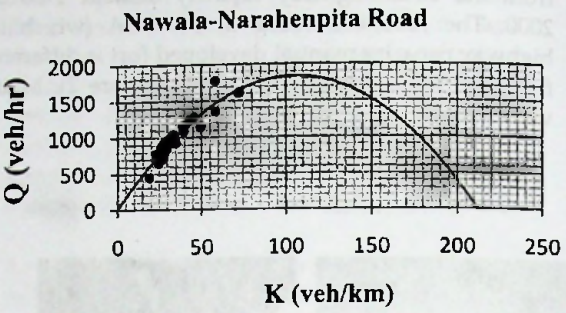
Figure 3 : Green shield Model

3. Results

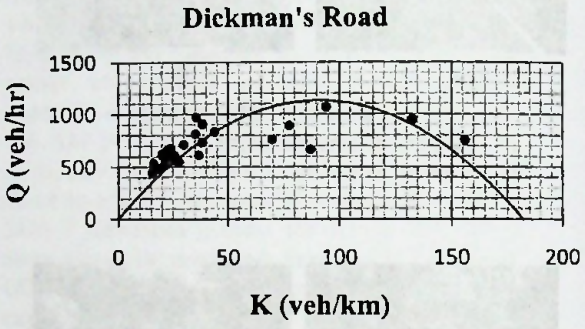
Category 1: Boralesgamuwa- piliyandala (Near Boralesgamuwa town)



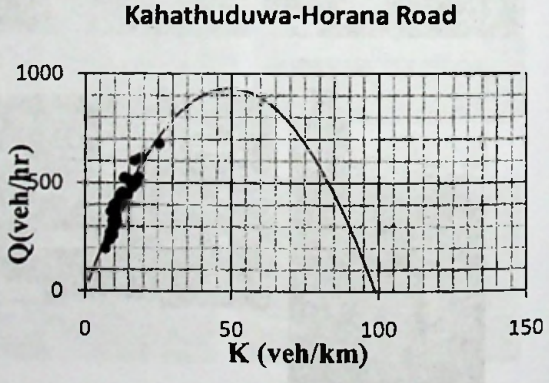
Category 2: NawalaNarahenpita Road



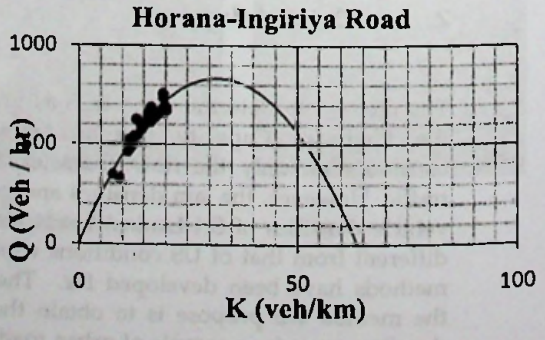
Category 3: Dickmen's Road



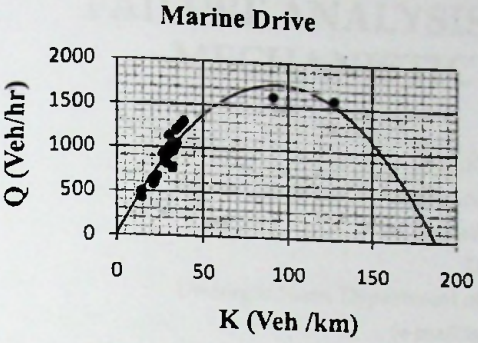
Category 4: Pilyandala - Horana (Near Kahathuduwa)



Category 5: Ingiriya - Horana



Category 6: Marine Drive



From the data it has been calculated the jam density, free flow speed and maximum flow rate for the each category of roads.

Table 1			
	k_j	u_f	q_{max}
Category1	235	33.926	1993.153
Category2	234	33.926	1984.671
Category3	152.5	30.549	1164.681
Category4	185	34.92	1615.05
Category5	76	49.932	948.708
Category6	241	36.156	2178.399

Table 2 : Results For Category 1				
Time	Volume	LOS		
		Actual	1986	2000
6.00 - 7.00	997	B	E	D
7.00 - 8.00	2121	C	F	E
8.00 - 9.00	2283	C	F	E
9.00 -10.00	1284	B	F	E
10.00 -11.00	1089	B	E	D

There are three models to analysis traffic flows. They are

- Green shield model
- Hydrodynamic model
- Eddie's model

We used green shield model as the most suitable model for our data.

Here the q_{max} represent the capacity of the road which is equivalent to the LOS E.

4. Conclusions

Highway Capacity Manual yields lowerlevels of service when used to determine the Levels of Service of Sri Lankan roads (Table 1 & 2). Therefore it is not a very reliable method to use for estimation of capacities and to determine the need for rehabilitation of existing roads.
These discrepancies can be attributed to the following major differences between Sri Lankan roads and US roads, which these equations had been developed for.

- Vehicle mix and the inability to incorporate this difference to the LOS equation given in the HCM
- Jam densities
- Roadside environment and number of accesses to the roads

Generally In USA has plan cities not like in Sri Lanka. In the local context it is unplan cities and road sides consist with both residential and commercial areas. Hence no consistent environment on the sides of the road and road side environment effect the manoeuvrability.

Considering the following, it is timely to develop new factors to account for the above to better approximate the LOS results obtained from the HCM equations to the actual conditions in Sri Lanka. Developing new factors would require further research and this research would be a strong starting point for future researches, which would pave way to the development of a new capacity manual for Sri Lanka.

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