GOVERNMENT OF PAKISTAN
PLANNING COMMISSION
NATIONAL TRANSPORT RESEARCH CENTRE

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PLANNING STANDARDS FOR ROADS IN PAKISTAN

NTRC–157

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SUMMARY

1. Capacity of a facility in general terms is defined as the maximum hourly rate at which persons or vehicles can reasonably be expected to traverse a point or uniform section of a road in a given time period under prevailing roadway traffic and control conditions.

2. Capacity is related to quality of flow called level of service which is rated from A to F. A represents free flow expected on motorways and freeways whereas F represents forced or breakdown flow manifested by long queues and jamp pack. The capacity in itself is a very variable term. It is lowest at level of service A and highest (called ultimate) at level of service E.

3. In Pakistan; the concept of road capacity was first introduced in 1962 by the American Consultants namely M/S Howard Needles Tammen and Bergendoff. They suggested, the following capacity standards for highway improvement:-

Road Type	Volume Limits (vpd)
24' shingled	50
Paved 12' shingled 12'	100
24' Paved (light duty)	500
24' Paved (intermediat duty)	3000
24' Paved (heavy duty)	7200
4-lane divided	48000

4. These standards were adopted by the then West Pakistan Highway Department and the Planning Commission. All highway planning since that time has been done on the basis of these standards.

It may, however, be noted that the capacity of any road in terms of vehicles per day depends primarily on the proportion of heavier and slower moving vehicles. In 1962, the composition of traffic was much different than it is now. There were lot more animal drawn vehicles (10 - 15%) and high proportion of heavy vehicles (75 - 80%). On the other hand, the smaller vehicles such as cars, etc were less than 10%. All these factors negatively influence the capacity of a road when measured in terms of vpd. Since that time, the animal drawn traffic have almost disappeared from the major highways, the proportion of heavy vehicles have declined to 40% and the cars have increased and capacity in terms of vpd for two lane and four lane road should now be higher than the figures recommended by M/S Howard Needles Tammen and Bergendoff in 1962.

5. With a view to up-date the planning standards for highway improvements, the JICA experts engaged by the Planning Commission for up-dating the National Transport Plan Study for

the Seventh Plan, were asked to examine the standards and recommend changes, if necessary. After thorough review of the local traffic conditions and using the basic approach of US-Highway Capacity Manual 1985, JICA experts suggested following capacity values for the highway planning purposes.

Pavement (ft)	Type of Pavement	Shoulder	Capacity (vpd)
12	Surface treatred	<6' untreated	500
20	Surface treated	<6' untreated	1500
24	Surface treated	<6' treated	4000
24	Carpetted Surface	6' treated	8000
48	Dual carriageway	6' treated	48000

It is worth noting that a higher capacity figure of 8000 vpd as compared to 7200 vpd was recommended by JICA experts for the two lane road after which it would require dualing.

6. The standards used in India were also checked and it was noted that the Central Road Research Institute (CRI), New Delhi, has done extensive work on road capacities and has suggested following capacity figures for different categories of roads in plain terrain for planning purposes:-

S.No.	Road Category	Capacity (vpd)
1.	Single lane	1000
2.	Two lane	10,000
3.	Four lane divided	50,000

It is seen that the capacity figures recommended in Indian Standards for different categories of roads are closer to the capacity figures recommended by JICA experts for Pakistan.

7. The capacity was theoratically worked out on the basis of procedures recommended by the U.S Highway Capacity Manual-1985 and using the values of various factors relevant to local conditions. The Manual suggest separate procedures for capacity calculations for Planning, Design and Operation. Since the objective of the present excercise is to determine Planning Standards, therefore the procedures recommended for planning were adopted.

8. The main factor which is influenced by the local condition is the k-factor i.e the ratio of the Peak Hourly volume (PHV) to Average Daily Traffic (ADT). The value of k-factor in U.S, based on their traffic conditions is taken as 15. The JICA team analysed the traffic data of NTRC's Permanent Traffic Count Stations at Attock, Jhelum, Bahawalpur and Kandiaro to determine the value of k-factor under local traffic conditions prevailing on the inter-provincial roads in Pakistan. The k-factor was found between 5.9 to 8.3, therefore an average value of 7.0 was recommended.

9. Using the basic equations of Highway Capacity Manual (1985) and taking into account the local conditions, the following capacity figures are calculated at level of service 'C' for different types of roads.

S.No.	Type of Road	Capacity (vpd)
1.	Single lane	500
2.	Two lane	12,000
3.	Four lane divided	57,000

10. To further varify the capacity figures calculated by HCM-85 and using local factors; traffic survey was carried out on eight roads in Islamabad. It was observed that traffic volume on some two lane roads exceeded 15,000 vpd, yet no signs of congestions were seen even during the peak hours. The survey also confirmed that the peak hourly volume ranged between 6.2 to 9.9% of ADT, therefore the value of k-factor (7%) recommended by JICA experts was correct. It therefore became apparant that the capacity values worked out on the basis of HCM-85 were quite conservative when compared with actual traffic volume during peak hour on two-lane roads in Pakistan.

Keeping in view the preceeding, following capacity standards are proposed to be adopted for future road improvements in Pakistan.

S.No.	Type of Road	Capacity (vpd)
1.	Single lane	500 vpd
2.	Two lane	10,000 vpd
3.	Four lane divided	50,000 vpd

The figures may however be reviewed at periodic intervals, to reflect the changes in the traffic flow composition and other relevant factors in Pakistan which are likely to occur in future.

CHAPTER-I

INTRODUCTION

1.1. The Problem :

Proper capacity standards of roads are a pre-requisite for the well planned development of road network in a country. Unfortunately no standards as regards to capacity of different types of roads have been developed in the country which could be used as criteria for road improvement works. The main issue that generally becomes the point of conflict at the time of improvement of certain road relates to the design capacity of the existing facility. Some road maintaining agencies prepare schemes proposing dualing of carriageways, although the existing carriageways have yet not reached the capacity. On the other hand, some roads reach over capacity which results in serious congestions but concerned agencies do not attempt to enhance the capacity.

There is a need for establishment of uniform policies and procedures in the country for highway planning in the most economical manner consistent with highway service consideration. Standards are developed to guide the planning of highways and to ensure that motorist convenience, environmental impacts, safety and esthetic considerations are implemented in the most economical manner.

Many agencies in the world have developed road standards considering traffic conditions existing in their countries. The American Association of State Highway and Transportation Officials (AASHTO) have published policies on highways. Similarly several states in USA have published their own planning mannuals to provide a guide for the engineers to excercise sound judgement. In Japan, Engineering standards and specifications for Highways have also been prepared. Indian Road congress (IRC) have developed road standards which are followed all over India as guide in preparation of roads and bridge projects.

The existing roads in Pakistan have not been developed following any fixed standards. Specifically as far as pavement widths, shoulders widths and type of pavement structures are concerned, each road link is different due to various planning standards and construction manners adopted in the past.

Different capacity improvement standards are presently being adopted by the different highway agencies in the country while preparing their road improvement schemes. The procedure and methodologies presented in these standards differ and are not representative of traffic flow characteristics in Pakistan. Therefore instead of refering to these standards, we need to

develop standards which could be applicable according to our prevailing roadway, traffic and control conditions.

1.2. Objective of the Study :

The objective of the study is the formulation of planning standards for different categories of roads which could be used as a guide/criteria for the road improvement works in the country. The study is aimed to recommend capcity of different roads in terms of vehicles per day (vpd) and when the daily traffic has reached or exceeded the capacity, it should be considered for improvement.

The study would address the need of the following:-

i) Would serve as ready reckoner for the highway engineers to identify the road sections reaching ultimate capacity and requiring improvement.

ii) Agencies involved in the Planning of highways to consider the road schemes for future improvement and lining up the financial resources well in time for such schemes.

iii) Would provide basis for the Engineers and Planners in the Planning Commission to appraise the road improvement schemes considering traffic volumes and road capacities and recommend to the government for implementation of schemes in order of priority.

Capacity planning standards have far-reaching consequences as it radically change the criteria of the highway planning in the country. Adopting lower traffic volume figures as the improvement criteria; would require widening of roads and construction of additional carriage-ways at an earlier stage than actually required and resulting in huge investments at much earlier stage than actually required. Conversally, adopting higher figures of traffic volume as road capacity would mean allowing huge traffic volumes on roads without improvement and thus allowing congestion and lowering the average speed of traffic. This would also result in economic loss in over all terms. Thus, the financial implications of preparing planning standards and adopting them for the timely improvement of roads is obvious.

CHAPTER-II

TRAFFIC FLOW CHARACTERISTICS

2.1. Basic Definitions: Following basic definitions are important to understand the traffic flow characteristics.

2.2. Speed : Speed is a simple measure of the quality of traffic flow. Basically, speed is the total distance traversed divided by the total time of travel.

There are three basic measures of speed namely Spot speed, Overall Speed and Running Speed.

Spot Speed : Spot speed is the "instantaneous" speed of a vehicle as it passes a specified point along a street or highway. Spot speed may be determined by manually measuring the time required for a vehicle to traverse a relatively short specified distance. Radar meters have also been widely used by traffic engineers and enforcement agencies to measure the spot speed.

Overall Speed : Overall speed is defined as the total distance travelled divided by the total time required, including traffic delays. It is average speed based on the total distance travelled and total time taken for that distance.

Running Speed: Running Speed is defined as the total distance travelled divided by the running time. The running time is the time; only when vehicle is in motion. In this case time spent on stops, waiting etc. is not included in the calculation.

Overall speed and running speed are considered over a relatively long section of street or highway between an origin and destination. These are normally measured by means of a test vehcile which is driven over the test section of a roadway. This method is called moving car observer method.

Speed vary with the quality of traffic flow. Speed is generally high on expressways and other well designed facalities and it is low on sections of road where traffic congestion is a dominant factor.

2.3. Traffic Volume: Traffic volume is defined as the number of vehicles that can pass a point on a roadway or traffic lane per unit time. Traffic volume is a measure of the quality of traffic flow. Volume is commonly measured in units of vehicles per day (VPD), vehicles per hour (VPH) or vehicles per minute and so forth.

Two measures of the traffic volume are of special significance to the highway engineers namely average daily traffic (ADT) and design hourly volume (DHV).

2.3.1 Average Daily Traffic (ADT) : The average daily traffic is defined as the total number of vehicles that can pass a particular point on a roadway within a period of 24 hours consectively and averaged over a period of 365 days. ADT is a fundamental measure of traffic volume needed for the determination of vehicle-kilometer of travel on various categories of rural and urban highway systems.
ADT values for a specified road section provide the highway engineer and planner with essential information needed for the prepartion of the design standards. Vehicle-kilometer values are important for the development of highway financing, the appraisal of safety programmes and as a measure of the service provided by the highway transportation.

Generally, it is quite costly to carryout continuous counts for 365 days of the year along every section of a highway system, therefore it is restricted only for the major highways or heavily trafficed roads.

2.3.2 Design Hourly Volume (DHV) : The design hourly volume is the future hourly volume that is used for designing a particular facility. It is usually the thirtieth(30th) highest hourly volume of the design year. Traffic volumes are much heavier during certain hours of the day or year and low during other periods. It is the 30th hourly volume also called design hourly volume which is used for the design of highways, intersections and other facilities. This implies that there could be congestions during 29 hours of the year which contains traffic volumes higher than the design hourly volume. It is generally considered un-economical to design highways and related facilities considering the highest hourly volume.

Experience has indicated that it would be too uneconomical to design an average highway for peak hourly volume, because traffic will be exceeded than the design hourly volume only 29 hours in a year. Therefore the hourly traffic volume chosen for the design purposes is that which occurs during the "thirtieth highest hour". Thus it is common practice to design a highway to accomodate this thirtieth-hourly volume for some stated future year.

2.4 Traffic Density : Traffic density or concentration is defind as the average number of vehicles accupying a unit length of a roadway at a given instant. It is generally expressed in units of vehicles per km. The traffic density bears a functional relationship to speed and volume. The theoretical speed-volume

curve, which is the fundamental diagram of traffic flow is given in figure-2.1.

2.5 Definition of Capacity : Capacity is defined as the maximum number of vehicles that can reasonably 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, assuming good weather and pavement conditions exist.

It is therefore broadly equivalent to "possible capacity" in the 1965 Highway Capacity Manual (HCM 65). However capacity figures used are for ideal conditions, similar to "basic capacity" in the 1985 Manual. Weather and pavement conditions are not specifically taken into account but local modifications may be used.

2.6 Time Period for Analysis: A major change in the 1985 Highway Manual capacity from the 1965 Manual is that a 15 minute analysis period is used in most cases. This is considered to be the shortest period in which stable flow exists. Design hourly volume must be converted into an equivalent 15-minute peak-flow rate using Peak Hour Factors, for comparison with computed Service Flow rates.

2.7 Un-interrupted Flow: This type of flow occurs on facilities which have no fixed elements, such as traffic signals, external to the traffic stream that cause interruptions to traffic flow. Traffic flow conditions are the result of inter-sactions among vehicles in the traffic stream, and between vehicles and the geometric and environmental characteristics of the roadway.

2.8 Interrupted Flow: This type of flow occurs on facilities which have fixed elements causing periodic interruptions to traffic flow, such as traffic signals, stop signs and other types of controls, irrespective of how much traffic exists.

The definition of uninterrupted flow covers a range of conditions. Freeways operate under the purest form of uninterrupted flow, whilst multi-lane and 2-lane roads may operate under uninterrupted flow in long segments between points of fixed interruptions. On these roads it will often be necessary to examine points of fixed interruption as well as uninterrupted flow segments.

It would appear that for rural roads, uninterrupted flow occurs as long as the traffic stream does not have to stop or slow because of traffic signals, STOP or YIELD signs. Thus, for example, inadequate provision for turning off the major road at major/minor priority junctions, longitudinal and transverse movements of pedestrians and slow moving vehicles, effects of vehicles entering or crossing the highway would appear not to alter the uninterrupted flow conditions.

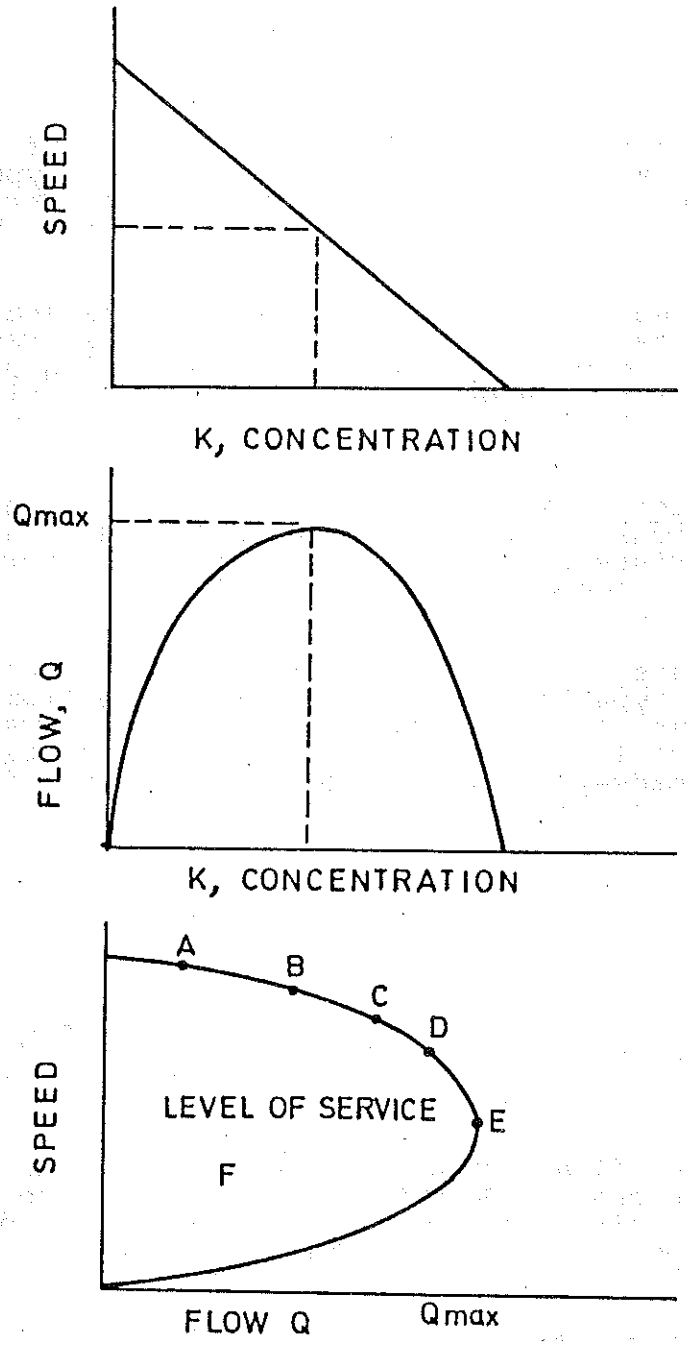

Figure – 2-1: FUNDAMENTAL DIAGRAMS OF TRAFFIC FLOW

2.9 Roadway, Traffic and Control Conditions: Roadway conditions refer to the geometric characteristics of the street or highway including the type of facility and its development environment, the number of lanes (by dirnction), lane and shoulder widths, lateral clearances, design speed, and horizontal and vertical alignments.

Traffic conditions refer to the traffic stream caracteristics such as the distribution of vehicle types in the traffic stream, the amount and distribution of traffic in available lanes of a facility and the directional distribution of traffic.

Control conditions refer to the types and specific design of control devices and traffic regulations present on a given facility, including location, type and timing of traffic signals, STOP and YIELD signs, lane use restrictions, turn restrictions. The control conditions thus relate to interrupted flow.

2.10 Level of Service : It is a qualitative measure describing operational conditions within a traffic stream, and their perception by motorists/passengers, in terms of factors such as speed, travel time, freedom to manoeuvre, traffic interruptions, comfort, convenience and safety.

2.11 Service Flow Rate : The flow rate which can be accommodated by various facility types at each level of service from A to F, in which vehicles can reasonably be expected to traverse a point or uniform section of lane or roadway during a given time period under prevailing roadway, traffic and control conditions while maintaining a designated level-of-service.

Maximum Service Flow Rates for each level of service for ideal conditions are then adjusted to reflect prevaling conditions.

2.12. Levels of Service for Un-interrupted Flow :

Level A: Free flow, very good freedom to select desired speeds and to manoeuvre within stream. Excellent levels of comfort and convenience. Individual users unaffected by presence of other vehicles.

Level B: Stable flow, presence of other vehicles starts to be noticeable. Freedom to select desired speeds is relatively unaffected, but a slight decline in freedom to manoeuvre exists, and a somewhat lower level of comfort and convenience.

Level C: Stable flow, but marks the beginning of the range of flow in which the operation of individual users become significantly affected by interactions with

others in the traffic stream. Selection of speed is affected by presence of other vehicles, monoeuvring in stream requires substantial vigilance. Noticeable decline in general level of comfort and convenience.

Level D: High density, but stable flow. Speed and freedom to manoeuvre are severely restricted and the driver experiences a generally poor level of comfort and convenience. Small increases in traffic flow generally cause operational problems at this level. (This appears to be a significant change from the 1965 Manual where level D was considered to be "approaching unstable flow". In view of possible operational problems at this level it is suggested that level D be considered for rural roads only in difficult circumstances.)

Level E: Operating conditions at or near ultimate capacity. All speeds reduced to a low but uniform value. Freedom to manoeuvre is difficult and accomplished by forcing vehicles to give way. Poor comfort and convenience and driver frustration. Unstable operation since small increase in flow or minor perturbations in the stream will cause breakdown of the flow.

Level F: Forced or breakdown flow. Demand exceeds capacity and queues form. Unstable stop-go and jamp-pack conditions.

2.13. Type of Terrain: The Highway Capacity Manual 1985, considers following type of terrains while calculating capacity.

Level Terrain: Any combination of grades and horizontal and vertical alignment permitting heavy vehicles (having equal or more than 4 types in the rear axle) to maintain approximately the same speed as passenger cars; this generally includes short grades of not more than 1-2%

Rolling Terrain: Any combination of grades and horizontal or vertical alignment causing heavy vehicles to reduce their speeds substantially below those of passenger cars, but not causing heavy vehicles to operate at crawl speeds for any significant length of time.

Mountainous Terrain: Any combination of grades and horizontal and vertical alignment causing heavy vehicles to operate at crawl speeds for significant distances or at frequent intervals.

CHAPTER-III

REVIEW OF DIFFERENT PLANNING STANDARDS

3.1. Planning Standards Recommend by American Consultants:

As far back as 1962, the then West Pakistan Highway Department engaged American Consultants namely M/S Howard Needles and Bergendoff, who among other things, suggested the following planning standards for highway improvement:-

Table-3.1 Highway Planning Standards (1962)

Road Type	Volume Limits (vpd)
24' shingled	0 - 50
Paved 12' shingled 12'	51 - 100
24' Paved (light duty)	101 - 500
24' Paved (intermediat duty)	501 - 3000
24' Paved (heavy duty)	3001 - 7200
4 Lane divided	7201 - 48000

These standards were adopted by the then West Pakistan Highway Department and the Planning Commission. All highway planning since that time has been done on the basis of these standards.

It may, however, be noted that the capacity of any road in terms of vehicles per day depends primarily on the proportion of heavier and slower moving vehicles. In 1962, the composition of traffic was much different than it is now. There were lot more animal drawn vehicles (10 - 15%) and high proportion of heavy vehicles (75 - 80%). On the other hand, the smaller vehicles such as cars, etc were less than 10%. All these factors negatively influence the capacity of a road when measured in terms of vpd. Since that time, the animal drawn traffic have almost disappeared from the major highways, the proportion of heavy vehicles have declined to 40% and the cars have increased and capacity in terms of vpd for two lane and four lane roads should now be higher than the figures recommended by M/S Howard Needles Tammen and Bergendoff in 1962.

3.2. Punjab Highway Department Standards (1972).

The Punajab Highways Department prepared its publication namely "Classification of Highway System and Design Criteria" in June 1972 and recommended construction standards for provincial highways planning purposes. These construction standards are given in table 3.2.

Table 3.2

Road Construction Standards for Highway Planning (1972)

Class	ADT on Opening (Mixed Traffic	Type of Pavement	Formation Width	Right of Way	Design Speed (Km/hr)	Level of Service On Opening.
I	100-500	12-ft (3.65m) Surface Treated	32 ft (9.35)	110 ft (33.53m)	L:80 R:65 M:40	C
II	500-1500	20-ft (60.Om) Surface Treated	44 ft (13.40m)	110 ft (33.53m)	L:90 R:80 M:40	B
III	1500-4000	24-ft (7.3m) Surface Treated	50 ft (15.20m)	220 ft (67.05m)	L:95 R:80 M:50	B
IV	4001-8000	24-ft (7.3m) Asphaltic Concrete + 6-ft Treated Shoulder	50 ft 15.20m)	220 ft (67.05m)	L:90 R:80 M:40	B
V	8001-48000	2x24 ft (7.3m) Asphaltic Concrete + 6-ft Treated Shoulder	96 ft (29.05m)	220 ft (67.05m)	L:110 R:100 M: 80	B

Note: The mixed traffic ADT of Class IV in above Road Construction Standards might be modified to be 4001-7200 for practical Pakistan Standard, although the ADT categorization is based on the information prevalent.

3.3. Indian Road Standards: Road capacities suggested by the Indian Road Congress are as given in Table-3.3.

TABLE-3.3 CAPACITY OF DIFFERENT TYPES OF ROADS

S. No.	Type of Road (in both directions)	Capacity (Passenger car units per day
1.	Single-lane roads having a 3.75m wide carriageway with normal earthen shoulders	1,000
2.	Single-lane roads having a 3.75m wide carriageway with adequately designed hard shoulders 1.0m wide.	2,500
3.	Two-lane roads having a 7m wide carriageway with normal earthen shoulders.	10,000
4.	Roads of intermediate width i.e. having a carriageway of 5.5 metres with normal earthen shoulders.	5,000

Note: Capacity of highways having a dual carriageway will depend on factors like the directional split of traffic, degree of access control, composition of traffic etc. Depending on the actual conditions, capacity of a 4-lane divided highway could be upto 20,000-30,000 pcus.

According to the Indian Roads Congress the standards in Table 3.3 are applicable where the visibility is unrestricted and there are no lateral obstructions within 1.75m from the edge of pavement. These also presume that only a nominal amount of animal drawn vehicles (say 5-10 per cent) are present in the traffic stream during the peak hour.

The cost of widening a single lane pavement to two-lanes is substantial. Thus, even though traffic intensity warrants the widening to two-lanes, (which is 1000 PCUs per day as per current IRC standards), financial constraints will stand in the way of such programme. The difficulty can be got over by providing adequately designed shoulders 1.0m wide on either side, thus increasing the capacity to 2500 PCUs per day. At the next stage, widening can be done to an intermediate width of 5.5m, depending upon the importance of the road, thus raising its capacity to 5000 PCUs per day.

The capacity of a two-lane road as per current IRC standards is 10,000 PCUs per day. If this standard is adhered to, a significant proportion of the N.H. System and some

proportion of the S.H.System would need to be widened to four lanes. This would be beyond the resources one could aniticipate to be made available. It is, therefore, suggested that when the traffic volume reaches 10,000 PCUs per day, adequately designed hard shoulders, 1.0-1.5m wide, should be provided on either side of the pavement. Such a road will effectively segregate slow moving traffic (cycles and animal drawn traffic) from the fast moving traffic. It can accommodate traffic volumes in the range of 15,000 to 20,000 PCUs per day. thus the question of widening to four lanes can be put off by 15 to 20 years. Only when the traffic reaches a level of (15,000-20,000) PCUs per day four-laning can be considered. If such a pavement is constructed, proper road marking must be provided. The centre-line and the two edges of the two-lanes must be marked.

Similarly, the capacity of Indian Roads suggested in the study "Road User Costs in India" is given in table-3.4.

3.4. Standards for Low Volume Roads Recommended by National Research Council.

The National Research Council of Transportation Research Board, Washington, D.C has recommended following different classes of low volume roads according to different traffic volumes. Traffic is the primary determinant for road standards. Follwing standards are proposed for low volume roads according to five design classes for different vNlumes of expected traffic per day on opening.

Class I	Under 50 vehicles
Class II	50 to 400 vehicles
Class III	400 to 1,000 vehicles
Class IV	1,000 to 2,000 vehicles
Class V	Over 2,000 vehicles

Traffic is expressed as the ADT of mixed vehicles.

3.5. Highway Standards in Manila.

Ministry of Public Works and Highways, Manila, has recommended values of minimum AADT at the time of opening of different types of roads as given in table-3.5.

Table-3.4 Suggested Capacity of Indian Roads

Sl. No.	Category	Maximum capacity in veh/hr in both direct.	Suggested design service volume in both	Suggested Design service volume in both directions in veh/day	in PUCs / day
1.	Single lane plain terrain with low curvature.	230	100	1000	2000
2.	Intermediate lane in plain terrrain with low curvature	600	300	3000	6000
3.	Two lane in plain terrain with low curvature	1500	750	7500	15000
4.	Two lane in rolling terrain	1100	550	5500	11000
5.	Two hilly terrain	500	250	2500	5000
6.	Four lane divided carriageway in plain terrain with low curvature	10000	5000	50000	100000
7.	Four lane divided carriageway in plain terrain with high curvature	8000	4000	40000	80000

Ref- Road User Costs in India

Table-3.5
Minimum Opening year Traffic Volume Per day
(AADT) For Surface and Width

Road Type	Min.AADT
4M Gravel with meeting bays (1 per 300M)	Less than 160
6M Gravel without shoulders	160
6M DBST with 2x2.0 M gravel shoulders	360
6M AC with 2x2.0 M gravel shoulders	550
7M AC with 2x2.5 M gravel shoulders	1,120
2x7M AC with 2x2.5M gravel shoulders	7,000

Opening year traffic volume per day indicates the traffic in the year, which would be the first technical possible opening year for an improved facility.

In cases where the traffic growth within the planning period would imply that the AADT would reach minimum AADT for higher standard, stage construction should be considered with initially up to maximum 15 meters prepared roadway for two-lane roads with initially justified surface type and width.

3.6. Standards Proposed by JICA (1983).

The Japan International Cooperation Agency (JICA), while preparing the National Transport Plan Study for Pakistan in 1983, recommended construction standards for highways as given in table-3.6.

The design speed for a Class III standard highway shall be 50 miles per hour. In extremely mountainous areas, where cost would be high and traffic volume low, a minimum speed of 20 miles per hour will be used.

Again in 1988, the JICA team revised the National Transport Plan and proposed revised road Standards for Highway Planning as given in Table-3.7.

Table-3.6 Recommended Construction Standard by Master Plan for Highways

Volume limits (vehicle/day)	Construction Standards	Type of Pavement	Formation Width	Right of Way
101 - 500	Class III	12-ft. surface treated	32 feet	110 feet
500 - 1500	Class II	20-ft. surface treated	44 feet	110 feet
1500 - 4000	Class I	24-ft. surface treated	50 feet	220 feet
4001 - 8000	Class I	24-ft. carpeted with 6-ft. treated shoulders.	50 feet	220 feet
8001 - 48000	4-Lane divided	Each 24-ft. carpetted with 6-ft. treated shoulders.	96 feet	220 feet

Note: The design speeds for Class I, and Class II standard highways will be adopted as follows:

Flat open terrain	-	70 miles per hour
Rolling hilly terrain	-	50 miles per hour
Semi-hilly terrain	-	40 miles per hour
Urban areas	-	50 miles per hour
Minimum speed allowed	-	30 miles per hour

Table-3.7 Proposed Revised Road Standard for Highway Planning

CLASSIFICATION	NUMBER OF LANES	DESIGN SPEED (Km/H)	PLANNING GUIDELINE (TRAFFIC) VOLUME LIMITS(MAX) (PCU/DAY)	PLANNING GUIDELINE (TRAFFIC) LEVEL [V/C OF RATIO] SERVICE	TYPICAL CROSS SECTION CARRIAGE-WAY WIDTH	SHOULDER WIDTH (LEFT)	MEDIAN WIDTH	FORMATION WIDTH	R.O.W	APPLICATION & TYPE OF PAVEMENT
I	4-Lane Divided	F:110 H:100 M: 80	90000	C [0.70]	14.60 m (24x2ft)	3.65 m (12ft)	3.65m (12ft)	29.20 m (96 ft)	66.90 m (220 ft)	PH AC
II	2-Lane Hard Shoulder	F:100 H: 80 M: 60	24000	C [0.70]	7.30 m (24 ft)	3.65 m (12 ft)	---	14.60 m (48 ft)	66.90 m (220 ft)	PH AC
III	2-Lane Soft Shoulder	F:100 H: 80 M: 60	24000	C [0.70]	7.30 m (24 ft)	3.65 m (12 ft)	---	14.60 m (48 ft)	66.90 m (220 ft)	PH/SH AC/TST
IV	2-Lane	F: 80 H: 60 M: 50	20000	C [0.70]	6.00 m (20 ft)	3.65 m (12 ft)	---	13.40 m (44 ft)	33.40 m (110 ft)	SH AC/TST
V	1-Lane	F: 60 H: 50	3500	D [0.85]	3.65 m (12 ft)	3.00 m (10 ft)	---	9.70 m (32 ft)	33.40 m (110 ft)	SH TST

Source: JICA Study Team

Abbreviation
F: Flat Area
H: Hilly Area (Rolling Area)
M: Mountainous Area
PH: Primary Highway
SH: Secondary Highway
AC: Asphalt Concrete
TST: Triple Surface Treatment

Note: Guideline Factors of Average Passenger-car Equivalents for Trucks and Buses (Heavy Vehicles)

Flat Area	3.0
Hilly Area	4.0
Mountainous Area	6.0

Details are shown in Appendix, Highway Capacity Analysis,, (3) Adjustment factors.

CHAPTER-IV

COLLECTION AND PRESENTATION OF DATA

4.1 Location of Points For Traffic Count Survey:

To have an idea about the capacity of existing two-lane roads under the prevailing roadway, traffic and environmental conditions representing local driving behaviour, 8 locations were selected in Islamabad for the traffic count surveys. Locations were selected on the basis that different composition of traffic, and heavy traffic volumes could be surveyed, A plan showing location of survey points is given in figure 4.1.

4.2 Traffic Count Surveys :

Classified Traffic Counts were conducted manually for eighteen hours from 0600 hours to 2400 hour. Traffic Counts for 24 hrs were also taken using the mechanical counters at each station.

Appendix table 4.1 provides summary of 24 hour traffic volume figures at all the eight stations. The 24 hour volume figures expressed in vehicles per day have been worked out using the manual readings of 18 hours from 0600 hours to 24 hours and counter readings from 24 hrs to 0600 hrs. Appendix table 4.1 shows that the maximum traffic is at station No.6 on Peshawar More to Pindora section with a traffic volume of 21,431 vpd. The next heavy traffic volume is at station No. 5 on the road section between Peshawar More to Zero point with a traffic of 19,306 v.p.d. However these figures include motor cycles also. The corresponding figures at these stations excluding motor cycles comes out to be 16,257 vpd and 16,162 vpd respectively.

The ratio of Peak hourly volume to ADT for the highest ADT section i.e Peshawar More to Pindora was found to be 6.8%, and for the 2nd highest section i.e. Peshawar More to Zero Point was 9.9%. The 24 hours traffic volume and peak hour factor for all the 8 stations is also given in appendix table 4.1. It may be seen from the table that the flow condition is almost same on all the eight stations. Appendix tables 4.2 to 4.9 show the hourly variations of traffic at all the eight stations. The highest hourly traffic as a percentage of 24 hourly traffic is also given in Appendix tables 4.2 to 4.9.

The Peak hourly volume as a percentage of ADT ranges between a minimum of 6.2% on the section Golra More to Sector G-11 and maximum of 9.9% on the section Peshawar more to Zero Point. This condition is almost same on most of our rural highways as studied by the JICA team while preparing the National Transport Plan Study in 1988.

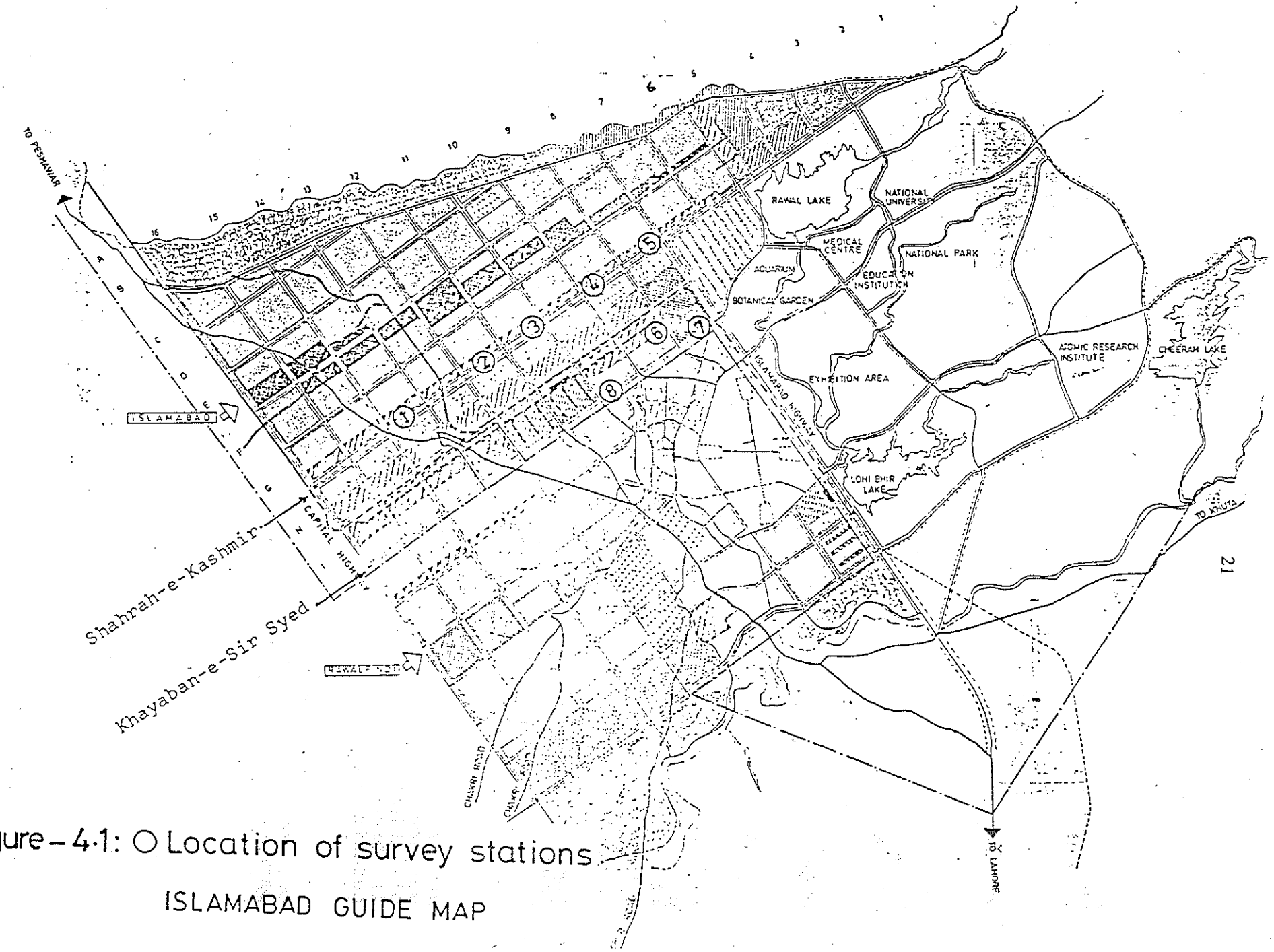

Figure – 4.1: O Location of survey stations

4.3 Congestion/Speed Surveys :

Speed survey was conducted on the two heavily trafficed sections namely Peshawar More to Pindora and Peshawar More to Zero Point using Radar gun. Speed survey was carried out during the peak hour period to ascertain the congestion. Speeds of different vehicles during peak hour at station No.5 and station No.6 are given in Appendix tables 4.10 & 4.11 respectively.

It may be seen from the speed profile of different vehicles that no congestion was observed on these road sections even during the Peak hour periods and the traffic flow was without any traffic jam.

According to speed survey, the average vehicular speed between Peshawar More to Pindora was between 40-50 kph, and on the section between Peshawar More to Zero Point, the average speed was between 50-60 kph.

The highest average speeds of 50 kph and 60 kph observed at these sections was of cars/jeeps followed by motor cycles respectively.

4.4 Road Geometric Surveys:

To ascertain the geometric features of the road sections such as road width, shoulder width, type and condition of shoulders, geometric survey was carried out at all the eight locations. Widths of shoulder and pavement was measured on both sides of the centre line. Details of geometric features are given in Appendix table 4.12.

It may be seen from the Appendix table 4.12 that all roads under the study were two-lanes, 24 ft. wide having each lane of 12'-0 width. The surface is fairly good with A-class bituminous carpetting. Width of shoulder varies from a minimum of 5 ft to a maximum of 10 ft on Pirwadhai-Pindora section. On the average, shoulder width is 6 ft.

Shoulders are made of compacted gravel. Due to lack of maintenance, shoulders are generally un-leveled with pavement surface. At the edge of the pavement; shoulders are lower in elevation than the pavement surface and as a result pavement edge is broken at certain places. Electricity and telephone poles certain places are errected in the centre of the shoulders and thus affecting the overall capacity of the road.

Bridges are mostly constructed only under the paved portion and shoulders are not carried through. The raised Bridge parapets between the black top portion and shoulders causes a serious capacity restraint.

4.5 Proportion of Heavy Vehicles :

To ascertain the proportion of heavy vehicles in the traffic mix, 24 hour classified traffic count data collected at two out of eight stations studied in Islamabad is analysed and given in Appendix tables 4.13 & 4.14. Data collected at 20 permanent traffic count stations containing the composition of different types of vehicles is given in Appendix tables 4.15 to 4.17.

Buses, trucks 2/axle and 3-axle and trailors are considered as heavy vehicles for capacity calculations. In Islamabad percentage of heavy during peak hour was found as 16.7% on section between Peshawar More to Pindora. Simlarly the percentage of heavies between Peshawar More to Zero Point during peak hour was found as 7.2%.

The percentage of heavy traffic on rural highways ranges from an average of 48% to about 80% on certain sections like Sadiqabad on National Highway N-5.

The composition of traffic with time has changed. Presently the compsition of traffic is much different than it was in 1962. There were lot more animal drawn vehicles (10% - 15%) and high proportion of heavy vehicles (75% - 80%). On the other hand, the smaller vehicles such as cars, etc were less than 10%.

CHAPTER-V

HIGHWAY CAPACITY ANALYSIS

5.1 Methodology

Generally, the design capacity of highway can be calculated using the following equations :

Multi-Lane Highways

SF = CB(M) X fw X fH X fE X fP X (V/C) X N

Two-Lane Highways

SF = CB(T) X fw X fH X fD X (V/C)

Where :

SF = Service flow rate, the maximum flow rate that can be accomodated by the multilane highway segment under study under prevailing road way and traffic conditions (Vehicles/hour).

CB(M) = Basic capacity per lane under ideal conditions (PCU/hour) for multi-lane highways.

CB(T) = Basic capacity in both directions under ideal conditions (PCU/hour) for two-lane highways.

fW = Adjustment factor for lane width and/or lateral clearance restriction.

fH = Adjustment factor for the presence of heavy vehicles in the traffic stream.

fE = Adjustment factor for development environment and type of multi-lane highway.

fP = Adjustment factor for driver population.

fD = Adjustment factor for directional distribution of traffic.

Et = Passenger car equivalent for heavy vehicles.

V/C = Maximum volume-to-capacity ratio for level of service.

N = Number of lanes per direction.

5.2 Basic Capacity

Basic capacity means the maximum rate of flow under ideal conditions. According to HCM'85, ideal conditions for multi-lane highways include :

- Level terrain.
- 12-ft lane widths.
- A minimum of 6-ft lateral clearance between the edge of travel lanes and obstructions at the road side or in the median.
- Passenger cars only in the traffic stream.
- A divided highway cross section in rural environment .

While ideal condition for two lane highways are defined as no restrictive, geometric, traffic, or environmental conditions. Specifically, they include :

- Design speed greater than or equal to 60 mph.
- Lane widths greater than or equal to 12 ft.
- Clear shoulder wider than or equal to 6 ft
- No "no passing zones" on the highway.
- All passenger cars in the traffic stream
- A 50/50 directional split of traffic.
- No impediments to through traffic due to traffic control or turning vehicles.

The basic capacity has been studied in the several countries. The basic capacity commonly used in USA and Japan is given in table 5.1.

Table 5.1
Basic Capacity of Highways

Type of Highway	Unit	USA	Japan	Recommended For Pakistan
Multi-Lane Highway	Per Lane (PCU/hr)	2,000	2,500	2,500
Two-Lane	Both directions (PCU/hr)	2,800	2,500	2,800

Considering the local conditions in Pakistan, the specified basic capacity for two-lane and multi-lane highway are recommended as the highest figures of capacity in USA and Japan.

5.3 V/C Ratio : (Level of Service)

Level of service is a key factor for the road improvement planning. This means the maximum volume to capacity ratio allowable while maintaining the performance characteristics of level of service. The V/C ratio's used in U.S.A. as given in HCM 1985, are on a higher side of planning level for Pakistan. Keeping in view the financial resources of Pakistan, JICA has recommended different V/C ratios against different level of service to be applied for the design standard of Pakistan both for multi-lane and two-lane highways as a guide line. Recommended (V/C) ratios for different levels of service are given in table 5.2.

Table-5.2

Recommended V/C Ratio for Highway Planning Level

Level of Service	V/C Ratio	Application
A	0.35	N.A
B	0.55	N.A
C	0.70	Class-I to Class-IV highways
D	0.85	Class-V highways
E	1.00	N.A

5.4 Adjustment Factor for Heavy Vehicles(fH)

Adjustment factor for the presence of heavy vehicles in the traffic stream is caculated as :

$$fH = \frac{1}{1 + pH(Et-1)}$$

Where :
pH = Proportion of Heavy vehicles (Trucks and Buses) in the traffic stream.

5.5 Capacity Analysis :

Since all the road sections in the study are two-lane highways, therefore the capacity analysis of two sections namely Peshawar More to Pindora and Peshawar Motor to Zero Point containing the highest traffic volume out of eight survey sections selected for the study is presented below. The existing level of service is also calculated to determine the quality of flow.

I) Station: Peshawar More to Pindora

The level of service which is determined from volume/capacity ratio i.e. V/C and service flow rate SF is determined with the help of following equation.

SF = 2800 X fw X fH X fD X (V/C)

SF = Determined using the following relationship :

$$SF = \frac{V}{PHF}$$

Where : V = Maximum hourly volume = 6.8% of AnT

= 1447 vehicles.

PHF = Peak hour factor which is the ratio of average flow in 15 minutes to the highest flow in the same time

= 0.9

therefore $SF = \frac{1447}{0.9} = 1608$ vehicles.

fW = Adjustment factor for the lane width and/or lateral clearance which is = 1 for the road under study (since lane width=12' and shoulder width=6'.

fD = Adjustment factor for the presence of heavy vehicles :

$$= \frac{1}{1 + PH\ (E-1)}$$

pH = Proportion of heavy vehicles (trucks and buses) in the traffic stream :

= 16.7% for the road section under study.

Et = Equivalent passenger car units for mix of heavy vehicles = 3 i.e. each bus or truck = 3 passenger car units.

therefore $fH = \frac{1}{1 + 0.167(3-1)} = 0.749$

$SF = 2800 \times fw \times fH \times fD \times (V/C)$

$1608 = 2800 \times 1 \times fH \times fD \times (V/C)$

$1608 = 2097 \times (V/C)$

therefore $V/C = \frac{1608}{2097} = 0.77$

Considering the recommended V/C ratios for highway. Planning level (table 3.4), the V/C ratio of 0.77 represents level of service 'D' on the section Peshawar More to Pindora.

During the speed survey, no congestion was observed on this section, therefore it could be said that even at level of service 'D' there were no visible signs of congestion.

The level of service 'D' has only been recommended for class-V highways, therefore limiting capacity is considered at desired level of service 'C' for two lane highways as calculated below.

Limiting Capacity at Desirable L.O.S. 'C'

This capacity can be calculated by subsituting value of V/C equal to 0.70.

$$SF = 2800 \times fw \times fH \times fD \times (V/C)$$

$$= 2800 \times 1 \times 0.749 \times 1 \times 0.7$$

$$= 1468 \text{ Vehicles/hr.}$$

Again from $SF = \frac{V}{PHF}$

$$V = SF \times PHF = 1468 \times 0.9 = 1321 \text{ V.P.H.}$$

Now taking V = 6.8% of ADT

$$ADT = 1321 \times \frac{100}{6.8} = 19430 \text{ VPD}$$

Hence limiting capacity of two-lane highway under study at desired level of service 'C' = 19430 VPD.

II. Station: Peshawar More to Zero Point.

i) ADT = 19306 VPD

ii) Maximum hourly volume = 1910 VPH

iii) Ratio of Maximum hourly Volume to ADT = 9.9%

$$SF = 28000 \times fw \times fH \times fD \times (V/C)$$

$$SF = \frac{V}{PHF} = \frac{1910}{0.9} = 2122 \text{ VPH}$$

fW = 1, lane width = 12', shoulder width=6'

fD = 1, 50/50 split in both direction

$$fH = \frac{1}{1 + pH\ (Et-1)}$$

pH = 7.2%, Et = 3

fH = 0.874

therefore

$$2122 = 2800 \times 0.874 \times (V/C)$$

$$V/C = \frac{2122}{2447} = 0.867$$

The V/C ratio of 0.867 explains that the road section between Peshawar More to Zero Point is operating at level of service between 'D' and 'E'. Again on this section no sign of congestions were seen during the speed survey. This shows that even operating at L.O.S. below 'D' the section can carry ADT of over 19000 vehicles without much congestion.

Limiting Capacity at Desired L.O.S. 'C'

Again substituting the value of V/C equal to 0.7, limiting capacity of the section is calculated as under.

$$SF = 2800 \times fW \times fH \times fD \times (V/C)$$

$$= 2800 \times 1 \times 0.874 \times 1 \times 0.7$$

$$= 1713 \text{ VPH}$$

$$V = SF \times PHF = 1713 \times 0.9 = 1542 \text{ VPH}$$

Taking V = 9.9% of ADT

$$ADT = 1542 \times \frac{100}{9.9} = 15,575 \text{ VPD}$$

Hence the limiting capacity of the road section between Peshawar More to Zero Point is about 15,600 VPD at desired L.O.S.'C'. Capacity analysis for all the sections studied has been made. A table showing the existing flow conditions i.e. level of service at which all the sections studied are operating and the limiting capacity at the desired level of service 'C' are given in table-5.3. Following values are taken for calculation of existing level of service and limiting capacity on the road sections, other than the two sections analysed earlier.

i) Percent of Heavy Vehicle = 10%

ii) Peak hour factor = 0.90

Table - 5.3

Capacities of Road Sections Studied

Station No.	Road Section	Existing Flow Conditions			Limiting Capacity at Desired LOS'C'
		ADT	V/C	L.O.S	
1.	G.T. Road N-5 to Golra More	7661	0.24	A	21925
2.	Golra More to Sector G-11	12224	0.36	B	23690
3.	Sector G-11 to Sector-10	8282	0.36	A	21290
4.	Sector G-10 to Sector G-9	9027	0.28	A	22600
5.	Sector G-9 to Zeropoint	19306	0.867	D	15500
6.	Peshawar More to Pindora	21431	0.77	D	19000
7.	Pindora to Faizabad	13111	0.39	B	23300
8.	Faizabad to Pirwadahi	17804	0.58	C	21290

Capacity Calculations for 4-Lane Divided Highways
Limiting Capacity at L.O.S 'C'

SF = CB (M) x fw x fH x fE x fP x (V/C) x N

CB(M) = 2500 PCU/hr

fw = 1

fH = 0.749

fE = 0.9

fP = 0.95

V/C= 0.7

N = 2

SF = 2500 x 1.0 x 0.749 x 0.9 x 0.95 x 0.7 x 2

= 2241 VPH

SF = V/PHF V = SF x PHF

V = 2241 x 0.9 = 2017 VPH

V = 7% of ADT

therefore ADT = 2017x 100/17 = 28814 VPD per direction

Considering 50/50 directional distribution

Total ADT in both directions

= 28814 x 2 = 57600 VPD

It is evident from the previous analysis that following factors have a strong bearing on the capacity of two lane road.

i) Proportion of heavy vehicles in the traffic stream.

ii) Width of pavement and shoulders.

Other factors namely, the directional distribution and the effect of gradient also affect the capacity of two-lane highway. The directional distribution on two-lane highways in Pakistan is generally 50/50. Therefore the value of fD=1 can be taken for all two lane roads. The length of road section having up and down grades and its steepness (% gradient) are also very important. The effect of gradient on capacity calculations is taken in to account by the fH factor. For the calculation of fH factor; higher Et values are taken for steeper and longer lengths of grades and smaller Et values for relatively mild grades and shorter lengths.

Analysis of data collected at 20 permanent traffic count stations of NTRC, given at Appendix tables 4.15 to 4.17 shows that proportion of heavy vehicles in the traffic mix on the average is 48%. Similarly pavement width also varies from 12' to 9' and large variations exist in shoulder widths and lateral clearances.

From the above paragraphs, it is clear that due to large variations, capacity of road varies from section to section. Therefore for the purpose of design; capacity of each link should be calculated separately taking in to account the effect of all factors mentioned earlier. However, for the planning purposes, capacity values are calculated considering different proportions of heavy vehicles and taking in to account the effect of lane width and shoulder width. Differennt values of factor fH and fW are given Appendix tables 5.3 and 5.4. Capacity values at L.O.S 'C' are given in Appendix tables 5.5 and 5.8. Ratio of peak hourly volume to ADT is taken as 7% and PHF of 0.9 is used for the analysis.

Based on the calculations, curves are drawn which are given in figure 5.1 and figure 5.2. These curves can be used as ready recknor to determine the capacity of two lane roads varying road way and traffic conditions.

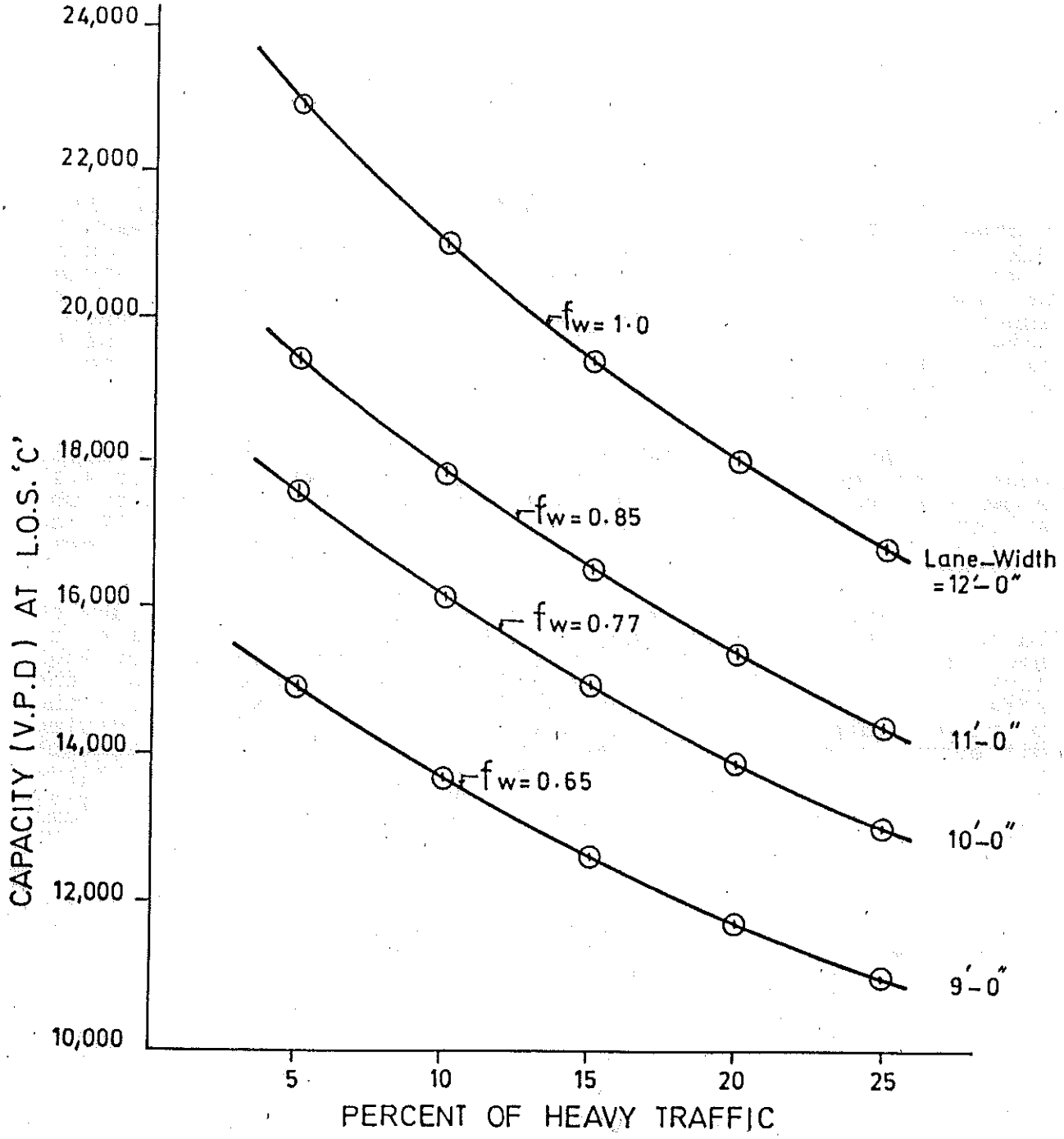

Figure – 5·1: CAPACITY OF TWO-LANE HIGHWAYS
(LEVEL SEGMENTS)

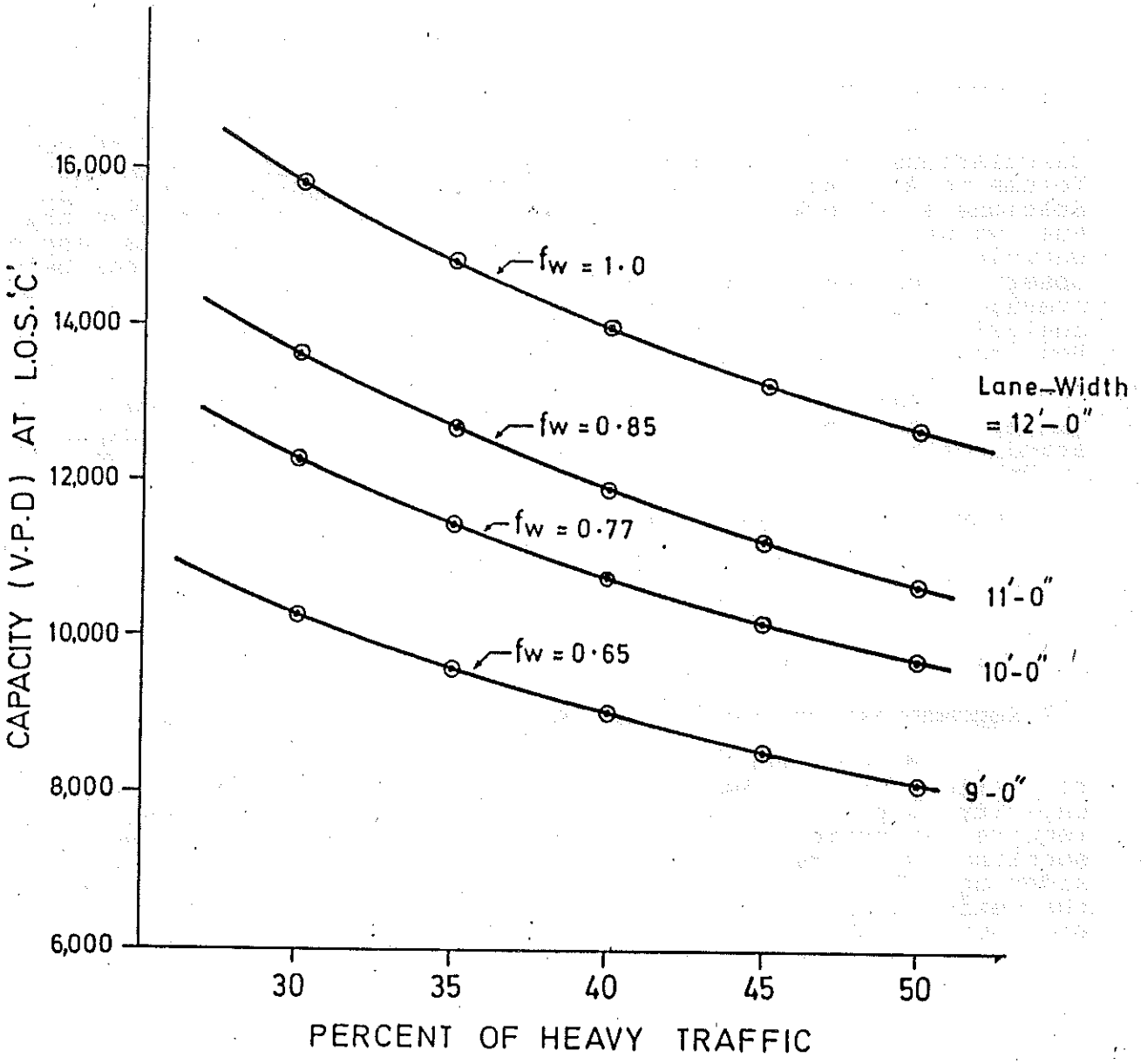

Figure – 5·2: CAPACITY OF TWO-LANE HIGHWAYS
(LEVEL SEGMENTS)

CHAPTER-VI

CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions:

The main factor which influence the capacity calculations is the k-factor which is the ratio of Peak Hourly Volume to ADT. Analysis of data of NTRC's Permanent Traffic Count Stations at Attock, Jhelum, Bahawalpur and Kandiaro revealed that the value of k-factor under local traffic conditions ranged between 5.9 to 8.3% of ADT. Almost the same ratio has been observed on the eight roads studied in Islamabad, therefore an average value of k-factor should taken as 7.0%in the capacity analysis. The JICA report (1988) also recommends the ratio of Peak hourly volume to ADT as 7.0%.

Based on the capacity calculations using HCM-85 and taking into ccount the local conditions, following capacity standards are proposed to be adopted for future road improvements in Pakistan.

S.No.	Type of Road	Capacity
1.	Single lane	500 vpd
2.	Two lane	10,000 vpd
3.	Four lane divided	50,000 vpd

6.2.Recommendations for Future Work:

Mostly there are two-lane roads in the country and due to variety in roadway and traffic conditions, their existing capacity may vary from section to section. The major issue which require attention is the time scheduling when different road sections will reach their limiting capacity and would require widening. The future research is therefore recommended to study the existing level of service and capacity of major national and provincial roads and based on traffic projections, work out the programme for future widening requirments.

References

1. Master Plan for Highways
   Howard, Needles, Tammen & Bergendoff
   C&W Department, Pakistan, 1965

2. Geometric Design Standards
   for Roads, Rural (Non Urban) Highways
   The Indian Roads Congress, New Delhi, 1980

3. Road User Costs Study in India,
   New Delhi

4. Geometric Design Standards for
   Low Volume Roads
   Transportation Research Board,
   National Research Council, Washington, D.C 1978

5. Guide Lines on Economic Evaluation
   of Design Standards of Pavements and Bridges,
   Ministry of Public Works & Highways, Manila, 1982

6. The National Transport Plan Study, JICA 1983

7. The National Transport Plan Study, JICA 1988

8. Guide to Highway Design Standards and
   Specifications,
   Central Roads Organization,
   Ministry of Communications, 1971

9. Effect of Highway Design Elements on the
   Capacity of 2-Lane Roads NTRC-8, 1976

10. A Review of Design Standards for Tertiary
    Rural Roads NTRC-78, 1984

11. Highway Improvement Priority Criteria
    NTRC-3, 1976

Appendices

Table 4.1

Development of Road Standards

Traffic volume

Station No.	Road Section	Traffic Volume of 6 Hrs. by T.Counter (00:00 to 06:00 Hrs)	Traffic Volume of 18 Hrs. by manual Count (06:00) 24:00 Hrs	Total 24 Hours Traffic Volume (vpd)	Maximum Hourly Volume (vpd)	Ratio of Maximum Hourly Volume to 24 Hrs. Traf.Vol.
1	2	3	4	5	6	7
1.	G.T.Road N-5 to Golra More	1023	6638	7661	510	6.7%
2.	Golra More to Sector G-11	1110	11114	12224	754	6.2%
3.	Sector G-11 to Sector G-10	700	7582	8282	571	6.9%
4.	Sector G-10 to Sector G-9	988	8039	9027	587	6.5%
5.	Sector G-9 to Zeropoint	403	18903	19306	1910	9.9%
6.	Peshawar More to Pindora	1103	20328	21431	1447	6.8%
7.	Pindora to Faizabad	1210	11901	13111	826	6.3%
8.	Pindora to Pirwadahi	890	16914	17804	1222	6.9%

Note:- Traffic Volume includes Motorcycles.

TABLE-4.2
HOURLY TRAFFIC VOLUME

STATION NO.1: G.T.ROAD (N-5) TO GOLRA MORE

DATED: 4.5.1991 DAY: SATURDAY

(18 HOURS MANNUAL COUNT+6 HOURS FROM COUNTER)=6638+1023=7661

HOURS	TOTAL VOLUME (v.p.h)	PERCENTAGE (%) OF 24 HOURS TRAFFIC
6 - 7	218	2.8%
7 - 8	324	4.2%
8 - 9	430	5.6%
9 - 10	432	5.6%
10 - 11	447	5.8%
11 - 12	393	5.1%
12 - 13	385	5.1%
13 - 14	314	4.1%
14 - 15	330	4.3%
15 - 16	330	4.3%
16 - 17	312	4.1%
17 - 18	486	6.3%
18 - 19	510	6.7%
19 - 20	470	6.2%
20 - 21	392	5.1%
21 - 22	337	4.4%
22 - 23	289	3.8%
23 - 24	293	3.1%
Total(18 Hrs.Mannual)	6638	86.6%
2400-6:00 from Counter	1023	13.4%
G.Total(v.p.d):	7661	100%

TABLE-4.3
HOURLY TRAFFIC VOLUME

STATION NO.2: GOLRA MORE TO SECTOR G-11

DATED: 5.5.1991 DAY: SUNDAY

(18 HOURS MANNUAL COUNT+6 HOURS FROM COUNTER)=11114+1110=12224

HOURS	TOTAL VOLUME (v.p.h)	PERCENTAGE (%) OF 24 HOURS TRAFFIC
6 - 7	326	2.7%
7 - 8	569	4.6%
8 - 9	753	4.2%
9 - 10	722	5.9%
10 - 11	655	5.3%
11 - 12	707	5.8%
12 - 13	663	5.4%
13 - 14	685	5.6%
14 - 15	692	5.7%
15 - 16	729	5.9%
16 - 17	754	6.2%
17 - 18	737	6%
18 - 19	753	6.2%
19 - 20	673	5.5%
20 - 21	590	4.8%
21 - 22	452	3.7%
22 - 23	362	3%
23 - 24	292	2.4%
Total(18 Hrs.Mannual)	11114	90.9%
2400-6:00 from Counter	1110	9.1%
G.Total(v.p.d):	12224	100%

TABLE-4.4
HOURLY TRAFFIC VOLUME

STATION NO.2: SECTOR G-11 TO SECTOR G-10

DATED: 5.5.1991 DAY: MONDAY

(18 HOURS MANNUAL COUNT+6 HOURS FROM COUNTER)=7582+700=8282

HOURS	TOTAL VOLUME (v.p.h)	PERCENTAGE (%) OF 24 HOURS TRAFFIC
6 - 7	209	2.5%
7 - 8	356	4.3%
8 - 9	579	7%
9 - 10	571	6.9%
10 - 11	566	6.8%
11 - 12	475	5.7%
12 - 13	483	5.8%
13 - 14	480	5.8%
14 - 15	468	5.7%
15 - 16	516	6.2%
16 - 17	486	5.9%
17 - 18	495	6%
18 - 19	399	4.8%
19 - 20	415	5%
20 - 21	350	4.2%
21 - 22	320	3.9%
22 - 23	240	2.9%
23 - 24	170	2.1%
Total(18 Hrs.Mannual)	7582	91.5%
2400-6:00 from Counter	700	8.5%
G.Total(v.p.d):	8282	100%

TABLE-4.5
HOURLY TRAFFIC VOLUME

STATION NO.2: SECTOR G-10 TO SECTOR G-9

DATED: 5.5.1991 DAY: TUESDAY

(18 HOURS MANNUAL COUNT+6 HOURS FROM COUNTER)=8039+988=9027

HOURS	TOTAL VOLUME (v.p.h)	PERCENTAGE (%) OF 24 HOURS TRAFFIC
6 - 7	190	2.1%
7 - 8	361	4%
8 - 9	558	6.2%
9 - 10	553	6.1%
10 - 11	513	5.7%
11 - 12	524	5.8%
12 - 13	529	5.9%
13 - 14	510	5.6%
14 - 15	519	5.7%
15 - 16	531	5.9%
16 - 17	514	5.7%
17 - 18	580	6.4%
18 - 19	587	6.5%
19 - 20	429	4.3%
20 - 21	385	4.3%
21 - 22	280	3.1%
22 - 23	249	2.8%
23 - 24	227	2.5%
Total(18 Hrs.Mannual)	8039	89.1%
2400-6:00 from Counter	988	10.9%
G.Total(v.p.d):	9027	100%

TABLE-4.6
HOURLY TRAFFIC VOLUME

STATION NO.2: SECTOR G-9 TO ZEROPOINT

DATED: 5.5.1991 DAY: WEDNESDAY

(18 HOURS MANNUAL COUNT+6 HOURS FROM COUNTER)=18903+403=19306

HOURS	TOTAL VOLUME (v.p.h)	PERCENTAGE (%) OF 24 HOURS TRAFFIC
6 - 7	322	1.7%
7 - 8	1196	6.2%
8 - 9	1910	9.9%
9 - 10	1343	7%
10 - 11	1300	6.7%
11 - 12	1128	5.8%
12 - 13	1129	5.8%
13 - 14	1536	8%
14 - 15	1451	7.5%
15 - 16	1279	6.6%
16 - 17	1201	6.2%
17 - 18	1132	5.9%
18 - 19	1074	5.6%
19 - 20	902	4.7%
20 - 21	838	4.3%
21 - 22	555	2.9%
22 - 23	391	2%
23 - 24	216	1.1%
Total(18 Hrs.Mannual)	18903	97.9%
2400-6:00 from Counter	403	2.1%
G.Total(v.p.d):	19306	100%

TABLE-4.7
HOURLY TRAFFIC VOLUME

STATION NO.2: PESHAWAR MORE TO PINDORA

DATED: 5.5.1991 DAY: THURSDAY

(18 HOURS MANNUAL COUNT+6 HOURS FROM COUNTER)=20328+1103=21431

HOURS	TOTAL VOLUME (v.p.h)	PERCENTAGE (%) OF 24 HOURS TRAFFIC
6 - 7	489	2.3%
7 - 8	1039	4.8%
8 - 9	1334	6.2%
9 - 10	1302	6.1%
10 - 11	1358	6.3%
11 - 12	1227	5.7%
12 - 13	1346	6.3%
13 - 14	1171	5.5%
14 - 15	1191	5.6%
15 - 16	1447	6.8%
16 - 17	1234	5.8%
17 - 18	1330	6.2%
18 - 19	1368	6.4%
19 - 20	1138	5.3%
20 - 21	1186	5.5%
21 - 22	860	4%
22 - 23	753	3.5%
23 - 24	555	2.6%
Total(18 Hrs.Mannual)	20328	94.9%
2400-6:00 from Counter	1103	5.1%
G.Total(v.p.d):	21431	100%

TABLE-4.8
HOURLY TRAFFIC VOLUME

STATION NO.2: PINDORA TO FAIZABAD

DATED: 5.5.1991 DAY: SATURDAY

(18 HOURS MANNUAL COUNT+6 HOURS FROM COUNTER)=1190+1210=13111

HOURS	TOTAL VOLUME (v.p.h)	PERCENTAGE (%) OF 24 HOURS TRAFFIC
6 - 7	413	3.2%
7 - 8	660	5.1%
8 - 9	726	5.5%
9 - 10	686	5.2%
10 - 11	663	5.1%
11 - 12	680	5.2%
12 - 13	634	4.8%
13 - 14	686	5.2%
14 - 15	755	5.8%
15 - 16	826	6.3%
16 - 17	755	5.7%
17 - 18	766	5.8%
18 - 19	766	5.8%
19 - 20	821	6.3%
20 - 21	637	4.9%
21 - 22	599	4.6%
22 - 23	458	3.5%
23 - 24	370	2.8%
Total(18 Hrs.Mannual)	11901	90.8%
2400-6:00 from Counter	1210	9.2%
G.Total(v.p.d):	13111	100%

TABLE-4.9
HOURLY TRAFFIC VOLUME

STATION NO.2: PINDORA TO PIRWADAHI

DATED: 5.5.1991 DAY: SUNDAY

(18 HOURS MANNUAL COUNT+6 HOURS=16914+890=17804.

HOURS	TOTAL VOLUME (v.p.h)	PERCENTAGE (%) OF 24 HOURS TRAFFIC
6 - 7	661	3.7%
7 - 8	1080	6.1%
8 - 9	1180	6.6%
9 - 10	995	5.6%
10 - 11	1047	5.9%
11 - 12	981	5.5%
12 - 13	1062	6%
13 - 14	975	5.5%
14 - 15	956	5.3%
15 - 16	964	5.4%
16 - 17	1007	5.7%
17 - 18	1194	6.7%
18 - 19	1222	6.9%
19 - 20	1090	6.1%
20 - 21	982	5.5%
21 - 22	723	4.1%
22 - 23	520	2.9%
23 - 24	275	1.5%
Total(18 Hrs.Mannual)	16914	9.5%
2400-6:00 from Counter	890	5%
G.Total(v.p.d):	17804	100%

Table 4.10

SPEED CHECKING SURVEY
DEVELOPMENT OF CAPACITY STANDARDS ROADS
BOTH DIRECTIONS

Section No.5 Road Section: Peshawar More-Zeropoint Location: Near AGPR
Date : 30-5-1991 Day : Thursday Time : 0800-0900

Speed Limit (KPH)	M/Cylce	Car/ Jeep	Wagon	Pickup	Buses M/Buses	Trucks 2-Axle	Trucks M/Axle	Other	Total
10-20	-	-	-	-	-	-	-	-	-
20-30	-	-	-	-	-	-	-	-	-
30-40	23	11	2	5	3	4	1	-	49
40-50	101	123	24	27	19	15	4	-	313
50-60	103	227	38	37	27	20	3	-	455
60-70	10	102	11	4	5	-	-	-	132
70-80	-	72	6	2	-	-	-	-	80
80-90	-	46	3	1	1	-	-	-	51
90-100	-	12	2	-	-	-	-	-	14
Over 100	-	4	-	-	-	-	-	-	4
Total :	237	597	86	76	55	40	7	-	1098

Table 4.11

SPEED CHECKING SURVEY
DEVELOPMENT OF CAPACITY STANDARDS ROADS
BOTH DIRECTIONS

Section No. 6 Road Section: Peshawrmore-Pindora Location: Near I-8
Date : 29-5-1991 Day : Wednesday Time : 1500-1600

Speed Limit (KPH)	M/Cylce	Car/ Jeep	Wagon	Pickup	Buses M/Buses	Trucks 2-Axle	Trucks M/Axle	Other	Total
10-20	-	-	-	-	-	-	-	-	-
20-30	9	10	5	2	-	3	-	-	29
30-40	42	49	13	20	9	15	4	1	153
40-50	66	155	33	31	27	44	9	2	367
50-60	4	43	11	9	6	5	-	-	78
60-70	-	13	-	7	-	2	1	-	23
70-80	2	3	1	2	-	-	-	-	8
80-90	-	3	-	-	-	-	-	-	3
90-100	-	1	-	-	-	-	-	-	1
Over 100	-	-	-	-	-	-	-	-	-
Total :	123	277	63	71	42	69	14	3	662

Table 4.12

COMPREHENSIVE ROAD GEOMETRY STATEMENT

St. No.	Road Section	Direction	Road Width	Shoulder Width	Remarks
1.	G.T. Road N-5 Golra More	G.T.Road N-5 to Golra More	12′	6′	Compacted gravel shoulders are un-levelled with the road pavement.
		Golra More G.T.Road N-5	12′	9′	
2.	Golra More Sector G-11	Golra More to Sector G-11.	12′	7′	Both side shoulder are un-levelled & there is a bridge under the paved portion only. Shoulders are not carried out through.
		Sector G-11 to Golra More	12′	6′	
3.	Sector G-11 Sector G-10	Sector G-11 to Sector G-10	12′	7′	The shoulders condition is very poor & un-levelled on one side. Cemented electricity poles are installed beside the shoulder. There are two small drains each side within the shoulder. Bridge porapet is also in the shoulder.
		Sector G-10 to Sector G-11	12′	7′	
4.	Sector G-10 Sector G-9	Sector G-10 to Sector G-9	12′	7′	There are two bridges within the shoulders and the shoulders of both sides are un-levelled with the road pavement.
		Sector G-9 to Sector G-10	12′	7′	
5.	Sector G-9 Zeropoint	Sector G-9 to Zeropoint	12′	7′	On one side there is a drain and on other side there are street light poles shoulders are not carried through bridges.
		Zeropoint to Sector G-9	12′	5′	

Table 4.12 (Contd)

St. No.	Road Section	Direction	Road Width	Shoulder Width	Remarks
6.	Peshawar More Pindora	Peshawar More to Pindora	12′	5′	Electricity poles are installed at the centre one side shoulders condition is very bad and un-levelled with the pavement so the road is broken at some distance shoulder side and there are two bridges without shoulders.
		Pindora to Peshawar More	12′	5′	
7.	Pindora Faizabad	Pindora to Faizabad	12′	6′	Street light poles are installed beside the side shoulder and the both sides shoulders are un-levelled with road pavement. Beside the other side shoulder there is little dirty water drain.
		Faizabad to Pindora	12′	9′	
8.	Pindora Pirwadahi	Pindora to Pirwadahi	12′	7′	Street light poles are installed beside shoulder. On the other side there are severage gutters in the centre of shoulder through out the road section and there is a little drain of dirty water beside the shoulder. Also there are electricity poles are installed in the centre of the shoulder through-out the road section. There are three bridges within the shoulder.
		Pirwadahi to pindora	12′	10′	

Table 4.13

MANNUAL COUNT STATEMENT

SECTOR G-9 TO ZEROPOINT

PROPORTION OF HEAVY VEHICLES

Station No.05:

Peak Hours	M/Cycle Rickshaw	Car/ Jeep	Wagon	Pickup	Buses/ M.Buses	Truck 2-Axle	Truck 3-Axle	Other	Total
1	2	3	4	5	6	7	8	9	10
8 - 9	468	1110	65	127	42	75	21	2	1910
Percentage	24.5	59.1	3.4	6.7	2.2	3.9	1.1	0.1	100%
A.D.T.	3144	11931	790	1563	490	1022	344	25	19306
Percentage	16.3	61.8	4.1	8.1	2.5	5.3	1.8	0.1	100%

% Heavy During Peak Hours = 2.2 + 3.9 + 1.1 = 7.2%.

Table 4.14

MANNUAL COUNT STATEMENT

PESHAWAR MORE TO PINDORA

PROPORTION OF HEAVY VEHICLES

Station No.06:

Peak Hours	M/Cycle Rickshaw	Car/ Jeep	Wagon	Pickup	Buses/ M.Buses	Truck 2-Axle	Truck 3-Axle	Other	Total
1	2	3	4	5	6	7	8	9	10
A.D.T	5174	9374	1288	1685	624	2597	671	18	21431
Percentage	24.1	43.7	6.0	7.9	2.9	12.1	3.1	08	100%
Peak Hours 15-16	300	697	99	109	37	159	45	1	1447
Percentage	20.7	48.2	6.3	7.5	2.6	11.0	3.1	0.1	100%

% Heavy During Peak Hours = 2.6 + 11.0 + 3.0 = 16.7%.

Table 4.15

PEAK HOUR VOLUME AS %AGE OF AADT

STATIONS	PERCENTAGE
01-ATTOCK	7.3187
02-JHARI KASS	7.9404
03-JHELUM	5.8938
04-PATTOKI	6.0582
05-SATLAJ	5.7764
06-SADIQABAD	5.8736
07-KHAIRPUR	5.8668
08-S.HIGHWAY	5.8841
09-GADDANI	6.9838
10-QUETTA	7.9285
11-KOHALA	7.8534
12-MATANI	7.7592
13-SAKHAKOT	7.7153
14-FATHEPUR	6.2724
15-KAMOKE	6.1008
16-SAKHI-SWR.	6.7398
17-SHIKAR PUR	7.1213
18-THATTA	6.4989
19-BESHAM	8.5375
20-PEZU	6.4926
Average:-	6.8308

Table 4.17

Classified Summary of Manual Count - All Station 1990

Stations	M/cy	Car	Wagon	Bus	Truck		Truck & Trailer				Other
					2 Axle	3 Axle	3 Axle	4 Axle	5 Axle	6 Axle	
Attock	0.85	47.36	12.78	11.71	24.84	1.36	0.27	0.31	0.17	0.13	0.22
J.Kass	3.39	39.30	28.52	15.52	10.71	0.56	1.14	0.19	0.06	0.02	0.59
Jhelum	4.09	46.18	13.10	9.90	22.42	2.70	0.26	0.61	0.29	0.22	0.23
Pattoki	2.03	36.83	10.86	12.85	27.71	4.43	1.34	2.66	0.46	0.32	0.51
Satlaj	6.70	28.53	9.62	12.24	29.37	7.70	0.28	4.90	0.40	0.24	0.02
Sdqabad	3.22	13.38	1.15	6.20	53.85	11.36	1.27	8.15	0.50	0.32	0.60
Khairpur	3.10	21.56	6.99	4.48	46.84	8.98	0.90	6.14	0.32	0.26	0.43
S/Hway	0.94	19.57	1.56	14.40	48.20	8.78	1.61	4.24	0.45	0.17	0.08
Gaddani	2.85	38.41	7.59	9.38	39.85	1.00	0.36	0.19	0.11	0.02	0.24
Quetta	6.27	38.30	7.64	11.76	29.14	4.41	2.10	0.04	0.01	0.00	0.33
Kohala	1.09	49.80	3.63	21.45	23.92	0.09	0.00	0.00	0.00	0.00	0.02
Matani	1.41	43.49	21.20	10.27	18.45	3.81	0.96	0.01	0.00	0.00	0.40
Skhakot	2.47	54.02	14.17	9.26	14.94	1.80	2.38	0.01	0.01	0.00	0.94
Fatehpr	6.52	27.98	5.56	7.70	32.18	10.65	1.86	3.17	1.29	0.98	2.11
Kamoke	1.11	47.35	25.61	8.95	12.38	1.68	1.39	0.54	0.24	0.18	0.57
Skh Swr	16.04	11.76	5.76	1.81	53.58	0.27	8.90	0.01	0.01	0.00	1.86
Shkpur	3.57	34.28	15.52	10.06	26.28	3.08	4.00	0.53	0.07	0.07	2.54
Thatta	4.28	26.17	1.76	6.29	42.19	0.58	0.56	4.84	3.58	8.68	1.07
Besham	2.22	68.07	9.74	1.54	17.42	0.35	0.29	0.02	0.03	0.00	0.32
Pezu	1.12	39.64	13.74	7.58	27.17	9.39	0.55	0.07	0.00	0.00	0.74
Average	3.66	36.60	10.83	9.67	30.07	4.15	1.52	1.83	0.40	0.58	0.69

Table 5.3

Factor for Heavy Vehicles

% Heavy	fH	Remarks
5	0.909	Urban Roads
10	0.833	"
15	0.769	"
20	0.714	"
25	0.666	Rural Highways
30	0.625	"
35	0.588	"
40	0.555	"
45	0.526	"
50	0.50	"

Table 5.4

Factor for Pavement and Shoulder Width Restrictions

Lane Width + Usable Shoulder Effect	fW
12′ - 0"	1.0
11′ - 0"	0.85
10′ - 0"	0.77
9′- 0"	0.65

Table 5.5

Capacity of Two-Lane Highway at L.O.S 'C'

(fw* = 1, fd = 1 and V/C = 0.7)

% Heavy	Service Flow Rate (SF) (VPH)	Maximum Hourly Volume (VPH)	Capacity (VPD)
5	1782	1604	22900
10	1633	1470	21000
15	1507	1356	19371
20	1400	1260	18000
25	1313	1182	16800
30	1225	1103	15757
35	1153	1038	14830
40	1088	979	13985
45	1031	928	13257
50	980	882	12600

* Roadway Conditions are considered ideal.

Table 5.6

Capacity of Two-Lane Highway at L.O.S. 'C'

(fw* = 0.85fd = 1, V/C = 0.7)

% Heavy	Service Flow Rate (SF) (VPH)	Maximum Hourly Volume (VPH)	Capacity (VPD)
5	1515	1364	19486
10	1388	1249	17840
15	1281	1153	16470
20	1190	1071	15300
25	1116	1004	14340
30	1041	937	13386
35	980	882	12600
40	925	833	11900
45	876	788	11257
50	833	750	10715

*Combined Effect of Narrow Lanes (11'-0) and Restricted Shoulders

Table 5.7

Capacity of Two-Lane Highway at L.O.S. 'C'

(fw* = 0.77fd = 1, V/C = 0.7)

% Heavy	Service Flow Rate (SF) (VPH)	Maximum Hourly Volume (VPH)	Capacity (VPD)
5	1372	1235	17640
10	1257	1130	16140
15	1160	1044	14910
20	1078	970	13850
25	1010	909	12985
30	943	849	12130
35	888	800	11430
40	838	754	10770
45	794	715	10214
50	755	680	9714

*Combined Effect of Narrow Lanes (10'-0) and Restricted Shoulders

Table 5.8

Capacity of Two-Lane Highway at L.O.S. 'C'

(fw* = 0.65 fd = 1, V/C = 0.7)

% Heavy	Service Flow Rate (SF) (VPH)	Maximum Hourly Volume (VPH)	Capacity (VPD)
5	1158	1042	14886
10	1061	955	13643
15	980	882	12600
20	910	819	11700
25	853	768	10970
30	796	716	10230
35	749	674	9629
40	707	636	9086
45	670	603	8614
50	637	574	8200

*Combined Effect of Narrow Lanes (9'-0") and Restricted Shoulders

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