IRC-SP:19-2001

MANUAL FOR SURVEY, INVSTIGATIONAND PREPARATION OF ROAD PROJECTS

I have composed initial few chapters of the code book for those field staff who are not immediately equipped with IRC:SP:19. Un-intended typing errors cannot be ruled out. Out of the 120 pages of the original printed book, only 34 pages are relevant to Pre-feasibility studies of road project. Erroneous typing if any may kindly brought to my notice.

- Bora Ete

1. INTRODUCTION

1.1 Preparation of highway projects involves a chain of activities, such as, field surveys and investigations, selection of alignment, carrying out various designs, preparation of drawings and estimates, etc. To be compatible with technical requirements, consistent with economy, it is essential that every project should be prepared after thorough investigations and collecting all relevant information and evaluating all possible alternatives.

1.2 The extent and quality of investigations have a strong influence on selection of the most cost-effective design, estimation of quantities cost and execution of the job itself. As such, accuracy and completeness of surveys deserves very special attention in project preparation. The objective can be achieved by carrying out the project preparation work either departmentally or with the help of consultants. In any case, it should be ensured that experts having the required knowledge are deployed on the work. Use of modern instruments and survey techniques ensure high degree of accuracy and can speed up the work. Quality Assurance Plan is required to be drawn before the start of field investigations.

1.3 Adequate funds should be earmarked for the work of survey, investigation and project preparation. Estimation of realistic fund and time requirement needed for project preparation will go a long way in making the project preparation a success. It will be found that in the long run, such investment pays more than for itself in the form of well prepared and cost effective projects, orderly schedule of work and timely completion.

1.4 Systematic presentation of project details is no less important. The project document is the very basis of technical, administrative and financial sanction of a project. It is also crucial for accurate execution of work in the field. The project should, therefore, be comprehensive enough for proper appreciation of the proposals as well as easy understanding of the details. This manual lays down guidelines both for survey and investigations and presentations of the project details.

1.5 The Indian Roads Congress first published this manual in 1977. Since then, considerable experience has been gained by the Highway Departments and Consultants in this field, making it necessary to revise the manual. The work was taken up by the Project Preparation, Project Contract and Management Committee of the Indian Roads Congress. Initial revised draft of the manual was prepared by Dr. L.R. Kadiyali. The Committee appointed a Sub-committee consisting of Sarvashri Devendra Sharma as Chairman, A.K. Mukherjee, A.K. Datta, D.C. De to finalize the revised draft of the manual. The Sub-committee in the meetings held on 12-1-1997, 5-1-1998 and 22-4-1998. The Project Preparation, Project Contract and Management Committee (H-8) (personnel given below) approved the draft in its meeting held on 6th July 198.

2. SCOPE

2.1 The manual deals with rural sections of National Highways, State Highways and Major District Roads. It does not deal with Other District Roads and Village Roads, for which a reference may be made to the “IRC:SP:20 Manual on Route Location, Design, Construction and Maintenance of Rural Roads”. However, the provisions and guidelines in this manual are expected to be applicable to a large extent to urban Roads, Expressways and BOT projects also. But for these roads, some additional specific requirements may be there, than those dealt in this document. The manual deals with new construction as well as improvements to existing roads. Special aspects of each have been highlighted wherever necessary. The selection of alignment of any road is generally not governed by the siting of cross-drainage structures except in case of major bridges of length more than 60 m. IRC:SP:54 "Preparation of Manual for Bridges" lays down guidelines covering the various aspects which are to be detailed in the preparation of a bridge project of length more than 6 m. The survey and investigation for small cross-drainage works with length less than 6 m is covered in IRC:SP:13. For hill roads road tunnels, reference may also be made to **IRC:52 "Recommendations about the Alignment, Survey and Geometric Design of Hill Roads"** and **IRC:SP:48 "Hill Road Manual"**.

2.2 In order to ensure that the surveys and investigations, Feasibility Report and Detailed Project Report are complete and no essential detail is missed, a checklist for each of those activities is presented in the ***Appendices – 4, 5 & 6***.

2.3 It should be understood clearly that the extent of operations involved in surveys and investigations including he detailing of the individual aspects, would depend very much on the size and scope of each project and the class of highway. Depending on needs of the situations, one or more phases of investigations might be curtailed, telescoped or made more extensive than prescribed in the manual.

2.4 The order in which various surveys are discussed in the manual should not be taken to mean that such work must strictly follow the same pattern or sequence. Some of the survey could easily be initiated in advance and carried out simultaneously overlapping each other. For example, some results of soil and materials survey and study of cross-drainage structures would be needed as an essential input to the Feasibility Report. But more detailed investigations on these aspects may be continued in the detailed engineering phase. It should be upto the Engineer-in-chare to exercise his discretion and adopt a flexible approach. The requirements of the funding agencies or the authority according administrative approval may also result in rescheduling the sequence of work and in refining the extent of coverage of each work.

3. STAGES IN PROEJCT PREPARATION

3.1 Broadly, the stages involved in the preparation and sanction of project are:

1. Pre-feasibility study
2. Feasibility study/preliminary project report preparation
3. Detailed engineering and plan of construction

3.2 In some cases, specially for externally funded and BOT projects, it may be necessary to prepare a pre-feasibility report to enable a funding agency or private financier to appreciate the broad features of the project, the levels of financial involvement and probable returns. This may be done on the basis of reconnaissance survey by collecting information on the present status of the road, deficiency/distress identification, development potential, environmental impact, traffic data (present and future), approximate estimation of cost and an economic analysis. The economic analysis may involve traffic allocation studies, assessment of resource generation potential, funding pattern and risk. Location of toll plaza sites may also need to be identified.

3.3 The Feasibility Study is intended to establish whether the proposal is acceptable in terms of soundness of engineering design and expected benefits from the project for the investments involved. The Feasibility Report enables the funding agency to accord approval to the project. This approval is commonly known as Administrative Approval (AA) in the Highway Departments/Public Works Departments in the country. When international finding is involved, the Feasibility Study forms a basis for an investment decision.

3.4 The Detailed Engineering covers detailed alignment surveys, soil and materials surveys, pavement design studies, drainage studies, environment management plan based on environment impact assessment studies, detailed drawings, estimates and implementation schedules and documents. On the basis of such work, Technical Approval and Financial Sanction (TA and FS) are accorded to the project, enabling it to be executed.

For externally funded and BOT projects, the requirements at various stages are different and may ask for specific information involving various degree of accuracy of surveys and investigation.

3.5 The sequence of surveys operations and project preparation may thus, have to be structures to meet the specific needs of the project, its funding option and the requirements of the authority sponsoring it.

3.6 Fig. 3.1 gives a follow chart of the operations involved in highway project preparation.

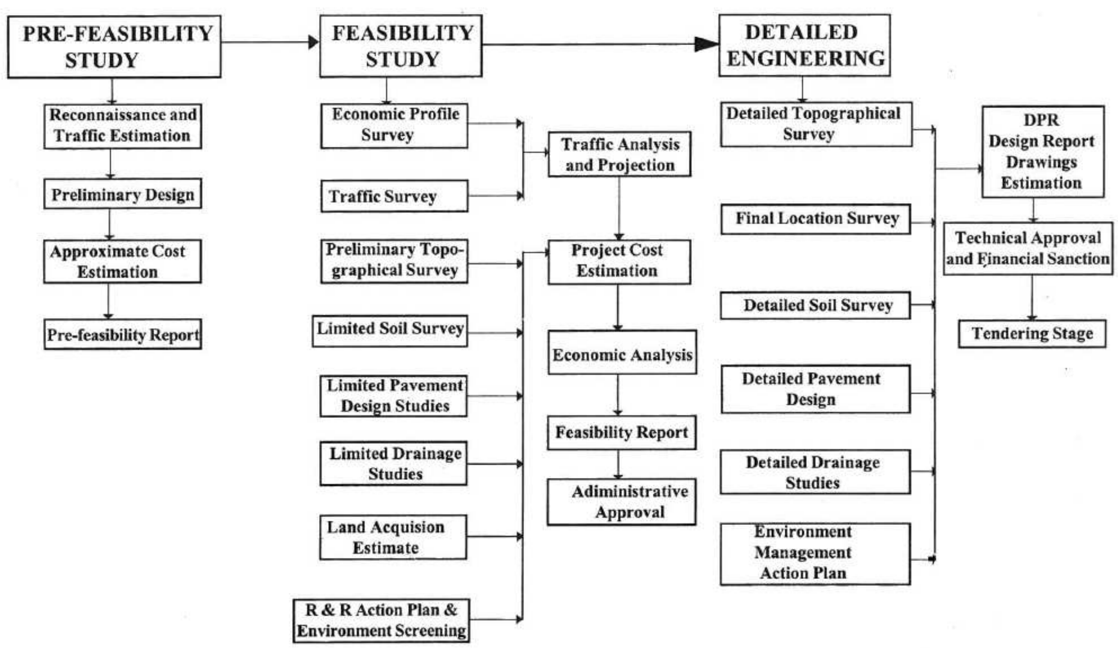

Fig. 3.1. Stages in Project Preparation

3.7 Land Acquisition

The process of land acquisition needs to be started immediately after finalizing the alignment.

Provision of he appropriate Land Acquisition Act will govern the various steps to be followed in the process of land acquisition. Depending on the quantum of land acquisition, creation of separate land acquisition authority may also be sometimes necessary. Acquisition of Government land, Private land, Forest Land and land falling under Costal Regulation Zone, etc. will attract different acts/regulations.

The various steps in land acquisition, namely, appointment of exclusive competent authority, if required declaring intention of acquisition, issuing notices and giving hearing to the affected parties, joint measurements, final notices and acquisition of the land, etc. require considerable time and need to be closely monitored to acquire the land within the desired time limit.

Temporary and permanent structure coming in the alignment, trees need to be cut, including those in the forest lands, need special attention for obtaining permission/valuation from the Competent Authority. Similarly, obtaining permission of the Ministry of Forest and Environment for the forest land and the land coming in the coastal regulation zone need to be processed in time.

Identifications and acquisition of land for borrow areas, quarries, etc. also need to be started in advance in case of large projects, such as, National Highway project and expressway projects.

4. GUIDING PRINCIPLES OF ROUTE SELECTION AND ALIGNEMNT IMPROVEMENT

4.1 The fundamental principle of route selection and alignment improvement is to achieve the least overall cost on transportation, having regard to the costs of initial construction of the highway facility, its maintenance, and road user cost, while at the same time, satisfying the social and environmental requirements. To achieve this objective, it will be necessary to make a detailed investigation before the location is finally decided. Factors that should be kept in view in the process are listed in ***Appendix-I*** and in Fig. 4.1. It should be understood that all these factors may not be applicable to each and every highway project and some of them, even if applicable, may not be feasible in many circumstances. For each case, the Engineer-in-charge has to exercise his own judgement to reach an optimum compromise solution in the light of the fundamental principle of minimum transportation cost enunciated earlier.

SUBJECT AREA	ENGINEERING/ECONOMICS				SOCIAL		ECOLOGY		AESTHETICS
FEATURES	CONSTRUCTION COSTS	MAINTENANCE COSTS	USER COSTS	RIGHT-OF-WAY COSTS	DEVELOPMENT POTENTIAL	SOCIO-ECONOMIC PROFILE	RECREATIONAL/ CONSERVATION	POLLUTION	SCENIC VALUE
FACTORS	Topography Geology Geomorphology Soils Materials Climatic Condition Drainage Design Criteria Safety	Climate Traffic Soils Materials Topography Drainage Geomorphology	Traffic Topography Travel Time Safety	Land Value Land Use Replacement Costs Traffic Design Criteria Utilities Tax Base	Agriculture Foresty Mineral Extraction Trade/Industry Tourism Personal/Mobility Political Strategy	Population Culture Land Use Tax Rate Land Value Institutions Transportation Historical Sites Utilities/Services Community Boundaries Traffic Employment Dynamic Change Tax Base	Land Use Vegetation Fish Life Scenic Areas Wildlite Drainage Topography Erodibility Sedimentation Land Marks	Noise Air Water Spillage Thermal Chemical Waste	Scenic Areas View from Road View of Road Eye Sores Topography Vegetation Drainage

Fig. 4.1 Factors Affecting Route Selection & Alignment Improvement

4.2 Where the project involves improvements to an existing road, every effort should be directed towards the inherent deficiencies with respect to

- Plan and profile
- Sight distance/visibility in horizontal as well vertical plan
- Carriageway, shoulder and roadway width
- Cross-drainage structures
- Road side drainage provisions as well as area drainage consideration
- Safety features.

Any disregard of these aspects may well lead to unnecessary expenditure, since at a later date the alignment may again have to be improved at considerable extra cost. It is, therefore, imperative that the final centre line of the road with respect to which, the improvements are designed and are to be carried out, is fixed with great care in the light of ultimate geometric requirements and economy. The other important point is removal of structural deficiencies with an eye on future needs with respect to pavement, culverts, road and area drainage requirement, etc.

4.3 Project location and orientations of cross-drainage structures is an important factor in the selection of road alignment. Their importance increases with their length and cost. In general for bridges having length between 60 to 300 m, siting of bridges as well alignment of the approaches will have equal priority and should be well coordinated. For bridges of length more than 300 m, sitting for the bridges will primarily guiding factor in route selection.

4.4 Apart from engineering factors, environmental impact of the proposal should be fully kept in view in terms of such aspects as air pollution, damage to life systems, soil erosion, drainage pattern, landscaping, disruption of local communities etc.

5. SURVEY OF SOCIO-ECONOMIC PROFILE

5.1 The economy of a region and its transport infrastructure are closely inter-related. The economic justification for a highway project often depends upon the economic activities in the region and potential for their further growth. The growth of traffic on the roads is likely to be closely governed by the inter-relationship between transport demand and certain selected economic indicators. A survey of the economic profile is, thus, an important component in project preparation.

5.2 The economic profile data are generally collected at two levels, viz., (a) Region or State and (b) Project Influence Area. The regional economic profile gives an idea of how the economic growth has taken place in relation to growth of traffic, thus, giving a basis for estimation of future growth of traffic for various scenarios of economic growth. The Project Influence Area is the zone in the near vicinity of the highway project such that investments in the project serve as a catalytic agent towards the speedy development of the area. Such a development generates additional traffic other than the normal.

5.3 The economic profile survey of the region should enable the presentation of an overview of the region's/State's economy, population and transport system over the past years and projected to future years. The data should be collected for the past about ten years. This item is also covered in ***Appendix-6***.

5.4 The socio-economic status of the Road Influence Area should provide a descriptive and quantified profile from available data on population, agricultural production, area under crops, annual industrial and mining production by type of establishment, tourism potential and the inputs and outputs moving by road. Information on major planned development projects (type of establishment and expected annual production) should be collected.

5.5 The historical trend data should be analysed statistically to determine the growth trends and elasticity of traffic with respect to GDP, population, industrial production and agricultural output. The planned rates of growth of those selected indicators in the future should be obtained.

6. TRAFFIC SURVEYS AND ANALYSIS

6.1 General

Information about traffic is indispensable for any highway project since it would form the basis for the design of the pavement, fixing the number of traffic lanes, design of intersections and economic appraisal of the project, etc. Traffic surveys required to be conducted in connection with the preparation of road project are as under:

(a) Classified Traffic Volume Counts
(b) Origin-Destination Surveys
(c) Speed and delay studies
(d) Traffic Surveys for the Design of Road Junction
(e) Traffic Surveys for Replacing Railway Level Crossings with Over Bridges/Subways
(f) Axle Load Surveys
(g) Accident Records

These are discussed below:

6.2 Count of traffic is the basic traffic study required in connection with many types of highway projects. A system of traffic census is in vogue in the country under which 7 day traffic counts are taken once or twice a year. The data from these can be indiciously made use of, if the census points fall on the proposed highway project. Time permitting, it is always desirable to undertake fresh traffic surveys. Guidance may be taken from **IRC:9 "Traffic Census on Non-Urban Roads"**. The count stations should be selected such that the results represent the traffic flow in homogenous sections of the highway. A seven day count will then give the Average Daily Traffic (ADT). This value may be converted to Annual Daily Traffic (AADT) applying seasonal considerations and using conversion factors from any continuous traffic count in the region.

When traffic census data from existing count stations are compiled, it may be found useful to collect past data (preferably about 10 years) so as to establish meaningful past growth trends for each vehicle class. A typical proforma 1 given in this Chapter may be used.

6.3 Origin-Destination (O-D) Surveys

6.3.1 When a new road is being planned, or extensive improvements are to be carried out to an existing road, or a bypass is under consideration, the amount of traffic likely to sue it cannot be ascertained from a simple census and it may become necessary to collect information about the origin and destination of traffic passing through the main area in which the road is situated. The origin and destination data should be comprehensive enough to cover al roads likely to be affected by the proposed scheme. The point at which the data is collected should be carefully chosen on the road network such that it should be possible to derive the volume of traffic likely to sue the facility under consideration.

6.3.2 The survey should normally conducted for three consecutive days, on sample basis, if possible during a representative week in the year and must encompass the weekly market day and one working day. For exceptional cases, in heavy density corridors and where the daily variation in the traffic is not much, at least one day's survey may be conducted on a normal working day. Care shall be taken during interpretation of the data keeping in mind the seasonal variation of traffic.

6.3.3 There are several methods available for conduction an O-D survey. Information on them is contained in **IRC:102 "Traffic Studies for Planning Bypasses Around Towns"**. Generally, the "Roadside Interview Method" is well-suited for roads in rural areas and can be conveniently adopted. This consists basically of interviewing drives of vehicles at suitably located points with reference to the type of road scheme in consideration. At these stations, the number as well as the type of all vehicle passing the station is recorded. However, only a percentage of the drivers at random need to be stopped and interviewed for origin, destination and other travel particulars, like, commodity carried. The sampling should be systematic. Generally, 15 to 20 percent of the vehicles may be covered in the peak periods and 25 to 30 percent in the normal periods.

6.3.4 The sample should e up-scaled to ADT and preferably hourly based classified vehicle type. The location of origin and destination zones will be determined in relation to each individual station and the possibility of traffic diversion to the project road from other road routes including bypasses. In principle, the zoning should bisect area where competing roads pass and the zonal configuration shall be adequate on either side of the O-D station; thereafter, districts will serve as zones within the State. Zoning outside the State will relate to individual or groups of States in accordance with the distance from the O-D station. For coding purposes, code lists or code maps (to be shown to motorists) will be prepared giving zone number and towns within that zone. The updated (ADT) numbers shall then be presented by trip matrix. Information on weight for trucks should, following up-scaling to ADT, to summed up b commodity type and the results tabulated, giving total weight and average weight per truck for the various commodity types. Sample size for each vehicle type should also be indicted. A sample of Zonal Division is indicated in Fig. 1.

Following processing of the O-D results, traffic is assigned from the trip matrix's elements to the project road's homogeneous sections, provided the route including he project road in its improved condition is the most desirable of the alternative routes available in terms of least vehicles operating costs.

6.4 Speed and Delay Studies

Highway improvements result in speeding up traffic and reducing congestion. Speed and delay studies on the existing facility provide the basis for estimating the causative problems and benefits of the improved facility. For this purpose typical proformae 2(a) and (b) in this chapter may be used.

The study is conveniently conducted by the "Moving Observer" method. By this method a test vehicle is run along with the traffic stream, at approximately the perceptible average speed of the traffic stream. A separate run is needed for each direction. The average of around six runs ensures accuracy of results. By noting down the travel time, including actual running time and stopped delays, the vehicles counted in the apposite direction and those overtaken/overtaking, it is possible to calculate the volume, speed and delay. For further information, IrC:102 "Traffic Studies for Planning Bypasses Round Towns" may be consulted. Proformae 3 (a) to (d) given in this Chapter may be found useful for this survey.

6.5 Traffic Surveys for the Design of Road Junctions

6.5.1 Road junction design requires information on directional movement of traffic in the peak hour. For this purpose, it would be sufficient to have counts for 2 hours each in the morning and evening peak periods unless there exist extended peak hours.

6.5.2 For simple 'T' or 4-way junction, the survey could be conducted by stationing enumerators on each arm of he junction to note the number of vehicles entering through the arm and the direction of their exit. At multi-legged junction or rotaries, quick judgement about the exit direction or vehicle may not be possible. In such cases, a licence plate survey may have to be conducted. This consists of noting the registration numbers (generally only the last three digits) of a sample of vehicles entering he intersection. Simultaneously, on each exit, the registration numbers of vehicles leaving the junction are noted. The two sects of numbers are then matched in the office to determine the directional movements. For recording traffic movement at a junction Table 3.1. Intersection Design Data given in **IRC:SP:41 "Guidelines for the design of At-Grade intersections in Rural and Urban areas"** needed to be used.

6.5.3 Usually, it is not necessary to conduct traffic surveys on junctions where traffic on the minor cross road is less than about 100 vehicles per day.

6.5.4 Special pedestrian survey needs to be conducted when the alignment passes by such locations, e.g., school, well, etc. on one side of alignment and the village on the other side), to decide the provisions of appropriate crossing, such as, subway.

6.6 Traffic Surveys for Replacing Railway Level Crossings with Over Bridges/Subways

6.6.1 Present criteria of replacing railway level crossings with over bridges/ underpasses are based on the product of gate closures and fast traffic per day. For this purpose, counts should be taken in a week spread over three consecutive days and 24 hours each day if such information is not already available. The number and duration of gate closures should be ascertained from the Railway Authorities and also counted at site by conducting a 24 hours survey.

6.6.2 Information should also be obtained on the angle of crossing of the roadway and the railway. In case the road alignment has curves near the railway crossing, to make it a perpendicular crossing, an index plan including these curves and the straight alignment beyond, should also be included to study the feasibility of improving the road alignment as part of the project for replacing the level crossing.

6.7 Axle Load Survey

Axle load survey is needed to generate data for pavement design. Portable weigh bridges are very useful for this purpose.

This survey shall be carried out along with classified volume count survey. Number of days of survey will depend on project location, the type of project and the intensity and expected variation in traffic. This survey duration may vary between 24 hours and 3 days, but should be carried out at least for one day at the traffic count stations on a random basis for commercial vehicles. Buses may be omitted as their weight can be easily calculated and they do not result in excessive overloads.

The period of conducting the survey should also be judiciously selected keeping in view the movement of commodity/destination oriented dedicated type of commercial vehicles.

While finalizing the design Equivalent Standard Axle load, the following should be considered.

(i) Past axle load spectrum in the region as well as on the road to the extent available.
(ii) Annual variation in commercial vehicles
(iii) Optimistic and pessimistic considerations of future generation of traffic
(iv) Generation of changing VDF factor during the project period.

A typical proforma 4 given in this chapter may be found useful for this survey.

6.7.1 Accident Records

If accident records are maintained in a methodical manner, they form a good basis for designing the improvements at accident-prone locations on existing roads. Such records, if available, should be invariably be consulted before deciding the improvement measures.

6.8 Traffic Projection

6.9.1 Traffic counts and O-D surveys would provide information about present traffic on the road (in the case of existing roads), or the possible diverted traffic (in the case of new construction, such as, bypasses). For design purpose, however, it is necessary that classified traffic should be predicted for the future horizon year for which the facility is to be designed.

6.9.2 Period of projection depends on the type of the project, importance of the road, availability of finances and other related factors. For major truck routes, the desirable and minimum forecast periods are 20 and 10 years, (excluding the period of construction) through occasionally an even shorter period could be adopted depending on the policies of the stage construction. In the case of lower category roads, the desirable period of projection is 10 years but it should not be less than 5 years.

6.9.3 Traffic growth should be assessed in the first instance on the basis of observed trend of traffic in the recent years and other economic indicators using the technique given in ***Appendix-2***. In this connection the guidelines for Traffic Prediction on Rural Highways, IRC:108 may be referred to. If reliable information is not available, as a broad guide, a compound growth rate of 7.5% per annum could be adopted for this purpose. Because of the many uncertainities surrounding the possible shape of future population, incomes, production, goods generation, etc., it is necessary that estimates of traffic based purely on past rate of growth should be used with caution.

6.9.4 Forecast of traffic based on past trends should also be modified for 'generated' traffic that may be using the highway facility after is it constructed. Generated traffic quite distinct from the diverted traffic and represents journeys induced by reduced journey times and higher level of travel comfort which would not otherwise have been made. It is not necessary to allow for generated traffic on small schemes, but this may be called for on comparatively larger projects. Estimation of generated traffic should be attempted after consulting standard on this project.

7. RECONNAISSANCE SURVEY

7.1 Purpose

7.1.1 The main objective of reconnaissance survey is of examine the general character of he area for the purpose of determining the most feasible routes, or routes, for further more detailed investigations. Data collected should be adequate to examine the feasibility of all the different routes in question, as also to furnish the Engineer-in-charge with approximate estimates of quantities of costs, so as to enable him to decide on the most suitable alternative or alternatives. The survey should also help in determining any deviations necessary in the basic geometric standards to be adopted for the highway facility.

7.2 Survey Method

7.2.1 The reconnaissance survey may be conducted in the following sequence

(a) Study of topographical survey sheets, agricultural, soil, geological and meteorological maps, and aerial photographs, if available.

(b) Aerial reconnaissance (where necessary and feasible)

(c) Ground reconnaissance (including another round of aerial reconnaissance for inaccessible and difficult stretches, where called for).

7.3 Study of Survey Sheets, Maps, etc.

7.3.1 Reconnaissance begins with study of all the available maps. The types of useful map information which are currently available in the country are as below:

(a) Survey of India (SOI) Maps.

(i) The most useful maps are the topographical sheets available in the scale of 1:25,000, 1:50,000. Maps coverage on 1:50,000 and 1:25,000 scale are available for the whole of India but map coverage with the preferable scale of 1:25,000 is at present, available only for about 30% of the country.

(ii) State maps on scale of 1:1,00,000.

These are useful as index maps or to indicate an overview of the project location and are available for most of the States

(iii) Plastic Relief Maps on scale of 1:15,000,000.

One may be lucky to have these maps for certain regions. For very difficult areas highway location planning may be very much helped if these three dimensional maps delineating ridges, valleys, peaks, etc. with contour information are available.

(b) Apart from the above mentioned SOI maps there are special purpose maps, like, Forest Survey of India, Vegetation Maps on scale 1:25,000,000 showing incidence of orchards, reserve forest, clusters of social forestry areas, etc. which may be helpful in special cases in selection of alignment.

Also, maps prepared by National Bureau of Soil Survey and Land use Planning (NBSS & LUP) indicating information on Soil, Wasteland, etc. and Geological Survey of India Maps (on scale 1:250,000 or smaller) with information on geology, geomorphology and changes in drainage, river courses, etc. are available for many cases.

These maps may also be fruitfully used when considered necessary.

7.3.2 After study of he topographical features on the maps, a number of alignments feasible in a general way are selected keeping in view the following points:

(i) The alignment should take into account all the control points and should be the shortest and most economical compatible with the requirements of gradient and curvature.

(ii) Shape of he alignments.

(iii) Avoidance, as far as possible, of marshy ground, steep terrain, unstable hill features and areas subject to severe climatic conditions, flooding and inundation.

(iv) Need for connecting important villages and towns.

(v) Bridging cross-drainage and drainage problems. (Guiding principle stated in para 4.2 shall be kept in view)

(vi) Need to preserve environment and maintain ecological balance.

7.3.3 If photographs of the area are not available, but the their need is considered imperative, aerial photography may be arranged for further study in the interest of overall economy.

The present status of Aerial Photography (AP) in India on scale 1:50,000 is available for he whole of India. Depending on their quality the negatives of these photographs, when necessary, can be enlarged easily by about five times without losing clarity and thus obtain AP enlargements on scale of 1:5,000 to 1:20,000.

These enlargements are quite adequate for the study of:

(i) Geology, geomorphology and ground water prospecting and
(ii) Environmental factors, e.g., vegetation, soil conditions, land use etc.

If stereoscopic technique are applied, aerial photographs can yield quantitative data showing the terrain in three dimension and if studied by a skilled photo-interpreter, can give significant soil and sub-soil information.

7.3.4 **Photogrammetry support to highway engineering**:

Photogrammetry technology is also useful to the highway engineer in many ways. Large scale maps on scales of 1:2,000 to 1:25,000 can be very precisely produced through photogrammetric process. The contouring can also be produce, the common intervals depending on he height of he camera. Very minute and precise measurements amounting to sub-mere accuracy can be obtained. In other words, profile (with height values) and cross-sections across highway centre-line can be extracted from optical model.

7.3.5 **Satellite remote sensing**: This technique is used with the help of satellites. At present, it gives resolution of the order of 6 metres. Photographic products of imagery are available from National Remote Sensing Agency, Hyderabad on scales of 1:12,500, 1:25,000 and 1:50,000. digital products are also available in floppy cartridges and tapes.

The cartridge/tape can be digitally processed in the computer and the image on the monitor can be interpreted with the possibility of enhancement of quality through manipulation of image processing software.

Major advantages of satellite imagery is its repeatability as orbiting satellites visit the same sot on earth every few weeks. Thus, the latest information regarding the physical features (like, the extent of a town or urban area, etc.) can be obtained to update on available map. The information on natural resources namely, geology, geomorphology, land use, soil status (water-logging, erosion, etc.), drainage, forest extent, etc. as available may be most useful input for the planners of highway alignment.

7.3.6 **Small format aerial photography (SFAP)**: In case of large projects with mapping as one of the main objectives conventional aerial photography in traditional format (23 cm x 23 cm) may also be useful. There are at least there known agencies in India for such aerial photography, namely he National Remote Sensing Agency (NRSA), Hyderabad, Air Survey Company, Calcutta and the India Air Force.

All aerial photography work requires clearance from the Ministry of Defence.

The major advantages of SFAP are:

- Very large scale true colour photography can be done in scales upto 1:1,000 to 1:2,000 (upto scales of 1:10,000). Acquisition plan along side highways can be suitably made in scale of 1:4,000.
- Monitoring of urban areas, villages and environment along the corridor are possible at comparatively lower cost than ground surveys.

7.4 Aerial Reconnaissance

7.4.1 An aerial reconnaissance will provide a bird's eye view of eh alignments under consideration along with the surrounding area. It will help to identify factors which call for rejection or modification of any of the alignment. Final decision about the alignments to be studied in detail on the ground could be taken on the basis of the aerial reconnaissance.

7.5 Ground Reconnaissance

7.5.1 The various alternative routes located as a result of the map study are further examined in the field by ground reconnaissance. As such, this part of the survey is an important link in the chain of activities leading to selection of the final route.

7.5.2 General reconnaissance consists of general examination of the ground walking or riding along the probable route and collecting all available information necessary for evaluating the same. In the case of hill sections, it may some time be advantageous to start the reconnaissance from the obligatory point situated close to the top. If an area is inaccessible for the purposes of ground reconnaissance, recourse may had to aerial reconnaissance to clear the doubts.

7.5.3 While carrying out ground reconnaissance, it is advisable to leave reference pegs to facilitate further survey operations.

7.5.4 Instruments generally used during ground reconnaissance include compass, Abney level/Altimeter, Pedometer, Aneroid barometer, Clinometer, Ghat trace, etc. Walkie-talkie sets, mobile phone and pagers are useful fro communication, particularly in difficult terrain. Use of the instruments mentioned above to obtain ground slopes, maximum gradients, elevation of critical summits or stream crossing, and location of obligatory points, serve as a check on the maps being used.

In difficult hilly and forest terrain assistance of new technology, like Global Position System (GPS) or Differential GPS (DGPS) may also be taken where the magnitude and importance of the work justify their provision. GPS is a comparatively new technology which utilizes the satellites orbiting around the earth. A minimum of four satellites are needed to indicate the coordinates (X, Y, Z) on the ground at any time of day and night with accuracy of a few centimeters, two geo-receivers are sued and this mode of using two GPS is known as differential GPS (DGPS).

7.5.5 Points on which data may be collected during ground reconnaissance are listed in ***Appendix-3***.

7.6 Reconnaissance Report

Based on the information collected during the reconnaissance survey, a report should be prepared. The report should include all relevant information collected during the survey, a plan to the scale of 1:50,000 or larger as available showing the alternative alignments studied along with their general profile and rough cost estimates. It should discuss the merits and demerits of the different alternatives to help the selection of one or more alignments for detailed survey and investigation.

8. PRELIMINARY SURVEY

8.1 Purpose

8.1.1 The preliminary survey is a relatively large scale instrument survey conducted for the purpose of collecting all the physical information which affects the proposed location of a new highway or improvements to an existing highway. In the case of new roads, it consists of running an accurate traverse line along the route previously selected on the basis of the reconnaissance survey. In the case of existing roads where only improvements are proposed, the survey line is run along the existing alignment. During this phase of the survey, topographic features and other features, like, houses, monuments, places of worship, cremation or burial grounds, utility lines, existing road and railway lines, stream, river, canal crossings, cross-drainage structures, etc. are tied to the traverse line. Longitudinal-sections and cross-sections are taken and bench marks established. The data collected at this stages will form the basis for the determination of the final centre line of the road. For this reason, it is essential that every precaution should be taken to maintain a high degree of accuracy.

8.1.2 Besides the above, general information which may be useful in fixing design features within close limits is collected during this phase. The information may concern traffic, soil, construction materials, drainage, etc. and may be collected from existing records as though intelligent inspection/simple measurements. **Detailed investigations dealt with in section 10 through 16 are not envisaged at this stage**. It may be found convenient to divide the road into homogeneous sections from traffic consideration and prepare a typical estimate for one km stretch as representative of each homogeneous section. With the data collected, it should be possible to prepare rough cost estimates within reasonably close limits for obtaining administrative approval, if not already accorded and for planning further detailed survey and investigations. In particular, information may be collected regarding:

(i) The highest sub-soil and flood water levels, the variation between the maximum and minimum, and the nature and extent of inundation, if any, gathered from local enquires or other records. These should be correlated to data about the maximum and minimum rainfall and its duration and spacing, etc. by appropriate hydrological analysis.

(ii) The character of embankment foundations including the presence of any unstable strata likes micaceous schists, poor drainage or marshy areas; etc. This is particularly necessary in areas having deep cuts to achieve the grade.

(iii) Any particular construction problem of the area, lie, sub-terranean flow, high level water storage resulting in step hydraulic gradient across the alignment canal crossing and their closure periods. Information regarding earlier failures in the area of slides or settlements of slopes, embankments and foundation, together with causes thereto may also be gathered from records and enquiry where feasible.

(iv) In cut sections, the nature of rock, i.e., hard, soft etc. should be determined by trial pits or boreholes. This is essential to make realistic cost estimates.

8.2 Survey Procedure

8.2.1 The preliminary survey starts with running of a traverse along the selected route, adhering as far as possible to the probable final centre line of the road. In difficult situations, a secondary traverse connected to the primary one at either end may also be run. In hilly areas, a trace cut 1.0 to 1.2 m wide, if required may be made during the preliminary survey. For details in this regard, reference may be made to **IRC:52 "Recommendations About the Alignment Survey and Geometric Design of Hill Roads"**.

8.2.2 The traverse consists of a series of straight lines with their lengths and intermediates angles measured very carefully. In difficult terrain, the alignment may have to be negotiated through a series of short chords, preferably, the traverse should be done with a theodolite with Electronic Distance Measurement (EDM) and all angles measured with double reversal method. Global Positioning System (GPS) is also very useful and appropriate for preliminary survey. The GPS will give locations in coordinates all the necessary points on the traverse. GPS is very fast reasonably accurate for preliminary system and computer friendly for data transfer. Control pillars in cement concrete should be fixed at suitable interval (ranging from 500 m to 2 kms) to have control on accuracy. It also helps in repeating the survey, if required, within the control pillars.

8.2.3 Distances along the traverse lines should be measured with EDM or total station. Accuracy of at least 1 in 10,000 should be aimed at in all distance measurement.

8.2.4 No hard and fast rule can be laid down as regards distance between two consecutive transit stations. In practice, the interval will be dictated by directional changes in the alignment, terrain conditions and visibility. The transit stations should be marked by means of stakes and numbered in sequence. These should be protected and preserved till the final location survey.

8.2.5 Physical features, such as, buildings, monuments, burial grounds, cremation grounds, places of worship, posts, pipelines, existing roads and railway lines, stream/river/canal crossings, cross-drainage structures, etc. that are likely to affect the project proposals should be located by means of offsets measured from the traverse line. Where the survey is for improving or upgrading existing road, measurements should also be made for existing carriageway, roadway and location and radii of horizontal curves. In case of highways in rolling and hilly terrain the nature and extent of grades, ridges and valleys and vertical curves should necessarily be covered. The width of land to be surveyed will depend on the category of road, purpose of the project, terrain and other related factors. Generally, the survey should cover the entire eight-of-way of the road, with adequate allowance for possible shifting of the centre line from the traverse line.

8.2.6 Leveling work during a preliminary survey is usually kept to the minimum. Generally, fly levels are taken along the traverse line at 50 metre intervals and at all intermediate breaks in ground. To draw contours of the strip of land surveyed, cross-sections should be taken at suitable intervals, generally 100 to 250 m in plain terrain, upto 50 m in rolling terrain, and upto 20 m in hilly terrain. To facilitate the leveling work, bench marks, either temporary or permanent, should be established at intervals of 250 to 500 metres. The levels should be connected to GTS datum.

8.2.7 Field notes of the survey be clear and concise, yet comprehensive enough for easy and accurate plotting.

8.2.8 Apart from traverse survey, general information about traffic, soil, drainage should be collected while the traverse is being run, as mentioned in para 8.1.2.

8.2.9 Check list on preliminary survey is available in ***Appendix-4***.

8.3 Map Preparation

8.3.1 Plans and longitudinal sections (tied to an accurate base line) prepared as a sequel to the preliminary survey are referred to for detailed study to determine the final centre line of the road. At critical locations, like, sharp curves, hair-pin-bends, bridge crossings, etc., the plan should also show contours at 1-3 metre intervals, particularly for roads in rolling or hilly terrain so as to facilitate the final decision.

8.3.2 Scales for the maps should generally be the same as adopted for the final drawings. The following scales are suggested:

(i) Built-up areas and stretches in hilly terrain – 1:1,000 for horizontal scale and 1:100 for vertical scale.

(ii) Plain and rolling terrain – 1:2,500 for horizontal scale and 1:250 for vertical scale.

8.3.3 For study of difficult locations, such as, steep terrain, hair-pin bends, sharp curves, bridge crossings, etc. it may be convenient to have plans to a larger scale than recommended above. If necessary these plans may shown contours preferably at 2 m intervals, though this could be varied to 1.5 m according to site condition.

Appendix-I

GUIDING PRICIPLES COVERING ROUTE SELCTION AND HIGHWAY LOCATION

1. General

1.1 The highway should be as direct as possible between the cities or towns to be linked, thereby, satisfying the major desired links. A direct highway link results in economy in construction, maintenance and operation.

1.2 The location should result in minimum interference to agriculture and industry.

1.3 The location should, as far as possible, facilitate easy grades and curvature.

1.4 The location should steer clear of obstruction, such as, cemetries, burning ghats, places of worship, archaeological and historical monuments, and as far as possible, from public facilities, like, hospitals, schools, play grounds, etc.

1.5 Where the proposed location interferes with utility, services, like overhead transmission lines, Water Supply lines, etc., decision between changing the highway alignment or shifting the utility services should be based on study of the relative economics and feasibility.

1.6 As far as possible, frequent crossing and re-crossing of a railway line should be avoided. For design requirements in such cases, reference may be made to IRC:39 "Standards for Road-Rail Level Crossings".

1.7 An important obligatory point in the selection of the roué is the location of river crossings. While crossings of major rivers (waterway exceeding 200 m) may have to be normal to the river flow if possible, with highway alignment subordinated to considerations of he bridge siting. Crossing of medium/medium streams should be generally governed by the requirements of the highway proper. If necessary, such structures could be made skew/located on curves.

1.8 The location should be such that the highway is fully integrated with the surrounding landscape of he area. In this connection, it would be necessary to study the environmental impact of the highway and ensure that the adverse effects of it are kept to the minimum.

1.9 The highway should, as far as possible, be located along edges of properties rather than through their middle so as to cause least interference to cultivation and other activities and to avoid the need for frequent crossing of he highway by the local people.

1.10 The location should be, such as, to avoid unnecessary and expensive destruction of wooded areas. Where intrusion into such areas is unavoidable the highway should be aligned on a curve if possible so as to preserve an unbroken background.

1.11 The location should, as far as possible, be close to sources of embankment and pavement materials so that haulage of these over long distances is avoided and the cost minimized.

1.12 A preferred location is one which passes through areas having better type of soil and permits a balancing of the cost of cut and fill for the formation.

1.13 Marshy and low-lying land, and areas having poor drainage and very poor embankment material should be avoided, as far as possible. Also, areas susceptible to subsidence due to mining operations should be by-passed.

1.14 Areas liable to flooding should be avoided, as far as possible.

1.15 Highways through villages and towns increase traffic hazards and cause delay and congestion. Wherever a serious problem of this nature is encountered it may be advisable to by-pass built-up area playing well clear of the limits upto which the town or village is anticipated to grow in the future.

1.16 As far as possible, areas likely to be unstable due to toe-erosion by rivers, shall be avoided.

1.17 During fixing of alignment by the side of a river, the direction of flow of the river and HFL records for pat 50 years shall be kept in view.

1.18 In spite of all conscious efforts to avid running through forest areas many times roads are required to be aligned passing through the forest land. With increase in traffic roads require to be widened of often leading to cutting of trees on one or both sides of the road. All these unavoidable feeling need to be made good by provision of compensatory afforestation in equal or additional areas at suitable locations. Project preparation needs to keep this aspect in view and make necessary provisions for compensatory afforestation where the same is warranted.

1.19 If prior to project preparation it is known that a facility under construction is to be widened to additional lanes, the project should be prepared by locating the first embankment and pavement in an eccentric position with respect to the total land available and also freeze the total land required for the entire envisages facility right in the beginning. The subsequent construction may then be undertaken symmetrically with respect to the centre line of the land.

If provision of additional lanes has to be made to an old road, it can be done either by addition of half the requirements symmetrically on each side on the entire new addition on one side only. The points to be considered in such a case are:

(i) the availability of land and convenience of additional acquisition in view of presence of buildings and existing constructions on each side.

(ii) felling of trees that may be involved on either side.

(iii) the width of new construction and facility of compaction equipment to operate and

(iv) technical convenience for construction of additional structures and necessary protection works for the same in the vicinity of the existing structures

(v) technical convenience for locations of additional two-lane carriageway preferably on up stream side of flow of water, providing better protection to the existing facility.

2. Special Problems of Locating in Hilly Areas

2.1 The route should enable the ruling gradient to be attained in most of the length.

2.2 Steep terrain and other inaccessible area should be avoided, as far as possible.

2.3 Unstable hilly features, areas having frequent landslide or settlement problems and up slope benched agricultural field with potential for standing water may be avoided as far as possible.

2.4 Locations, along river valley have the inherent advantage of comparatively gentle gradients, proximity of inhabited villages, and easy supply of water for construction purposes. However, this solution is be-set with disadvantages, such as, the need for large number of cross-drainage structures and protective works against erosion. It would, therefore, be necessary to take the various aspects into account before the final selection.

2.5 The alignment should involve least number of hair-pin bends. Where unavoidable, the bends should be located on stable and gentle hill slopes.

2.6 In certain cases, it may be expedient to negotiate high mountain ranges through tunnels. For such cases, the decision should be based on relative economics or strategic considerations.

2.7 In crossing mountain ridges, the location should be such that the highway preferably crosses he ridge at their lowest elevation.

2.8 An alignment likely to receive plenty of sunlight should receive due preference over the one which will be in shade.

2.9 Areas liable to snow drift should be avoided.

2.10 As far as possible, needless rise and fall must be avoided, specially where the general purpose of the route is to gain elevation from a lower point to a higher point.

2.11 Areas of valuable natural resource and wild life sanctuaries shall be avoided.

3. Special consideration for locating roads in desert area

3.1 Locations where sand is loose and unstable should be avoided and the alignment selected along ridges having vegetation.

3.2 Preference should be given to areas having coarse sand than to areas having fine wind blown sand.

3.3 In locating a road in an area having longitudinal sand dunes, the best location is always at the top of a ridge or in the inter-dunal space. Location along the face of longitudinal dunes should be avoided.

3.4 The alignment of road should as far as possible run parallel to sand dunes, sand dunes should be crossed without disturbing their existing profile.

4. Special Consideration in Expansive Soils

4.1 Suitable forms of stabilization, specially mixing of lime in pulverized soil may be necessary to achieve desired gain in strength.

5. Special Consideration of Road in Saline Soils

5.1 Location where large salt deposits occur should be bypassed.

5.2 In locating the road in medium and highly saline soil precautions for diversion of water way from road bed should be taken.

5.3 On wet saline soils, highway embankment should be constructed of good imported soil free from salts.

6. Special Consideration in Marine Clay

In case the marine clay site is under the influence of tide rise and fall of water, the sub-grade should be 1.0 meter above the highest tidal water level.

Marine clay are soft and compressible. Therefore, stability of fill and the magnitude and time rate of settlement needs to be evaluated and considered. If these factors are not within the acceptable limit ground improvements methods may be adopted.

7. Special Consideration in Water Logged Areas

7.1 Embankment height should be adequately above level of standing water.

7.2 Provision of capillary cut-off or blanket drainage facility below pavement may be necessary.

8. Points of Guidance on Prevention of Soil Erosion needing attention in the Construction of Road in Hilly Areas:

8.1 The road construction project estimates should provide for not only the requisite scale of investigation but also the necessary measures against soil erosion so that these can be built into the project with adequate financial provision.

8.2 Before finalising the alignment erosion potential of each alternative should be carefully examined and the one involving least disturbance to the natural ground should be preferred.

8.3 Roads should not be located in geological by unstable strata, if this can be avoided. Study of the geological maps of the area and consultation with the local Geological Department will be helpful in this regard.

8.4 Road alignment should avoid large scale cutting and filling and follow the profile of the land as far as possible. Use of tunnels to avoid deep cuts should be considered where feasible and economical.

8.5 To the extent feasible, roads should be aligned away from streams except where these are to be crossed, since he greatest damage always occur along the water courses. Special attention is necessary to create protective belts of forests on both sides.

8.6 It will be advisable, at least for important roads, to have consultation with officers of Forest Department at the stages of roués alignment selection, surveys and investigations, etc., so as to ensure that the selected alignment has minimum potential for soil erosion and that the project designs and estimates provide for the necessary soil erosion control measures.

8.7 On hill Slopes half cut and half fill type of cross-section which involves least disturbance to the natural ground, should be adopted subject to consideration of economy and road stability being satisfied.

8.8 The cut slope should be made stable for the type of strata in the initial construction stage itself by resorting to stable cut slopes with benches, etc., including the use of slope stabilizing structures, like, breast walls, pitching, etc.

8.9 Area for clearing and grubbing should be kept minimum subject to technical requirements of the road. The clearing area should be properly demarcated to save desirable trees and shrubs and to prevent over-clearing.

8.10 Location and alignment of culvert should be so chosen as to avoid adverse erosion at outlets and siltation at inlets.

8.11 The cross-drainage structures should discharge safely on the valley side and in this connection all necessary precautions/safe guards should be taken to ensure that the discharging water does not cause erosion even when they flow for long period.

8.12 Drainage of water from the roadside must be given top attention and necessary system of drains will be received to deal the run-off to natural water course.

8.13 Appropriate mitigating measure, like, ground cover planting and compulsory afforestation may be catered for.

Appendix-2
(Ref. para 6.9.3)

TRAFFIC GROWTH RATE ESTIMATION

1.1 Traffic growth rate is required to be estimated to assess the future corridor traffic. To be realistic, this projection must be made by considering traffic flow pattern by Origin-Destination pairs and changes in vehicle mix expected during the time horizon of the study. Since the transport demand can change due to shift in the pattern of economic activities, it is also necessary to consider trip generation potentials within a region. In view of this, projecting regional socio-economic characteristics, plus the rate of change likely to take place in the economy, the population size, urbanization and the spatial distribution of the economic activities are required to be considered in estimation of growth rate for traffic project. Simple methods which may be considered suitable are described below:

1.2 Time Trend Analysis

For this purpose classified volume count data are to be collected at selected survey location which are reasonably representative of the traffic flow conditions along the corridor.

The analysis is then carried out generally by Linear Regression Analysis. AR^2 value of 0.75 or more would be acceptable for forecasting. Erratic and scattered of value of R^2 may required consideration of other parameters and appropriate unbiased purification of data base or adjustment of growth rates, nevertheless, this method has its limitations particularly in its applications to a new facility. Secondly, historical growth rates do not cover the changes in he socio-economic structure, as such, fail to reflect fully the prospective growth envisaged in the economy and the spatial distribution of economic activities, population size and, urbanization. These may require to have some zonal-level forecasting along the corridor. Thus, something more than simple extrapolation of historical growth rates by vehicle type is required.

1.3 Systematic Forecasting Method

This method is more related to the projections of Origin-Destination at the zonal-level, as related to the prospective growth in population and the economy.

The traffic forecasting models developed for the study involved the estimation of future transport demand, in terms of future growth rates based on the growth of population and State Domestic Project (SDP), together with the elasticity of transport demand for both passengers and freight, in relation to income and population.

The data inputs required by this method for the determination of growth rates of vehicular traffic comprise:

(a) the growth of population
(b) income (in real terms) and
(c) the elasticity of transport demand in relation to population and income

The data, particularly the income and transport demand elasticity, are generally not available at zonal level, the state level data may be used with due consideration of the zone under consideration.

1.4 Simplified Approach

This approach is primarily based on the broad guidelines for economic analysis for highway investments circulated for schemes under he proposed assistance by the Asian Development Bank.

Forecast future normal demand for transport by project road based on, but not necessary limited to, annual population and real income per capita growth rates (in percent per year) estimated in Road Influence Area (RIA), elasticity of transport demand in relation to income and estimated annual production increases (in percent per year) in RIA. In other words, annual traffic growth must be related to specific economic activity in each RIA. Transport demand should be projected on an annual basis over the project period. The formulae for annual growth (in percent) of passenger vehicles and trucks may be assumed as follows:

(a) Passenger Vehicles

Example: Assumptions

(i) Population growth : 2.1 percent a year during 1981-91 (expected population growth rates during 1991-2001 2 percent year)

(ii) Real income per capita growth : 3.0 percent per year

Then,

Growth Rate (%) = [1.020 x 1.03 – 1] x 100 x E

	First Five Years	Second Five Years	Third Five Years
E for Cars, Jeeps and Vans	2.0	2.0	1.8
E for Buses	1.6	1.6	1.5
E for Two and Three Wheelers	2.5	2.3	2.1

Where E is the elasticity of transport demand

(b) Freight Traffic

Estimation of freight traffic more complex in nature and involves the process of iteration as well as subjective decision so as to be compatible with the regional perspective plans and other indicators. The basic steps will comprise:

(i) From socio-economic profile find out the annual weighted average growth rate in percent in the agricultural, industrial, mining and tourism sectors (assumed as the predominant sectors) from the State Domestic Product (SDP) data base. This growth may be computed in five (5) year blocks;

(ii) To the above growth rate, apply the elasticity of transport demand. For example

For the first five years 2.0, second five years 1.8 and third five years 1.6;

(iii) Based on the above generate movement quantum in terms of commodity tonnage in the same block of years;

(iv) Now assume percentage of likely market shares by LCV, HCV and MAV during the project period;

(v) Further assign lead distance to connect the commodity movement into tonne-km and using step (iv), generate numbers of vehicles in blocks of give years;

(vi) As a check back calculate the growth rates to examine its appropriateness in the context of regional development perspective and other development parameters. Apply suitable corrections, on subjective basis, to finalise the growth rates and generate annualized traffic streams in terms of LCV, HCV and MAV for use in pavement design as well as economic analysis.

1.5 Conclusion

From the findings of the alternative methods described, appropriate growth rates may be adopted for the project road concerned.

Appendix-3

POINTS ON WHICH DATA MAY BE COLLECTED DUIRNG GROUND RECONNAISSANCE

1. Details of route vis-à-vis topography of the area, whether plain, rolling or hilly.
2. Length of the road along various alternative.
3. Bridging requirements number, length.
4. Geometrics Features:
   (a) Gradient that are feasible, specifying the extent of deviations called for
   (b) Curves hair-pin bends, etc.
   (c) Railway crossings.
   (d) Ground constraints.
5. Existing means of surface travel-mule path, jeep track, earthen cart tracks, railway lines, water way, etc.
6. Right-of-way available, bringing out constraints on account of built-up-area, monuments, and other structures.
7. Terrain and soil conditions:
   7.1 Geology of the area
   7.2 Nature of soil, drainage conditions and nature of hill slopes
   7.3 Road length passing through
      (i) Geology of the area
      (ii) Steep terrain
      (iii) Rocky stretches with indication of the length in loose rock stretches
      (iv) Areas subject to avalanches and snow drift
      (v) Areas subjected to inundation and flooding
      (vi) Areas subjected to sand dunes including location of dunes
      (vii) Areas of poor soils and drainage conditions
      (viii) Areas with very poor sub-soil strength, e.g. marshes
      (ix) Areas of high salinity or wet saline soil.

   7.4 Cliffs and gorges
   7.5 Drainage characteristics of the area including susceptibility to flooding
   7.6 General elevation of the road indicating maximum and minimum heights negotiated by main ascents and descents in hill sections
   7.7 Total number of ascents and descents in hill sections
   7.8 Disposition and location of sand dunes
   7.9 Vegetation – extent and type
8. **Climatic Conditions**
   8.1 Temperature – monthly maximum and minimum readings
   8.2 Rainfall data – average annual, peak intensities, monthly distribution (to the extent available)

8.3 Snowfall data – a average annual, peak intensities, monthly distribution (to the extent available)

8.4 Wind direction and velocities

8.5 Visibility

8.6 Exposure to sun

8.7 Water Table and its variation between maximum and minimum

8.8 History of unusual weather, like, cloudbursts, etc.

9. **Facility Resources**

9.1 Landing ground in case of hilly stretches

9.2 Dropping zones in case of hilly stretches

9.3 Foodstuffs

9.4 Labour – local availability and need for import

9.5 Construction material timber, bamboo, sand, stones, shingle, etc. with extent of their availability, leads involved and availability of easy access

9.6 Availability of water, especially in arid zones

9.7 Availability of local contractors

10. Value of land-agriculture land, irrigated land, built-up land, forest land etc.

11. Approximate construction cost of various alternatives.

12. Access points indicating possibility of induction of equipment.

13. Period required for construction.

14. Strategic considerations.

15. Recreational potential.

16. Important villages, town and marketing centres connected.

17. Economic factors:

    (i) Population served by the alignment
    (ii) Agricultural and economic potential of the area
    (iii) Marketing centres

18. Other major developmental projects being taken up in the area, e.g., railway project hydro-electric projects, railway projects, dams, reservoirs, mining/agricultural projects, etc.

19. Crossings with Railway Lines and other existing highways.

20. Location of existing or proposed utilities along the alignment.

21. Necessity of by-passes for towns and villages.

22. Position of ancient monuments, burial grounds, cremation grounds, religious structures, hospitals and schools.

23. Ecology and environmental factors.

24. Aspects of needing coordination with other administrative authorities.

25. Traffic counts from existing records.

Appendix – 4
(Ref. para 8.2, 2.9 & 12.5.3

CHECK LIST OF MAJOR OPERAIONS INVOLVED IN THE SURVEY AND INVESTIGATION FOR A ROAD PROEJCT

1. **Reconnaissance Survey (See Section 7)**
   - (i) Map study
   - (ii) Aerial reconnaissance
   - (iii) Ground reconnaissance
2. **Preliminary Survey (See Section 8)**
   - (i) Collection of general information about traffic, soil, sub-soil and surface drainage, etc.
   - (ii) Establishment of reference bench marks
   - (iii) Traverse survey
   - (iv) Fly level s and cross-sections
   - (v) Map preparation
3. **Determination of Final Centre Line in the Design Office (See Section 10)**
4. **Final Location Survey (See Section 12)**
   - (i) Staking of final centre line
   - (ii) Referencing of HIPs, POTs, etc.
   - (iii) Establishment of permanent bench marks
   - (iv) Longitudinal and cross-sections
5. **Survey of Economic Profile**
6. **Traffic Survey (See Section 6)**
   - (i) Study of data from records
   - (ii) Traffic counts, O-D Surveys, etc
   - (iii) Traffic projections
   - (iv) Collection of traffic particulars for railway level crossings and road junctions
   - (v) Axle load surveys
   - (vi) Analysis of accident records
7. **Soil and Materials Survey (See Section 12)**
   - (i) Study of available information
   - (ii) Soil investigations for low embankments and demarcation of borrow areas
   - (iii) Special investigation for high embankment
   - (iv) Detailed investigations for flexible pavement/rigid pavement
   - (v) Survey and evaluation of naturally occurring aggregates
   - (vi) Manufactured aggregates/items
   - (vii) Water for construction purposes
8. **Drainage Studies (See Section 15)**
   - (i) HFL and ponded water level
   - (ii) Depth of sub-soil water table
   - (iii) Special investigations for cut sections and seepage glows
   - (iv) Surface run-off
9. **Cross-drainage Structures (See Section)**

Appendix – 5
(Ref. paras 9.2.1 & 9.5.4)

RECOMMENDED MIGIGATIONG MEASURES AND SUGGESTED GRADINGS FOR INITIAL ENVIRONMENTAL EXAMINAITON (IEE)

(Clause 9.2.1)

Actions affecting environmental resources and values		Recommended feasible mitigating measures	Environmental Examination grading (Suggestive)
(a)	**Environmental Impacts Due to Project Location**		
	(i) Disruption to hydrology	May be avoided through planning measures	D2
	(ii) Resettlement	Suitable compensation and resettlement planning require consideration	D1
	(iii) Environmental aesthetics degradation	Care shall be taken to avoid/minimize effect	D2
	(iv) Inequitable locations for rural roads	Cross roads suitably clubbed for access to the road. For the purpose, suitable connectors to be planned as part of project	D3
	(v) Loss of terrestrial ecology including forests and wildlife	May be avoided through planning exercise or minimize the effect with mitigation measures	D2
	(vi) Loss of swamp ecology	May be avoided through planning exercise or minimize the effect with mitigation measures	D2
(b)	**Impacts During Construction Phase**		
	(i) Site run off from cut and fill area	Suitable measures to be adopted during construction	D1
	(ii) Safety of works from accidents	All safety measures may be incorporated in tender document	D1
	(iii) Slum creation hazards	Appropriate planning for housing of construction workers must be made	D1
	(iv) Cultural difference hazards	Should preferably be avoided and public learning be made and considered	
	(v) Escape of hazardous materials	Strict monitoring the movement of hazardous materials	D2
	(vi) Escape of air) pollution (including dusts)	Suitable measures will be adopted to prevent/minimize	D1
	(vii) Noise and vibrations	Effect shall be assessed and measures	D1

Actions affecting environmental resources and values		Recommended feasible mitigating measures	Environmental Examination grading (Suggestive)
		taken based on significance	
	(viii) Quarrying hazards (including use of explosives)	Appropriate planning operation of blasting and use of operating quarries	D3
	(ix) Disruption of utilities along route	Shifting of utilities shall be planned in advance and provision kept in the project	D2
	(x) Disruption of traffic along route	Judiciously planned to avoid/minimize disruption	D1
(c)	**Impacts from Project Operations**		
	(i) Noise disturbance	Shall not go up from present level	D1
	(ii) Vibration disturbances	Appropriate planning and post-construction monitoring may be made	D1
	(iii) Air pollution	Appropriate planning and post-construction monitoring may be made	D1
	(iv) Continuing erosion	Protective vegetation and other methods shall be adopted	D2
	(v) Highway runoff contamination	Appropriate planning and post-construction monitoring to take care	D2
	(vi) Highway spills of hazardous materials	Appropriate spills control programe and post construction monitoring to take care	D1
	(vii) Escape of sanitary waste	Appropriate planning/post-construction monitoring to be considered	D2
	(viii) Congestion at access/exit points	Post-construction monitoring is recommended	D3

IEE grading scale	D1	-	Not significant
	D2	-	Small significant effect
	D3	-	Moderate significant effect
	D4	-	Major significant effect

Appendix – 6
(Ref. para 10.14)

CHECK LIST FOR A HIGHWAY PROJECT FEASIBILIYT REPORT

1. FEASIBILITY REPORT

1.1 Executive Summary

1.2 Economic and social setting

(i) State's economic profile, including GDP, agricultural production, industrial output, mining, etc. and their growth rates.
(ii) State's population and growth rates
(iii) Potential of industrial and other economic growth in the project influence area.

1.3 Transport system of the State

(i) Main transport mode and their extent
(ii) Road network in km by classification, carriageway width and surface type
(iii) Vehicle fleet and its growth
(iv) Annual expenditure on roads (original works and maintenance) by road class
(v) Annual road taxes (State and Central)
(vi) Profile of road transport industry
(vii) Road maintenance norms and allotments
(viii) Road accident statistics
(ix) Consumption of petrol and diesel and growth trend

1.4 Organization structure of PWD/Highway Department

1.5 Socio-economic profile of the project area

1.6 Project description

(i) Scope
(ii) Necessity
(iii) Sources of funding and budget provision
(iv) Selection of route
(v) Management
(vi) Alignment
(vii) Cross-sectional elements
(viii) Drainage facilities
(ix) Construction technology

1.7 Methodology adopted for the studies

(i) Division into homogenous sections
(ii) Traffic studies like classified counts, Origin-Destination, Axle Load Survey
(iii) Traffic growth rates
(iv) Road inventory, including roughness data
(v) Survey and Investigation results
- Soil Survey
- Material Survey
- Pavement deflection data
- Design of cross-drainage works

1.8 Design, Report

(i) Project road inventory
(ii) Engineering surveys and investigation data
(iii) Design standards and specifications
(iv) Special site conditions effecting design
(v) Pavement design
(vi) Design of cross-drainage and other structures

1.9 Cost estimates

(i) Item rates and rate analysis
(ii) Escalation

1.10 Construction Programme

1.11 Economic analysis

(i) Vehicle operating costs
(ii) Time costs
(iii) Accident costs
(iv) Economic costs and benefits
(v) Shadow pricing
(vi) Sensitivity analysis
(vii) Discussion of results

1.12 Construction arrangement

(i) Prequalification procedure
(ii) Bidding procedure
(iii) Supervision arrangements

1.13 Conclusive and recommendation

2. DRAWINGS

(i) Locality map
(ii) Plans showing various alternative alignments considered and the selected alignment
(iii) L-section of the selected alignment
(iv) Typical cross-sections showing pavement details
(v) Strip plan
(vi) Drawing showing cross drainage and other structures
(vii) Road junction plans
(viii) Roadways land acquisition plan

Appendix – 7
(Ref. para 14.1)

INVENTORY & CONDITION SURVEY FOR BRIDGES

Road Name :
Section :

Road No. :
Date of Survey :

Sl. No	Location	Name of River and Type of crossing	Length of Bridge/Span Arrangement (m)	Average Cectical Clearnace (m)	Type of Bridge			Year of Construction	Details of Superstructure			HFL (m)	Thickness of Girder/Dlab (m)
					Super-structure	Sub-structure	Foundation		Features	Type	Condition (VG/G/F/P/VP)		
									Deck				
									Carriageway				
									Footway				
									Railing				
									Deck				
									Carriageway				
									Footway				
									Railing				
									Deck				
									Carriageway				
									Footway				
									Railing				

Note: VG=Very Good G=Good P=Poor VP=Very Poor Surveyed by: ……………..

INVENTORY & CONDITION SURVEY FOR CULVERTS Sheet No.

Road Name :
Section :

Road No. :
Date of Survey :

Sl. No	Location	Type of Structures (Pipe, Slab, Box, Arch)	Thickness of Slab (m)	Span arrangment and total ventway (Nos., Length) (m)	Carriage way Width (m)	Width of Culvert (m)	Details of Protection works		Details of Superstructure					Height above Bed Level		Presence of Scour	Adequacy of Waterway	Remarks
							Type	Condition	Slab/ Pipe/ Box/Arch	Head wall	Wing Wall	Return Wall	Parapet Handrail	U/S side (m)	D/S side (m)			

Note: VG=Very Good G=Good P=Poor VP=Very Poor Surveyed by: ………………………………..

PAVEMENT CONDITION SURVEY Sheet No.

Road Name :
Section (From) : To
District (From) : To

Road No. :
Date of Survey :
Weather :

Chainage		Pavement Composition			Shoulder		Riding Quality		Riding Quality		Pavement Condition			Pavement Edge drop (mm)	Embankment condition (G / Fair/ Poor)	Road side Drain (NE/ PF/F)***	Remarks
From (Km)	To (Km)	Composition	Type*	Thickness (mm)	Composition	Condition (Fair/ Poor/Failed)	Speed (Km/Hr)	Quality (G/F/ P/V P)	Cracking (%)	Ravelling (%)	Potholes (No. and % 100 m)**	Rut (None/ Moderate / Severe)	Patching (No. and (% 100 m)**				
		Surface															
		Binder															
		Base															
		Sub-base															
		Sub-grade															
		Surface															
		Binder															
		Base															
		Sub-base															
		Sub-grade															

Note * : BUSG = Built up Spray Grout; AC = Asphaltic Concrete; SDC = Semi Dense Concrete; PC = Premix Carpet; MSS = Mix Seal Surfacing
WBM = Water Bound Macadam; DBM = Dense Bituminoous Macadam; BM = Bituminous Macadam; BS = Brick Soling; SS = Stone Soling
: No. and %/100 m = Total No. of Pothholing/Patching and %age area of Potholing / Patching 100 m of length of road
: NE = Non Existing; PR = Prtically Functional; F = Functional

Surveyed by ……………………………

ROAD INVENTORY DATA SHEET																		Sheet No.
Road Name :															Road No. :			
Section (From Km) :						To									Road Classification :			
:															Date of Surve :			
From Km	To	Terrain (Plain/ Rolling/ Hilly)	Land Use (Built up/ Agrt/ Forest/ Industrial/ Barren)	Name of Villages/ Town	Formation Width (m)	Carriageay			Shoulder+			Embankment Height (m)	Submergency (cm)	Details of Cross Roads			Remarks	
						Type* (BT/ CC/ GR/ER)	Width (m)	Condition** (G/F/P/VP)	Type* (BT/CC/ GR/ER)	Width (m)	Condition** (G/F/P/VP)			Location (km)	Road No (Km)	Carriagway width (m)		

NOTE: TYPE*: BT=Bituinous GR=Gravel ER=Earthen
CONDITION G=Good P = Poor VP=Very Poor
+ Information about left and right shoulder's if of different nature, may be according recorded.

Surveyed by …………………………….

BRIDGE INVENTORY

Name of Project ____

Bridge No.	Location (Km)	Name of River bridge	Year of Construction	Number of spans	Span arrangement (expansion Joint to expansion joint (m)	Clear Spans	Length of bridge fact to face of abutment (m)	High level or submersible	Clear Roadway width between kerbs (m)	Total outer width of bridge (m)	Width of footpath (m)	Superstructure: Gradient	Superstructure: Type	Superstructure: Type of Bearing	Superstructure: Thickness of slabs (m)	Superstructure: Material of slab	Superstructure: Handrail /parapet thickness & Height (m)	Details of wearing coat: Type	Details of wearing coat: Thickness (m)	Sub-structure: Type	Sub-structure: Thickness on Pier (m): Top	Sub-structure: Thickness on Pier (m): Bottom	Sub-structure: Height of pier & abutment	Sub-structure: Materials used: Abutment	Sub-structure: Materials used: Pier
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	26	27	27

PIER FOUNDATION: Type	PIER FOUNDATION: Material	ABUTMENT FOUNDATION: Type	ABUTMENT FOUNDATION: Material	PROTECTION WORK: Bed	PROTECTION WORK: Approach	Skew angle (Degree)	Vertical clearance (below / bottom of deck slab) (m)	Road formation Level (m)	Direction of flow	PRESENT CONDITION OF BRIDGE: Abutment	PRESENT CONDITION OF BRIDGE: Piers	PRESENT CONDITION OF BRIDGE: Slab	PRESENT CONDITION OF BRIDGE: Bearing	PRESENT CONDITION OF BRIDGE: Parapet	Clear water way (m)	Design of Loading	High Flood Level (HFL)	Lowest Water Level (LWL)	Design Discharge (Cu.m.)	Maximum design velocity (m/sec)	Remarks
28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49

ROUGHNESS MEASUREMENTS USING BUMP INTEGRATOR

Chainage Km	Direction 1				Direction 2				Mean Value (A+B) 2 cm/km
	Bump Reading B R	Wheel Revolution W R	Road Condition (Type of Surface Thickness, Drainage, etc.	UI cm/Km A	Bump Reading B R	Wheel Revolution W R	Road Condition (Type of Surface Thickness, Drainage, etc.	UI cm/Km B	