THE EFFECT OF THE HEAVY RECREATIONAL TRAFFIC ON THE DESIGN OF THE FREEWAY

Asma Th. Ibraheem (Ph.D)

Faculty Member in Civil Engineering, College of Engineering, Al-Nahrain University, Baghdad, Iraq, drasmathamir@yahoo.com

ABSRACT

Traffic engineers frequently are engaged in evaluating the performance of different facilities of the highway system. The facility in this project includes freeway section. In design of a freeway, a forecast demand volume is used with known design standards for geometric features and a desired level of service to compute the number of lanes required for the freeway section in question. The design application is straight forward for each usage, but trial-and- error operation analysis may be required to evaluate alternative design. Design requires a detailed traffic forecast, including volumes, peaking characteristics, traffic composition, and specifics of vertical and horizontal alignment for the section under study.

The aim of this paper is the design analysis of a freeway with a heavy recreational vehicles. This analysis involves the consideration of three examples of freeways. Given known geometric roadway conditions and projected traffic conditions , the design analysis yields an estimation of the number of lanes and of the speed and density of the traffic stream. This paper has described the procedure for determining the number of lanes of freeway basic sections as presented in the Highway Capacity Manual (HCM, 2000) and HCS2000 software.

KEYWORDS: Design, Freeway, Operational Analysis, Planning, Recreational vehicles, Traffic Engineering, Transportation Engineering.

NOTATIONS

D   = Density (pc/km/ln) ,

V_p = Flow rate (pc/h/ln) , and

S   = Average passanger-car speed (km/h).

MSF = maximum service flow rate per lane for LOS i under ideal conditions in pcphpl.

$(v/c)_i$ = maximum volume to capacity ratio associated with LOS i.

C_j = capacity under ideal conditions for freeway element of design speed j.

SF_i = service flow rate for LOS I under prevailing roadway and traffic conditions for N lanes in one direction , in Vph;

N   = number of lanes in one direction of the freeway;

f_w = factor to adjust for the effects of restricted lane widths;

f_{hv}= factor to adjust for the effect of heavy vehicles (trucks , buses , and recreation vehicles) in the traffic stream, and

f_P = factor to adjust for the effect of driver population .

v_p = 15-min passenger-car equivalent flow rate (pc/h/ln),

V = hourly volume (veh/h),

PHF = peak-hour factor,

N = number of lanes,

f_{HV} = heavy-vehicle adjustment factor, and

f_p = driver population factor.

1. INTRODUCTION

The governments of many of the developing nations of Africa and Asia have begun modernization and industrialization programs that include the building of new roads. Industrialized nations continue to improve and expand their road systems. Engineers today continue to seek ways of increasing highway safety through better construction. They also seek to improve traffic flow by using computers to help plan road systems (Boyce, 2002).

Road is a strip of land that provides routes for travel by automobiles and other wheeled vehicles. Roads and highways are vital lifelines, which often called streets. Farmers use them to ship their products to market. Trucks can transport manufactured products from one area to another. Roads carry automobiles, buses, bicycles, and other vehicles on business and pleasure trips (Boyce, 2002).

Freeways or superhighways, called motorways in some countries, are main highways with full access control and grade-separated interchanges. Those with four or more lanes are divided by a median strip. Freeways in congested parts of large cities are often elevated (build below surface streets) (AASHTO, 1994).

The term Freeway refers only to the free flow of traffic. Motorists may have to pay a toll to travel on these roads. Roads that are requiring a toll called toll ways or toll roads (Boyce, 2002).

Planning is a continuous process concerned with the allocation and proper utilization of available resources in projects that take into account the desires and objectives set out by society. The strategy of the development plan defined by the decision-maker decides the objective and policy of the transportation plan.

The transportation plan depends on the general data for the prediction of the future factors that affect the growth of traffic. The properties and classifications of the required transportation systems are decided according to the needs of existing and newly planned activities (Garber and Hoel, 2002).

Highway planners study everything from the long-range needs of a region or an entire country to a particular section of a single route. This planning determines what the highway needs of the region are and how these needs can best be fulfilled and paid for.

Much roadwork involves improving existing roads. This may mean paving over a dirt road that is experiencing increasing traffic. New roads may be needed to cope with increasing traffic or to connect with a new town or development area.

2. RECREATIONAL VEHICLE (RV)

Recreational vehicle provides temporary living quarters for year-round travel, camping, or recreation. Some RV's have an engine and can be driven. Others are towed by an automobile, van, or truck. Still other RV's are carried on the bed of a pickup truck. All can be moved easily and travel almost anywhere on land.
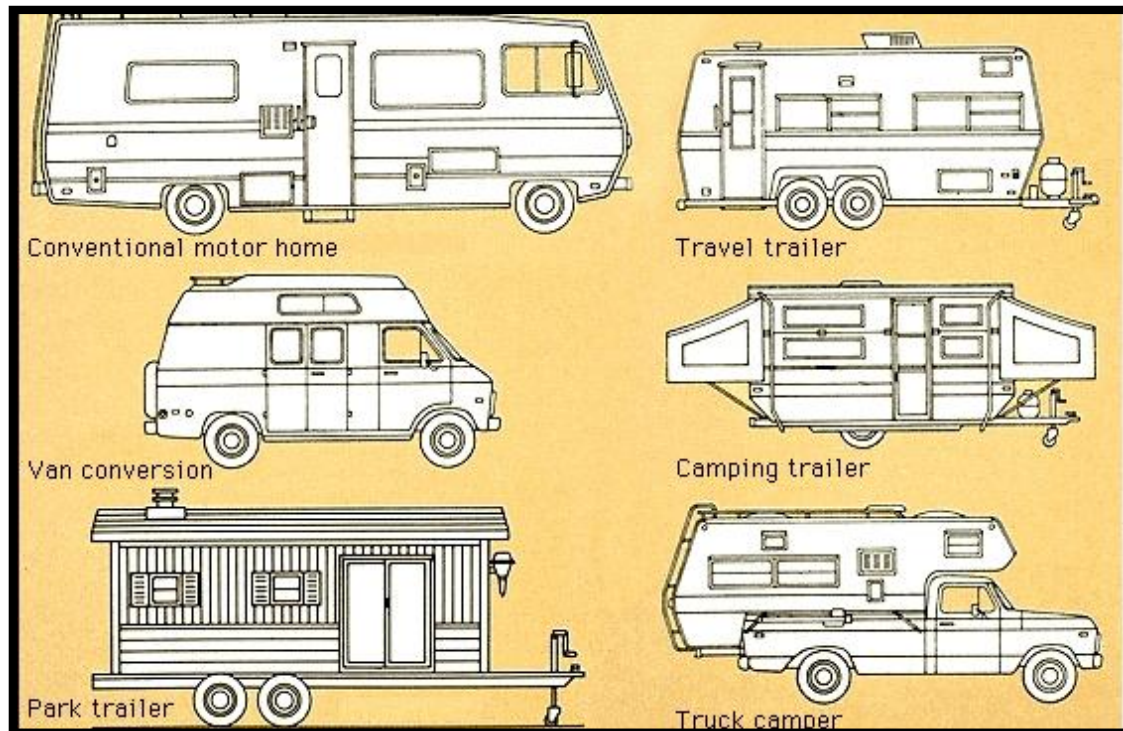
Figure (1): Popular recreational vehicles (Boyce, 2002).

Early models of the recreational vehicle appeared in the 1920's. During the 1960's, RV's came into wide use as a means of comfortable and economical travel. In the early 1990's, about 10 percent of the households in the United States that had a motor vehicle owned an RV. Today, the basic types of recreational vehicles are (1) motor homes, (2) van conversions, (3) travel trailers, (4) folding camping trailers, (5) park trailers, and (6) truck campers (Boyce, 2002).

3. <u>HIGHWAY PLANNING</u>

A master plan of any city is to make community life more comfortable, enjoyable, safe, and profitable. A good plan provides transportation facilities that enable people to get to and from stores, offices, and factories quickly, easily and safely. It also provides enough recreation areas, schools, and shopping facilities.

The transportation planning process comprises seven basic elements. The information acquired in one phase of the process may be helpful in some earlier or later phase, so there is a continuity of effort that finally results in a decision. The elements in the process are (Garber and Hoel, 2002):

- Situation definition.
- Problem definition.
- Search for solutions.
- Analysis of performance.
- Evaluation of alternatives.
- Choice of project.
- Specification and construction.

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In planning a system or a route, planners must learn: (1) where people live, (2) where they want to go, (3) by what means and route they get there, (4) where goods are produced, (5) what markets the goods are sent to, and (6) how the goods reach their final users. Traffic counts tell how many and what kinds of vehicles travel on a road, and when traffic is heaviest. From these and other facts about the past and present, planners try to predict future growth in population and industry, changes in land use, and how such growth and change will affect highway needs (Boyce, 2002).

Public participation in road planning is essential. In many countries, planners hold public hearings on most major highway projects. These meetings enable citizens to present their views before a project begins.

Engineers have set standards for various kinds of roads, highways, and bridges. These standards govern the thickness and kind of foundation and surfacing for different kinds of traffic; the number of lanes needed; the sharpness of curves; and the steepness of hills.

Highway planners must also prepare an environmental impact statement before beginning construction. The purpose of such a statement is to discover in advance all the possible good and bad effects that a new highway may have on the public and on the environment (Boyce, 2002).

4. TRAFFIC MANAGEMENT STRATEGIES

Demand management Highway traffic management is the implementation of strategies to improve Highway performance, especially when the number of vehicles desiring to use a portion of the Highway at a particular time exceeds its capacity. There are two approaches to improving system operation. Supply management strategies work on improving the efficiency and effectiveness of the existing Highway or adding additional Highway capacity. Demand management strategies work on controlling, reducing, eliminating, or changing the time of travel of vehicle trips on the Highway while providing a wider variety of mobility options to those who wish to travel. However, in actual application, some strategies may address both sides of the supply/demand equation.

The important point is that there are two basic ways to improve system performance. Supply management and demand management Supply management strategies are intended to increase capacity. Capacity may be increased by building new pavement or by managing existing pavement. Supply management has been the traditional form of Highway system management for many years (HCM, 2000).

Increasingly, the focus is turning to demand management as a tool to address Highway problems.

Demand management programs include alternatives to reduce Highway vehicle demand by increasing the number of persons in a vehicle, diverting traffic to alternate routes, influencing the time of travel, or reducing the need to travel. Demand management programs must rely on incentives or disincentives to make these shifts in behavior attractive.

Highway traffic demand management strategies include the use of priority for high-occupancy vehicles, congestion pricing, and traveler information systems. Some alternative strategies such as ramp metering may restrict demand and possibly increase the existing capacity. In some cases, spot capacity improvements such as the addition of auxiliary lanes or minor geometric improvements may be implemented to better utilize overall Highway system capacity. In the remainder of this section the process of evaluating Highway management strategies and the most common Highway traffic management techniques will be presented. The Highway traffic management process is used to assess the effect on Highway performance that these strategies might produce (HCM, 2000).

5. HIGHWAY TRAFFIC MANAGEMENT PROCESS

Highway traffic management is the application of strategies that are intended to reduce the traffic using the facility or increase the capacity of the facility. Person demand can be shifted in time or space, vehicle demand can be reduced by a shift in mode, or total demand can be reduced by a variety of factors. Factors affecting total demand include changes in land use and elimination of trips due to telecommuting, reduced workweek, or a decision to forgo travel. By shifts of demand in time (e.g., leaving earlier), shifts of demand in space (e.g., taking an alternative route), shifts in mode, or changes in total demand, traffic on a Highway segment can be reduced. Likewise, if Highway capacity has been reduced (e.g., as the result of an incident that has closed a lane or adverse weather conditions), improved traffic management can return the Highway to normal capacity sooner, reducing the total delay to travelers (Garber and Hoel, 2002).

The basic approach used to evaluate traffic management is to compare alternative strategies. The base case would be operation of the facility without any Highway traffic management. The alternative case would be operation of the facility with the Highway traffic management strategy or strategies being evaluated. The alternative case could have different demands and capacities based on the conditions being evaluated.

The evaluations could also be made for existing or future traffic demands. Combinations of strategies are also possible, but some combinations may be difficult to evaluate because of limited quantifiable data.

6. HIGHWAY MANAGEMENT STRATEGIES

Highway traffic management strategies are implemented to make the most effective and efficient use of the Highway system. Activities that reduce capacity include incidents (including traffic accidents, disabled or stalled vehicles, spilled

cargo, emergency or unscheduled maintenance, traffic diversions, or adverse weather), construction activities, scheduled maintenance activities, and major emergencies (such as earthquakes or flooding). Activities that increase demand include special events. Highway traffic management strategies that mitigate capacity reductions include incident management; traffic control plans for construction, maintenance activities, special events, and emergencies; and minor design improvements (e.g., auxiliary lanes, emergency pullouts, and accident investigation sites). Highway traffic management strategies to reduce demand include plans for incidents, special events, construction, and maintenance activities; entry control/ramp metering; on-Highway HOV lanes (High Occupancy Vehicle); HOV bypass lanes on ramps; traveler information systems; and road pricing.

Capacity Management Strategies Incident management Incident management is the most significant Highway strategy generally used by operating agencies. Incidents can cause significant delays even on facilities that do not routinely experience congestion. It is generally believed that more than 50 percent of Highway congestion is the result of incidents. Strategies to mitigate the effects of incidents include early detection and quick response with the appropriate resources (HCM, 2000).

The number of vehicles entering the Highway system is the primary determinant of Highway system performance. Entry control is the most straightforward way to limit Highway demand. Entry control can take the form of temporary or permanent ramp closure. Ramp metering, which can limit demand on the basis of a variety of factors that can be either preprogrammed or implemented in response to measured Highway conditions, is a more dynamic form of entry control. Highway demand can be delayed (changed in time), diverted (changed in space to an alternative route), changed in mode (such as HOV), or eliminated (the trip avoided). The difficult issue in assessing ramp-metering strategies is estimating how demand will shift as a result of metering. HOV alternatives HOV alternatives such as mainline HOV lanes or ramp meter bypass lanes are intended to reduce the vehicle demand on the facility without changing the total number of person trips. Assessing these types of alternatives also requires the ability to estimate the number of persons who make a change of mode to HOV. In addition, it is necessary to know the origin and destination of the HOV travelers to determine what portions of the HOV facility they can use, since many HOV facilities have some form of restricted access. Special events Special events result in traffic demands that are based on the particular event. These occasional activities are amenable to the same types of Highway traffic management used for more routine activities such as daily commuting. In the case of special events, more planning and promotion are required than are typically needed for more routine activities. Road pricing Road pricing is a complex and evolving Highway traffic management alternative (HCM, 2000).

7. <u>LEVEL OF SERVICE</u>

The LOS for basic freeway segment is based on the reasonable range for speed-flow-density on that segment . Six levels of service , designed A through F have been established with level F designating the worst service procedures given in the 1994 Highway Capacity Manual of the Transportation Research Board . The density is the parameter used to defined level of service for basic freeway segment .

LOS criteria for basic freeway segments are given in Table (1) for 70-mph, 60-mph, and 50-mph design speed elements (HCM, 2000).

Table (1): LOS criteria for basic freeway segment (HCM, 2000).

Criteria	LOS				
	A	B	C	D	E
FFS = 120 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	120.0	120.0	114.6	99.6	85.7
Maximum v/c	0.35	0.55	0.77	0.92	1.00
Maximum service flow rate (pc/h/ln)	840	1320	1840	2200	2400
FFS = 110 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	110.0	110.0	108.5	97.2	83.9
Maximum v/c	0.33	0.51	0.74	0.91	1.00
Maximum service flow rate (pc/h/ln)	770	1210	1740	2135	2350
FFS = 100 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	100.0	100.0	100.0	93.8	82.1
Maximum v/c	0.30	0.48	0.70	0.90	1.00
Maximum service flow rate (pc/h/ln)	700	1100	1600	2065	2300
FFS = 90 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	90.0	90.0	90.0	89.1	80.4
Maximum v/c	0.28	0.44	0.64	0.87	1.00
Maximum service flow rate (pc/h/ln)	630	990	1440	1955	2250

Note:
The exact mathematical relationship between density and v/c has not always been maintained at LOS boundaries because of the use of rounded values. Density is the primary determinant of LOS. The speed criterion is the speed at maximum density for a given LOS.

The first step in determining LOS of a basic freeway segment is to define and segment the freeway facility as appropriate. Second, on the basis of estimated or field measured free flow speed (FFS) an appropriate speed-flow curve of the same shape as the typical curves as (Figure 2) is constructed. On the basis of the flow rate, Vp , and the constructed speed-flow curve, an average passenger-car speed is read on the y-axis of Figure (2). The next step is to calculate density using the equation:
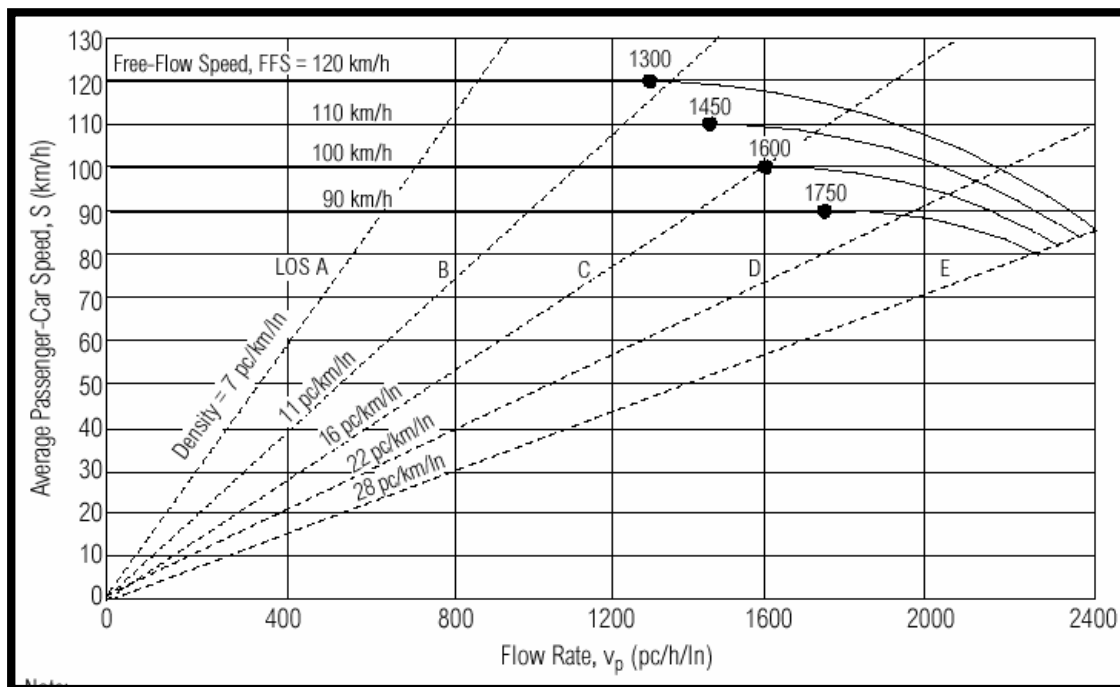
$$D = \frac{V_p}{S} \qquad ...(1)$$

where :

D   = Density (pc/km/ln) ,

V_p = Flow rate (pc/h/ln) , and

S   = Average passanger-car speed (km/h) .

Figure (2): Speed-Flow curves and LOS for basic freeway segments (HCM, 2000).

LOS of the basic freeway segment is then determined by comparing the calculated density with the density range in Table (1).

8. FACTORS INFLUENCING FREEWAY DESIGN

Freeway Design is based on several design standards and control, which in turn depend on (Garber and Hoel, 2002):

- Functional classification of freeway being designed,
- Expected traffic volume and vehicles mix.
- Design speed
- Topography of the area in which the free way will be located.
- Level of service to be provided.
- Available funds.
- Safety.
- Social and environmental factors

8.1 Maximum Service Flow Rate Per Lane

The value of Maximum Service Flow Rate (MSF) are computed from the volume to capacity ratios, v/c (HCM, 2000):

$$MSF = C_j (v/c)_i \qquad ...(2)$$

where:

MSF = maximum service flow rate per lane for LOS i under ideal conditions in pcphpl.

$(v/c)_i$ = maximum volume to capacity ratio associated with LOS i.

C_j = capacity under ideal conditions for freeway element of design speed j.

8.2 Service Flow Rate

The "MSF" values represent ideal condition of 12-ft lane , adequate lateral clearauces and all passenger cars in the traffic stream . Therefor , the maximum service flow rates must be adjusted to reflected any prevailing conditions that are other than ideal , and to reflected the total number of lanes in one direction on the freeway . This is accomplished by (HCM , 2000)

$$SF_i = MSF_i * N * f_w * f_{HV} * f_P \qquad\qquad ...(3)$$

where:

SF_i = service flow rate for LOS I under prevailing roadway and traffic conditions for N lanes in one direction , in Vph;

N = number of lanes in one direction of the freeway;

f_w = factor to adjust for the effects of restricted lane widths;

f_{hv}= factor to adjust for the effect of heavy vehicles (trucks , buses , and recreation vehicles) in the traffic stream, and

f_P = factor to adjust for the effect of driver population .

9. FREEWAY DESIGN STANDARDS

Selection of the appropriate set of geometric design standard is the first step in the design of any highway. This is essential because no single set of geometric standards can be used for all highways. Therefore, the characteristics of the highway should be considered in selecting the geometric design standards (HCM, 2000).

9.1 Design Hourly Volume

The design hourly volume (DHV) is the projected hourly volume that is for design. This volume is usually taken as a percentage of expected ADT on the freeway.

9.2 Design Speed

Design speed is defined by AASHTO as "a selected speed to determine the various geometric features of the roadway ". Design speed depends on the functional class of the highway, the topography of the area in which the highway is located, and the land use of the adjacent area. For freeway design, topography is generally classified into three groups: level, rolling and mountainous terrain. Design speed range from 20m/h to 70m/h, note that a design speed is selected to achieve a desired level of operation and safety on the freeway (AASHTO, 2001).

10. FREEWAY DESIGN ANALYSIS

A design analysis is made to determine the number of lanes required on the freeway to provide the desires level of service for the forecasted traffic volume and traffic characteristics.

10.1 Data Requirements

Design analysis requires information concerning the projected directional design hour volume, DDHV, the traffic characteristics that describe it. Design standards, such as design speed, lane width and lateral clearances, must also be specified. The horizontal and vertical alignment of the facility would generally be established before the consideration of capacity, traffic characteristics must be specified such as the

composition (percentage of trucks, recreation vehicles and buses), the peak hour factor (DHF), and the driver population (weekday, commuter, recreational) (HCM, 2000).

10.2 Segmenting the Freeway for Design

The freeway must be divided into segments yielding uniform characteristic. The horizontal and vertical alignments must be examined to identify points at which the terrain changes, and to isolate specific grades requiring separate analyses. It is often necessary to segment freeway at ramps and major junctions because the volume generally will change at these points.

10.3 Design Criteria

Design analysis also requires the selection of a design LOS, which determines the design value of volume capacity (v/c) ratio. In design, table (1) is used to select a design v/c ratio. Values of v/c, in increments of 0.1 from 0.30 to 0.80, are given, as are the equivalent values of MSF, together with LOS, speed, and density which would occur at values. Using these design values (AASHTO, 2001).

AASHTO standards recommended that urban freeways should not operate with volume higher than 1500 to 1700 pc ph Pl, and rural freeways no higher than 1000 to 1200 pc ph pl. With respect to design levels of service, current AASHTO recommendations are approximately comparable to the following ratios (AASHTO, 2001):

| Rural freeways | 0.60 |
| Urban and Suburban | 0.80. |

10.4 Procedural steps

The key to design analysis for number of lanes (N) is establishing an hourly volume. All information, with the exception of number of lanes, can be entered in the flow input and speed input portion of the worksheet (Figure 3). First of all, cover the directional design hour volume (DDHV) to an equivalent peak flow rate, which is set equal to the service flow rate, SF:

$$SF = DDHV \ / \ PHF \qquad ...(4)$$

Then Find all adjustment factors and passenger-car equivalents, base on forecast traffic characteristics and selected design standards (HCM, 2000). An FFS, either computed or measured directly, is entered on the worksheet. The appropriate curve representing the FFS (Figure 2) is established on the graph. The required or desired LOS is also entered. Then the analyst assumes N and computes flow, vp, with the aid of the exhibits for passenger-car equivalents. LOS is determined by entering the speed-flow graph with vp at the top of the worksheet. Then, the derived LOS is compared with the desired LOS. This process is then repeated, adding one lane to the previously assumed number of lanes, until the determined LOS matches or is better than the desired LOS. Density is calculated using vp and S.

11. Proposed Example

New suburban freeway is being designed from Arbil airport to the center of the city in the north of Iraq. Therefore we need to find how many lanes are needed to provide LOS D during the peak hour. The following facts are given:

- 4,000 veh/h (one direction), .0.85 PHF,
- Level terrain, .0.9 interchanges per kilometer,
- 15 percent trucks, **20 percent RVs**, and
- 3.6-m lane width, .1.8-m lateral clearance.
- Assume commuter traffic. Thus, f p = 1.00.
- Assume BFFS of 120 km/h.
- Assume that the number of lanes affects free-flow speed, since the freeway is being designed in a suburban area.

All input parameters are known. Flow rate, speed, density, and LOS are calculated starting with a four-lane freeway and then increasing the number of lanes to six, eight, and so forth until LOS D is achieved. The following steps should be achieved:

1. Convert volume (veh/h) to flow rate (pc/h/ln)

$$v_p = V/(PHF)(N)(f_{HV})(f_p) \qquad \qquad ...(5)$$

where:
v_p = 15-min passenger-car equivalent flow rate (pc/h/ln),
V = hourly volume (veh/h),
PHF = peak-hour factor,
N = number of lanes,
f_{HV} = heavy-vehicle adjustment factor, and
f_p = driver population factor.

2. Find the adjustments for heavy vehicles f $_{HV}$:

$$f_{HV} = 1/[1 + P_T(E_T - 1) + P_R(E_R - 1)] \qquad ...(6)$$

where:
E_T, E_R = passenger-car equivalents for trucks/buses and recreational vehicles (RVs) in the traffic stream, respectively;
P_T, P_R = proportion of trucks/buses and RVs in the traffic stream, respectively; and
f_{HV} = heavy-vehicle adjustment factor.

Adjustments for heavy vehicles in the traffic stream apply for three vehicle types: trucks, buses, and RVs. There is no evidence to indicate distinct differences in performance between trucks and buses on freeways, and therefore trucks and buses are treated identically. In many cases, trucks will be the only heavy-vehicle type present in the traffic stream to a significant degree. Where the percentage of RVs is small compared with the percentage of trucks, it is sometimes convenient to consider all heavy vehicles to be trucks. It is generally acceptable to do this where the percentage of trucks and buses is at least five times the percentage of RVs. Thus:

$$f_{HV} = 1/[1 + (0.15)(1.5 - 1) + 0.20(1.2 - 1)]$$
$$f_{HV} = 0.897$$

3. For four-lane option (use Equation 5).
   $v_p = 4,000 / [(0.85)(2)(0.897)(1.00)] = 2,624$ pc/h/ln

4. The four-lane option is not acceptable since 2624 pc/h/ln exceeds capacity of 2400 pc/h/ln.

5. For six-lane option (table 1):
   $v_p = 4,000 / (0.85)(3)(0.897)(1.00) = 1,749$ pc/h/ln

6. Compute free-flow speed for a six-lane freeway (use Exhibits 23-4, 23-5, 23-6, 23-7, and Equation 23-1 of the HCM, 2000):
   $$FFS = BFFS - f_{LW} - f_{LC} - f_N - f_{ID} \qquad ...(7)$$
   $FFS = 120 - 0.0 - 0.0 - 4.8 - 8.1$
   $FFS = 107.1$ km/h

7. Determine level of service (use table 1 and figure 2):LOS D

Six lanes are needed, as it is clear from the result of the HCS 2000 software (See Appendix A),
LOS = D,
Speed = 107 km/h, and
Density = 16.5 pc/km/ln.
<u>Number of required lanes are: **N = 3 at each direction**</u>.

When we repeat the above computations but assuming that there is no recreational vehicle, we found that a four-lane freeway is sufficient (two lanes at each direction).

12. <u>CONCLUSIONS</u>

Design analysis requires the selection of a design LOS, which determines the design value of v/c. The characteristics of modern freeway with a heavy RV's flow make it difficult to use table (1) directly for this purpose. As the demand volume increases, vehicle interaction and density increases, resulting in the gradual lowering of the speed that can be safely achieved by the drivers. The LOS of a new design of any project with heavy recreational vehicles is indicated by the concept of level of service, which uses qualitative measures that characterize both operational conditions within a traffic stream and motorists and passenger's perception of them.
From the above design analysis of freeway with a heavy recreational vehicle was conclude the following:
1. The major effective variables are the driver behavior and type of vehicles, which are considered non-uniform variables.
2. The design procedure results in a direct computation of N for a given freeway segment. Care should be exercised in such design computations because N may be different for successive segments.

3. It is clear from the results of the case study that a four-lane is not sufficient because of the high percent of RV's. Thus, a six-lane freeway, with no climbing lanes would be the recommended design.

4. The values of f_p range from 0.85 to 1.00. In general, the analyst should select 1.00, which reflects commuter traffic (i.e., familiar users), unless there is sufficient evidence that a lower value should be applied. Where greater accuracy is needed, comparative field studies of commuter and recreational traffic flow and speeds are recommended.

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Figure (3): Basic freeway segment worksheet (HCM, 2000).

15. <u>APPENDIX A:</u> HCS2000 Software Result of the Case Study:

```
_____Flow         Inputs          and
Adjustments_____


Volume, V                                          4000
veh/h
Peak-hour factor, PHF                      0.85

Peak 15-min volume, v15                            1176
v
Trucks and buses                           15
              %
Recreational vehicles                      20
              %
Terrain Type                               Level

    Grade                                  0.00
          %
    Segment length                             0.00
km
Trucks and buses PCE, ET                   1.5

Recreational vehicles PCE, ER              1.2

Heavy vehicles adjustment, fHV             0.897

Driver population factor, vp               1.00

Flow rate, vp                                      5247
pc/h
Desired level of service                   D


_____Speed         Inputs          and
Adjustments_____
Lane width, LW                                     3.6
m
Right-shoulder  lateral  clearance,  LC            1.8
m
Interchange density, ID                            0.90
interchange/km
```

```
Free-flow speed:                              Ideal

    FFS or BFFS                               120.0
km/h
Lane width adjustment, fLW                      0.0
km/h
Lateral clearance adjustment, fLC               0.0
km/h
Interchange density adjustment, fID             8.1
km/h
Number of lanes adjustment, fN                  4.8
km/h
Free-flow speed                               107.1
km/h
                                            SUBUrban
Freeway
_____LOS     and     Performance
Measures_____


Desired level of service                  D

Design flow rate, vp                           5247
pc/h
Design free-flow speed, FFS                   107.1
km/h
Number of lanes required, N               3

Average passenger-car speed, S                106.0
km/h
Density, D                                     16.5
pc/km/ln
Level of service                          D
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```
Free-flow speed:                              Ideal

    FFS or BFFS                               120.0
km/h
Lane width adjustment, fLW                      0.0
km/h
Lateral clearance adjustment, fLC               0.0
km/h
Interchange density adjustment, fID             8.1
km/h
Number of lanes adjustment, fN                  4.8
km/h
Free-flow speed                               107.1
km/h
                                            SUBUrban
Freeway
_____LOS     and     Performance
Measures_____


Desired level of service                  D

Design flow rate, vp                           5247
pc/h
Design free-flow speed, FFS                   107.1
km/h
Number of lanes required, N               3

Average passenger-car speed, S                106.0
km/h
Density, D                                     16.5
pc/km/ln
Level of service                          D
```