Chapter 35

Capacity and Level of service

35.1 Overview

Capacity and Level of service are two related terms. Capacity analysis tries to give a clear understanding of how much traffic a given transportation facility can accommodate. Level of service tries to answer how good is the present traffic situation on a given facility. Thus it gives a qualitative measure of traffic, where as capacity analysis gives a quantitative measure of a facility. Capacity and level of service varies with the type of facility, prevailing traffic and road conditions etc. These concepts are discussed in this chapter.

35.2 Capacity

Capacity is defined as the maximum number of vehicles, passengers, or the like, per unit time, which can be accommodated under given conditions with a reasonable expectation of occurrence. Some of the observations that are found from this definition can be now discussed. Capacity is independent of the demand. It speaks about the physical amount of vehicles and passengers a road can afford. It does not depend on the total number of vehicles demanding service. On the other hand, it depends on traffic conditions, geometric design of the road etc. For example, a curved road has lesser capacity compared to a straight road. Capacity is expressed in terms of units of some specific thing (car, people, etc.), so it also does depend on the traffic composition. In addition, the capacity analysis depends on the environmental conditions too. Capacity is a probabilistic measure. It varies with respect to time and position in the maximum number of units of demand it can accommodate by similar facilities. Hence it is not always possible to completely derive analytically the capacity. In most cases it is obtained, through field observations.

35.3 Level of service

A term closely related to capacity and often confused with it is service volume. When capacity gives a quantitative measure of traffic, level of service or LOS tries to give a qualitative measure. A service volume is the maximum number of vehicles, passengers, or the like, which can be accommodated by a given facility or system under given conditions at a given level of service.

For a given road or facility, capacity could be constant. But actual flow will be different for different days and different times in a day itself. The intention of LOS is to relate the traffic service quality to a given flow rate of traffic. It is a term that designates a range of operating conditions on a particular type of facility. Highway capacity manual (HCM) developed by the transportation research board of USA provides some procedure to

determine level of service. It divides the quality of traffic into six levels ranging form level A to level F. Level A represents the best quality of traffic where the driver has the freedom to drive with free flow speed and level F represents the worst quality of traffic. Level of service is defined based on the measure of effectiveness or (MOE). Typically three parameters are used under this and they are speed and travel time, density, and delay. One of the important measures of service quality is the amount of time spent in travel. Therefore, speed and travel time are considered to be more effective in defining LOS of a facility. Density gives the proximity of other vehicles in the stream. Since it affects the ability of the driver to maneuver in the traffic stream, it is also used to describe LOS. Delay is a term that describes excess or unexpected time spent in travel. Many specific delay measures are defined and used as MOE's in the highway capacity manual.

35.4 Types of facilities

Most important classification of transportation facilities from the engineering perspective is based on the continuity of flow, that is *uninterrupted flow* and *interrupted flow*. Uninterrupted flow is the flow of traffic in which there is no obstructions to the movement of vehicles along the road. Freeway is one example for this type of facility. In a freeway, when a vehicle enters a freeway, there is no need for the vehicle to stop anywhere till it leaves the freeway. There are three sections in a freeway - basic unit, weaving section and ramps(on/off). Vehicles will be entering the freeway through ramps. Ramps used for entering the freeway is called on-ramps and those used for exiting the freeway are called off-ramps. Freeways generally have 4, 6, or 8 lane alignments. Multilanes also provide uninterrupted flow. In many roads, there will be signalized as well as unsignalized intersections. Uninterrupted flow is possible in sections of rural and suburban multilane highways between signalized intersections where signal spacing is sufficient to allow for uninterrupted flow. Two lane highways also provide uninterrupted flow facilities.

Interrupted flow refers to the condition when the traffic flow on the road is obstructed due to some reasons. This is experienced in signalized intersections, unsignalized intersections, arterials etc. At signalized intersections, there will be some kind of active control and the vehicle will have to stop or sometimes to reduce its speed and the flow of traffic is interrupted. Thus the capacity is defined in terms of control delay ie sec/veh. Arterials are roads of long stretches with many intersections in between and obviously there will be interruption to the flow of traffic. Here, the capacity is expressed in terms of average travel speed. Some other facilities are facilities for pedestrians, bicycles, bus-transit, rail-transit etc. Example for pedestrian facility is a provision of subway exclusively for the use of pedestrians. Here, the capacity may be expressed in terms of number of passengers. In bus transit system, the buses has to stop at the bus bays and also it has to share the road with the other vehicles. Hence the capacity will be affected by the control characteristics and the traffic conditions prevailing in the road. Since trains have exclusive right of way, the capacity is strictly governed by the control characteristics. It has two types of capacities - line capacity and station capacity. Line capacity is based on the number of tracks available between two stations. Station capacity refers to the facilities available in the platform of the station,and other facilities.

For uninterrupted flow of traffic, mesure of effectiveness (MOE) is density in freeways. Speed also becomes important in two-lane highways and multilane highways. In the case of interrupted flow, MOE is delay. The delay of travel time becomes an important factor in calculating the capacity.

35.5 Highway capacity

Highway capacity is defined by the Highway Capacity Manual as the maximum hourly rate at which persons or vehicles can be reasonably expected to traverse a point or a uniform segment of a lane or roadway during a given time period under prevailing roadway, traffic and control conditions. The highway capacity depends on certain conditions as listed below;

1. **Traffic conditions**: It refers to the traffic composition in the road such as the mix of cars, trucks, buses etc in the stream. It also include peaking characteristics, proportions of turning movements at intersections etc.
2. **Road way characteristics**: This points out to the geometric characteristics of the road. These include lane width, shoulder width, lane configuration, horizontal alignment and vertical alignment.
3. **Control conditions**: This primarily applies to surface facilities and often refer to the signals at intersections etc.

Again capacity can be defined for a *point* or *uniform* section. Capacity is estimated for segments having uniform conditions. Points where these conditions change represent the boundaries where separate analysis may be required. Capacity is the maximum flow rate that a facility can afford. This maximum flow rate is taken for the worst 15 minutes of the peak hours while finding out the capacity. Capacity is measured as a reasonably expected value and not the maximum flow rate ever observed in the facility. This is because the measured capacity at a single location will show significant variation from day to day. Further, local driving habits also produce variations in the observed capacity.

35.6 Factors affecting level of service

Level of service was introduced in Highway capacity manual(HCM) to denote the level of service one can derive from a road under different operating characteristics and traffic volumes. The factors affecting level of service (LOS) can be listed as follows:

1. Speed and travel time
2. Traffic interruptions/restrictions
3. Freedom to travel with desired speed
4. Driver comfort and convenience
5. Operating cost.

Highway Capacity Manual(HCM) used travel speed and volume by capacity ratio (v/c ratio) to distinguish between various levels of service. The value of v/c ratio can vary between 0 and 1. Depending upon the travel speed and v/c ratio, HCM has defined six levels of service, level A to level F based on a graph between operating speed and v/c ratio as shown in the figure 35:1. Level of service A represents the zone of free flow. Here the traffic volume will be less, traffic will be experiencing free flow also. The drivers will be having the complete freedom to choose their desired speed. Even at maximum density, for this LOS the average spacing between vehicles is 167 m. Lane changes within the traffic stream, as well as merging and diverging movements, are

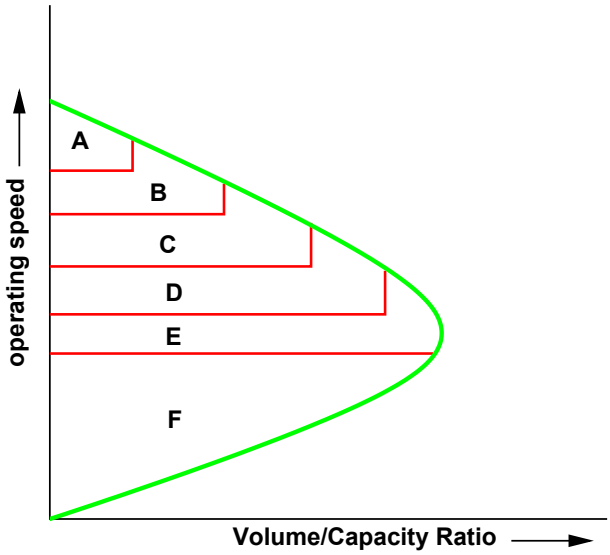

Figure 35:1: Level of service A to F

made relatively easy. The effect of minor incidents and point breakdowns are easily aborted at this level. Level of service B represents zone of reasonably free flow. Free flow speeds are still maintained at this level of service. The drivers freedom to choose their desired speed is only slightly restricted The lowest average spacing between vehicles is about 100 m. The effects of smallincidents and point breakdowns are still easily contained. At level of service C, the presence of other vehicles begins to restrict the maneuverability within the traffic stream. Average speeds remain at or near the freeflow speed level, but significant increase in driver vigilance is required at this level. Minimum average spacing between the vehicles is in the range of 67 m. Queues may be expected to form behind any significant blockage. At level of service D, the average speeds begin to decline with increasing flows. Freedom to maneuver within the traffic stream is noticeably restricted. At this level, density deteriorates more quickly with flow. The spacing between the vehicles is about 50 m. As the traffic stream has little space to absorb disruptions, minor incidents can lead to queuing of vehicles. Level of service E define operation at capacity. At this level, the stream reaches it's maximum density limit. There will be no usable gaps in the stream and even slight disruptions will cause a breakdown, with queues forming rapidly behind the disruption. Maneuvering within the traffic stream becomes extremely difficult. Level of service F describes conditions in a queue that has formed behind a point of breakdown or disruption. As vehicles shuffle through the queue, there may be periods when they move quickly, and others when they are stopped completely. Thus this level of service is used to describe the point of breakdown as well, eventhough operations downstream of such a breakdown may appear good. Level of service F represents the region of forced flow, having low speed .

35.7 Summary

Capacity and level of service are two important terms applied to traffic operation and are given suitable defintions by highway capacity manual. Capacity represents the ability of the system to handle traffic whereas level of service looks at the system from the drivers perspective. The fundamental diagrams of traffic flow can be used in the representation of level of service. Level of service ranges from level A to F, representing the free flow conditions and F representing the worst traffic conditions like less speed, high density etc.

35.8 Problems