Indian Roads Congress
Special Publication 54

PROJECT PREPARATION MANUAL FOR BRIDGES

NEW DELHI 2000

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Published by :
THE INDIAN ROADS CONGRESS

Copies can be had from
The Secretary, Indian Roads Congress,
Jamnagar House, Shahjahan Road,
New Delhi - 110 011

NEW DELHI 2000

Price Rs. 200/-
(Plus packing and postage)

IRC:SP:54-2000

First Published	:	April, 2000
Reprinted	:	September, 2003
Reprinted	:	September, 2006
Reprinted	:	March, 2010

Printed at : I. G. Printers Pvt. Ltd., New Delhi
(500 copies)

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PROJECT PREPARATION MANUAL FOR BRIDGES

BACKGROUND

The Project Preparation Manual for Bridges was drafted by the members of the Project Preparation, Contract and Management Committee (B-1) of IRC (personnel given below). The draft was discussed in a number of meetings of the committee and approved in its meeting held on the 14th July, 1997:

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The draft was subsequently approved by the Bridge Specifications and Standards Committee (B.S.S.) and the Executive Committee in their meetings held on the 27th September, 1997 and 18th April, 1998 respectively. The draft came up for discussion in the Council meeting held on the 22nd May, 1998. The Council approved the draft and authorised the Convenor, B.S.S. Committee to approve the document after incorporating the observations and comments of the council members. The Convenor, Project Preparation, Contract and Management Committee modified the draft in light of the comments of the Council members and forwarded the same to the Convenor, B.S.S. Committee for approval. The Convenor, B.S.S. Committee approved the modified draft on the 6th December, 1999.

1. INTRODUCTION

1.1. Bridge structures are essential component of any road network. Preparation of bridge projects involves a chain of activities such as survey and investigations, selection of site, fixing of waterways, selection of type of structure, design of structural elements, preparation of drawings and cost estimates, economic evaluation, preparation of contract documents, quality assurance scheme, maintenance manual and schedule.

Guidelines and codal requirements already exist on different aspects of these activities. The preparation of a bridge project will not only be guided by codal provisions but also by the need to optimise the investments. The structure should have an assured safety and level of performance over its expected life. These considerations demand that the project should be prepared after thorough investigations, collecting all relevant information, evaluating all possible alternatives for selecting the most effective solution, both from the technical angle and the economic point of view.

1.2. The extent, nature and quality of investigations and analysis of data help in ensuring safety and cost-effectiveness of the structure. The best design and technologically superior option emerges only if investigations have been concluded with the utmost accuracy and completeness. Project preparation work can be carried out either by the owner himself or with the help of consultants. In case consultants are employed, their competence and capability to carry out the work should be properly established.

Adequate funds and time should be earmarked for all activities needed for planning, investigation and design. Such investments in the initial stages of a project shall prove worthwhile in the long run. The techniques adopted and the equipment used should be such as to give the desired level of accuracy.

1.3. Presentation of project details in a comprehensive and systematic manner helps in many ways. Such a project report enables a quick scrutiny by technical, financial and administrative authorities who are required to judge the technical soundness and economic benefits and financial viability as applicable, of a project before according investment sanction. When external funding of a project is sought, a well prepared and properly presented report becomes all the more necessary to improve the chances of funding. If private financing is envisaged, the selection of a project depends upon its competitive cost and its ability to recover the investments within a reasonable time span.

The project document ultimately also forms the basis for bidding, selection of the contractor and for its successful execution. The care that should be taken in preparing such a document cannot be over-emphasised.

1.4. This manual lays down guidelines covering the various aspects which are to be detailed in the report for a bridge project. It is hoped that use of these guidelines, would result in a uniformly good quality and comprehensive report which would help in speedy evaluation and subsequent successful execution of the project.

2. SCOPE

The manual covers bridge structures for all classes of highways in urban and non-urban areas. The word "bridge structures" used in this Manual covers bridges across rivers, canals, viaducts, structure for interchanges including under-passes and flyovers across the road, flyover and under-passes across railways, acquaduct/syphon in combination with highway structures and retaining walls which may be considered critical for the design and safety of the main structure. The Manual is applicable for all bridge structures with bridge length more than 6 m. These are general guidelines and specific requirements of the bridge project, shall be prepared on the basis of these guidelines as applicable keeping in view the magnitude and complexity of the project.

3. STAGES IN PROJECT PREPARATION

Generally there are three stages in project preparation :

(i) pre-feasibility report,
(ii) feasibility report/preliminary project report, and
(iii) detailed project report.

Project preparation work starts with the identification of the project. This phase is known as pre-feasibility phase. For this stage, the broad features of the project are identified. The possible locations, nature of crossing, traffic dispersal system for different alternatives are identified. The effect of implementation on the traffic scenario in immediate vicinity is also broadly considered. The reconnaissance visit to the area of the intended bridge site is sufficient at this stage.

In the feasibility stage, preliminary surveys, data collection and investigations are carried out, alternative sites are investigated, outline design and rough cost estimates for various alternatives are made. Sometimes pre-feasibility and feasibility stages are combined into the feasibility stage. A feasibility report covering recommended alignment including alternatives considered, span arrangements, preliminary cost estimate, economic and financial viability (as required) is prepared. This should include recommendations regarding need for carrying out model studies, where required. Special design requirements for the project, if any, and schedule for all pre-construction activities shall also be included in the feasibility report.

The third stage is known as detailed engineering. In this stage detailed surveys and investigations are carried out on approved site alignment. Detailed designs are worked out on the basis of results of survey and investigation and detailed drawings are prepared. An accurate cost estimate is made along with the Bill of Quantities and the specifications are finalised. The detailed project report (DPR) incorporating all these aspects is prepared. DPR should clearly indicate the required budget provision for the project and also include, if required by the client, documents for pre-qualification of contractors and the tender documents.

In addition, the detailed engineering stage should include preparation of a work programme (CPM/PERT Chart), the quality assurance system and maintenance manual.

4. PRE-FEASIBILITY REPORT

In the pre-feasibility report a matrix is evolved based on which minium number of sites required for conducting feasibility study is identified. A matrix covering land acquisition problem, nature of crossing, likely foundation depth, length of approaches, length of bridge, firmness of banks, suitability of alignment of approach road, etc., are required to be examined and tabulated in the form of decision of matrix by giving suitable weightage to each factor. From the decision matrix, 2 to 4 sites are identified for feasibility study. Pre-feasibility study need not be carried out for widening and rehabilitation project. Pre-feasibility study is specially required in the case of bridges on missing links.

5. PREPARATION OF TECHNO-ECONOMIC FEASIBILITY REPORT

5.1. General

The techno-economic feasibility study report prepared with the data readily available as well as that collected during the feasibility studies should indicate in detail various alternatives in respect of the technical, economic and social aspects. The quality of feasibility report depends upon the accuracy and extent of data, its analysis and the investigation that goes into its preparation. The nature and extent of data needed depends upon the type of crossing as well as on its size.

5.2. Identification of Data Needs

The data collection should be carefully planned. While the data collected should be comprehensive enough to aid engineering judgement, a disciplined effort is required to identify specific data needs for any given project. Data needs for long span bridges such as cable stayed and suspension bridges, arch bridges or P.S.C. box construction of cantilever method would be different from those for more conventional bridges. Site data requirement, discussed hereunder, can be treated as a general guide.

Depending on the requirements of a particular site, activities in respect of site data collection, evaluation of design data and structure design may have to be repeated on demand. Hence, these activities should be planned so as to afford the required site flexibility. Also the aspects wherein repetition can be avoided should be identified at the earliest.

Data collected should be continuously reviewed, which may sometimes lead to identification of supplementary data needs or revision of data already collected.

The data collection team should have regular interaction with the design department/highway administration.

For selection of alternative bridge sites and approach alignments, reference may be made to "Pocket Book for Bridge Engineers" and "Pocket Book for Highway Engineers" published by IRC.

Economic viability of the bridge project on alternative locations play a vital part in selection of the site.

5.3. Data Collection

5.3.1. Maps, plans and topographical features

i) Index Map

An index map is needed to locate the project area with reference to its connection with the capital city of the State and near by major towns. It should give a bird's eye view of the project area and the overall road and rail network in the State. The alternate sites investigated/the general topography of the country, the important towns, villages, etc., in the vicinity are to be shown in the index map. The largest scale topographical maps available (1:50,000) may be used for preparing the index map. Smaller scale (1:250,000) may be used in addition for major projects for covering larger area.

ii) Site Plan

A site plan drawn to a suitable scale should show details of the sites considered in the feasibility study and extending not less than 100 m upstream and down-stream from the centre line of the crossing. It should cover the approaches to a sufficient distance, which in the case of major bridge shall not be less than 500 m on either side of the channel. In case the river is meandering in the vicinity of the proposed bridge site, the course of the river extending a suitable distance not less than 2 loops on either side of the proposed crossing shall be plotted on the site plan. The name of the channel or the bridge and of the road and identification number allotted to the crossing are to be indicated, the direction of flow of water, the alignment of existing approach, angle of skew, location and value of permanent bench mark, the location of cross sections and longitudinal sections taken, location of trial pits or boring, other details such as building or any permanent structure, places of worships, well, nallah, burial ground, out crop area, etc., are also to be indicated.

iii) Contour Survey Plans

The contour plan of the stream should show all topographical features and extending upstream and downstream of any of the proposed sites, to the distance indicated below (or such other greater distances as the Engineer responsible for the design may direct) and to sufficient distance on either side to give a clean indication of the topographical or other features that might influence the location and design of the bridge and its approaches. All alernative sites considered shall be shown on the plan.

(a) 100 m for catchment area less than 3 sq. km
(scale not less than 1 cm = 10 m)

(b) 300 m for catchment area of 3 to 15 sq. km
(scale not less than 1 cm = 10 m)

(c) 1.5 km or the width, between the banks, which ever is greater, for catchment areas more than 15 sq. km
(scale not less than 1 cm = 50 m)

In case of meandering river, the above provision has to be suitably reviewed.

iv) Topographical Map

The topographical map is essential for finalising the site alignment. Such a map could be prepared from topographical maps published by the Survey of India. If deemed necessary, due to the scope and size of the project, combined with scarcity of data, etc., aerial survey may be made to provide sufficient updated data. For very large bridge projects or for bridges in difficult terrain, satellite imagery may also be obtained to fix alternative sites. For major bridges, ground survey of site may be needed to include the relevant portion of approaches and the river reach relevant to the protection work.

v) **Catchment Area Map**

In order to determine the basic parameters of discharge, etc., it will be necessary to prepare the catchment area map from available topographic maps. In restricted areas where topographic maps are restricted, the concerned departments should make efforts to procure the same for the project. Actual parameters of scale and size to be used in the catchment area map depend to great extent on the needs of each individual project and a studied judgement is required on the part of the engineer responsible.

vi) **Geological Map**

Geological maps, when required for reference in route alignment and bridge site selection for assessing geological stability, should be procured from the Survey of India, State Geological Departments, etc.

5.3.2. **Traffic data** : Basic design parameters such as the number of traffic lanes required, the approach gradients, need for a central verge etc. are determined by the type, intensity and volume of traffic to which the bridge has to cater.

In case of bridges forming part of road projects, the traffic figures collected for the design of road could be directly utilised. In case of independent bridge projects, traffic survey should be conducted if adequate data is not readily available.

Depending upon the importance, relevance and complexity of the project and the traffic scenario, the type of data which will be needed are:

a) Classified Traffic Volume Count
b) O-D Survey
c) Speed and Delay Survey
d) Pedestrain Volume Survey
e) Socio-economic profile of the project influence area for the last 5 years

5.3.3. **River cross-section for a bridge project** : The river cross-sections yield information on channel profile, bank characteristics, depths of water, etc. However, these data are usually collected during lean flow periods, their direct application in estimation of the design discharge may not be feasible or reliable.

The number of river cross-sections should be such as to yield sufficient data for design of waterway, proposed structure and the approach embankment. At least one cross-section should be taken along the proposed alignment of the bridge for each alternative site. The location of cross-sections shall be indicated on the site map. The number of cross-sections studied should conform to the provision of relevant clauses of IRC:5.

5.3.4. **Hydrologic data and river characteristics** : The basic purpose of collecting hydrological data is to study the rain fall pattern (like intensity, duration, frequency) and run off characteristics of the basin under consideration, and thereby determine the likely discharge through the channel and thus decide upon the optimum waterway for the bridge.

The extent of hydrological data collection and subsequent analysis should be commensurate with the type and size of crossing under study.

5.3.5. **Catchment area characteristics** : The catchment area of a bridge site should be identified and marked clearly on the topographical map. The identified catchment should also include the contour and existing land use pattern like forests, cultivated land, barren land, desert, etc., to the extent possible.

The run-off of a stream at a given site is determined by two factors: (i) precipitation and (ii) physical characteristics of the catchment area. In general, the size of the catchment area plays a dominant role in the determination of run-off. However, it is possible that some other characteristics such as slope, soil characteristics, etc., becomes equally important at specific sites. This possibility should be thoroughly investigated during the data collection stage and appropriate measures taken to obtain a full set of data. Likely changes in the catchment environment and land use should also be kept in view. Future development in the vicinity of the alignment specially for urban-areas which might influence the run-off characteristics, (if indicated in any perspective plan already developed) should also be looked into.

5.3.6. **River/Channel characteristics** : All details of configuration of the river/channel as may be relevant to hydrological analysis may be obtained from ground/aerial survey. All controls, natural (drops, rapids, bends, debris) and artificial (dams, barrages, weirs, spurs, road and railway bridges, etc.) should be identified and relevant information obtained. Details, if any, of future work that may affect the stream hydraulics should be collected. Degradation of a river channel may invite higher flood discharge whereas aggradation may result in higher flood levels and bank spills. These factors have a direct bearing on the design of waterway clearances and approaches as well as the bridge structure itself. All information which may help evaluate present or possible future aggradation/degradation of channel should also be collected. Efforts should also be made to collect data regarding the quantity, size and nature of debris and floating materials and the period of occurrence of debris in relation to flood peaks.

5.3.7. **Flood flow data** : A reliable assessment of the flood discharge and of the corresponding water levels are basic for a proper design of the bridge and its approaches.

a) Historical Data

Major floods that are known to have occurred at the site before the start of maintaining records may be called historical floods. All data relating to these events including the years in which they have occurred, the magnitude, the area flooded, flood water levels, flood marks or other positive evidence of the height of historical flood etc. should be collected from all available sources. Local enquiry can also provide useful data. A critical analysis of the reliability of such data is of paramount importance.

Personnel with necessary experience in flood flow determination can detect flood marks or other positive evidence of the height of historical floods, which may prove invaluable as additional data.

b) Flood Data Records

Flood discharge data at the nearest gauging station and other flood related data that may be available from records of irrigation or other authorities/

agencies shall be collected. It is readily recognised that gathering such data depends on the co-operation extended by the concerned authorities/agencies.

The hydraulic performance of existing bridges or other structures under flood situations in the vicinity of the proposed facility should be used to augment the available hydrologic data. The effect of flood control structures in the upstream stretch needs to be investigated and appropriately assessed and accounted for.

The discharge and linear waterway should be calculated as per IRC:5 General Features of Design (Section-I)

5.3.8. **Sub-soil data** : Information on the soil in bed and banks is necessary for evaluation of sediment, movement, and the stability of bed and banks in general. The size and particle distribution of soil, soil classification and other relevant information shall be obtained. IRC: 78 and relevant IS Codes may be referred.

Borings for foundation-soil exploration will yield data regarding scour, sound founding strata, S.B.C., settlement characteristics etc.

5.3.9. **Meteorological data** : All relevant meteorological records of temperature, wind, cyclones, etc. that may determine the loading and other design specifications of structure or affect construction operations shall be collected. This would be required in the case of major bridge structures only.

Information on wind speeds, temperature variations in summer and winter, rainfall, humidity likely to prevail and their expected duration is also required for planning of construction operations.

5.3.10. **Construction materials** : Information on availability of construction materials with special reference to their quality, quantity and proximity of their source should be carefully collected.

Majority of the road bridges are built in reinforced or prestressed concrete. The prime object of material-surveys is to identify good quality aggregate (conforming to specifications) sources at site or in its vicinity. It is important to appreciate that concrete of adequate quality can be made economically with aggregates of widely divergent characteristics and hence the number of sources to be investigated with respect to economic and technical viability will necessarily be large.

5.3.11. **Environmental data** : All data relevant to 'environmental examination' have to be collected for projects for which such study is demanded. A description of the environmental aspects of the site supported by sketches and photographs may be furnished where necessary.

In general, care should be taken to minimise the degradation of the existing environment of the proposed site.

5.3.12. **Special design requirements** : Special design requirements may be required or asked for some specific projects. These may relate to special road traffic requirements. Water-transport requirements, hydraulic-model study, wind-tunnel testing, dynamic analysis and seismic design controls etc.

For major bridge projects the span arrangement is, to some extent, dictated by the river regime. Establishing flow patterns, discharge distribution etc. become difficult for many reasons (such as soil conditions, presence of obstruction in the form of other structures, meandering course of the river). Model studies can help in finding an optimum solution.

In general, model studies are expensive and hence should be taken recourse to only where essentially required. Model studies are more justifiable for major bridges and/or bridges located in strategic areas etc.

Model studies give more definitive ideas about preferred alignment, flow patterns, discharge distribution, form, type and extent of guide bund etc., than analysis of data and studying of maps. It will also help to find out the effect of siltation particularly for bridges near ports, jetties, etc. to assess the appropriate length. However, results of model studies require careful scrutiny and an intelligent interpretation. Situations leading to inaccurate results from model studies should be identified and corrective measures taken.

5.3.13. **Existing services** : A strip plan showing existing service facilities such as telephone lines, electric lines (high tension and low tension), underground cables, underground water lines, sewer lines, etc. is required to be prepared. The strip plan should also show the position of relocation of such service facilities.

5.3.14. **Labour accommodation** : Information regarding the supply and demand aspects of skilled and unskilled labour have to be collected, especially for major bridge projects. Availability of such labour locally has to be investigated. Land requirement for storage, labour accommodation, offices, etc. may be quite considerable in major projects and demand close scrutiny.

In addition, requirements for labour camps such as drinking water, sanitation at site, housing, electricity and other facilities may also be investigated and reported to the extent necessary.

5.3.15. **Other authorities** : Information about other authorities whose clearance is required for the project should be collected. Interaction with these authorities to ascertain their specific requirements would help in collection of any additional data and preparation of the project in a well planned manner.

5.3.16. **Data regarding existing bridges** : Functioning of existing bridges on the stream in the vicinity of proposed bridge location (Road bridge, Railway bridge etc.) should be studied and data collected. Data collected should include hydraulic data, geometric data and structural data to the extent possible.

5.4. Organisation of Activities

Major activities required for preparing the feasibility report have to be identified and placed in proper sequence so as to provide a smooth flow of operation.

Activities leading to preparation of a well documented feasibility report may be classified as given below :

a) Collection of data

b) Preliminary investigations
   - Topographic survey
   - Hydrological survey
   - Traffic survey
   - Sub-soil investigation
c) Analysis of data
d) Identification of alternative bridge sites/alignments
e) Development of design philosophy
f) Preliminary design, general arrangement drawings and preliminary cost estimates
g) Environmental impact examination and economic evaluation
h) Model study where required through appropriate agency and taken up as a parallel activity to items (e) to (g).

It is quite obvious that many of the activities stated above are interlinked.

5.5. Source of Data

The sources of site data may include :

i) Maps
ii) Records
iii) Govt. Deptts. such as Industries, Agriculture, Planning Board etc.
iv) Field inspection
v) Information obtained from local enquiry
vi) Geological details

At least one site inspection should be conducted. The purpose of site inspection varies with the level of the team involved. It ranges from identification of data needs and collection of raw data at the elemental level to a global appraisal of the project to aid in analysis, decision making and financing. Careful planning of field inspection activities is necessary for a successful site/field inspection visit.

The need for conducting data collection in stages, review of the collected data and the decisions based on the same, lead to multiple site inspections throughout the project preparation exercise. The initial field inspection should also identify the number and type of field inspection which may be needed in later stages. A reconnaissance survey may be carried out to examine the general character of the area. Data collected would be useful in deciding alternative sites to be examined.

5.6. Preliminary Investigation

5.6.1. **General** : After collecting the data, preliminary investigation is to be undertaken keeping in view the data collected. As the preliminary investigation results are analysed, there might be need for more details in particular areas. The extent of gaps in investigation could be reduced by careful planning prior to taking up preliminary investigation.

5.6.2. **Topographic survey** : A review of the available topographic data should reveal the additional details required. Efforts should be made to collect these through an accurate instrument survey. The data collected should be accurate, detailed and exhaustive enough for use in the detailed design stage.

Ground surveys conducted at site help in preparation of site map and river cross sections. Keeping in mind that these maps are to be used in the identification of alternative locations and alignments, the surveys should be planned to be sufficiently exhaustive.

Establishment of permanent bench marks at site linked to GIS levels which are to be used during detailed survey construction and maintenance must precede such survey.

5.6.3. **Hydrological survey** : For bridge projects across any stream/ river, a hydrological survey should be carried out.

5.6.4. **Traffic survey** : Traffic survey should be carried out in accordance with relevant IRC Code.

5.6.5. **Sub-soil investigation** : In the feasibility stage, the sub-soil investigation should be carried out in a representative manner.

The investigation carried out should give sufficient details for various alternatives under consideration. Extent of subsoil investigations including number of bore holes should be predetermined.

5.7. Preliminary Engineering

5.7.1. **Design philosophy** : Design philosophy of criterion is a clear, comprehensive and precise elucidation of the general principles to be adopted and the significant parameters to be used in the actual design of a highway bridge structure. Design philosophy forms the basis of design and also serves as a reference for the design procedure.

Design philosophy flows from design requirements as per codes; nature of data base; the extent of available data; special requirements specified for the particular bridge structure by the client viz. special loads, increased clearances and current practice. As far as possible minimum number of expansion joints should be kept in the structure for better serviceability by adopting larger span or continuity in structure.

5.7.2. **Analysis of data** : The data collected and investigation results should be analysed to determine the following :

i) HFL
ii) LWL
iii) LBL
iv) Erodibility of bed/scour level
v) Design discharge
vi) Likely foundation depth
vii) Safe bearing capacity
viii) Engineering properties of sub-soil
ix) Artisian conditions
x) Settlement characteristics
xi) Vertical clearances
xii) Horizontal clearance
xiii) Free board for approach road
xiv) Severity of environment with reference to corrosion (severe/moderate)
xv) Data pertaining to seismic and wind load
xvi) Availability of suitable construction material
xvii) Requirement of model study

Data for various types of a bridge structure, such as a river-bridge, a flyover, an underpass etc., need to be analysed within the framework of function of the structure.

The analysis of data should be relevant and exhaustive enough to be of adequate use in the development of design philosophy.

5.7.3. **Finalisation of design philosophy** : A design philosophy is arrived at based on the codal requirements for design, results of data analysis, special requirements specified by the client and current practices. The design philosophy should include following general principles to be followed in the design, such as, relevant methods of analysis and design, parameters of design, like design loads, flood levels, etc., special design requirements, namely traffic dispersal system, construction methodology etc., codes to be followed in the order of precedence, special literature.

While finalizing the design philosophy, aesthetic form and function of the bridge structure should be given due consideration. Appropriate durability criteria should be adopted for bridge structures. For bridges in marine environment, requirement for protection of reinforcement against corrosion should be considered.

(a) Additional consideration for aqueduct

It is possible that a site chosen for an aqueduct is also an ideal location for a highway bridge to cross the river. It is also possible that considerable savings in costs may be achieved where an aqueduct and a highway bridge are combined. In this case, it is quite likely that the approach roads of the highway may not follow the most preferred alignment.

Design philosophy for a combined structure should reflect the concerns and the needs for both the elements. Comprehensive design philosophy should detail out factors that are relevant to each element, viz. the aqueduct and bridge, and also those which are common to both. This entails concurrence of ideas of the various concerned departments such as the irrigation, bridges, highways, etc. The design philosophy should take cognizance of the relevant Codal provisions for aqueduct design and the IRC specifications, codes and special publications for highway bridges.

The factors which have to be worked during discussions among the concerned authorities, inter-alia, are : the alignment, the formation level, slopes, if any, of the structure, relative positions of the two elements, the structural system, loads, construction methodology and sequences.

(b) Additional considerations for subways and underpasses

Major factors to be given consideration in subway/underpass designs and construction are : (i) stability of the structure against uplift due to buoyancy as a whole and also during construction; (ii) water tightness of the structure to prevent seepage; (iii) drainage of the subway; (iv) construction aspects such as excavation, traffic diversion scheme etc.; (v) existing services and future provision, if required; (vi) ventilation consideration; (vii) lighting and other utilities.

The structure should be checked for overall stability against uplift, the calculations for such a determination depend upon the level of the water table assumed. The highest water table level is arrived from the study of data collected over a reasonably long period in the past at the proposed site. In the absence of such data, the maximum water table level may be set at a depth of 0.5 metre from the existing ground level. However, decision regarding the water table level shall be made on the basis of discussion among all concerned parties.

The methods to be adopted to overcome any uplift have to be indicated in the design philosophy. These methods generally fall into two major categories viz. those which increase the weight of the structure such as iron ore filling and those which anchor the structure such as providing ground anchors. When ground anchors are proposed, the suitability of the soil conditions have to be ascertained by additional tests, if necessary. When the weight of the structure is to be increased, the availability and economy of the heavier fill materials should be investigated. Artesian condition, if any, should be studied for finalisation of the foundation location and type of foundation.

Underground structures, e.g., subways are highly susceptible to water leakage and subsequent structural damage which reduces serviceability and durability of the structure. To ensure water tightness, the structure may be designed as uncracked, or more prudently, with limited crack widths. Crack widths may be limited to values acceptable to all the concerned parties, say 0.1 mm and the same may be achieved by limiting the strain in steel and by providing smaller diameter reinforcing bars at closer spacings etc. These details need to be agreed upon by all concerned parties. Additional water proofing may be needed and details of the procedures for the same need to be mentioned in the design philosophy. Alternatively use of water pressure release system may be resorted to where feasible and after discussions with owner.

Drainage of subways is an important consideration. Wherever possible, gravity led drainage should be given preference. However, gravity assisted drainage should be augmented where required by providing a sump-pump facility. This will entail the incorporation of facilities such as pumphouse etc. in the overall plan of the structure.

The design philosophy for subways and underpasses should include details of the excavation procedure to be arrived at after a detailed analysis of nature of the soil, economy, suitability of the scheme envisaged in construction, traffic diversion programmes, location of existing underground services etc. Special precautions which need to be taken during excavation, such as safety of neighbouring structures, movement of pedestrain and vehicular traffic etc. have to be mentioned in detail. Proposed methods of dewatering during construction is also a major aspect which should be dealt with-in the design philosophy.

Provision for ventilation in case of subways should be based on acceptable levels of pollution and should be detailed in the design philosophy, keeping in view comfort of the public.

Lighting of subways should also be detailed in the design philosophy. Glare-free lighting luminaire to achieve a lux level of 100 lux or as decided in consultation with concerned authorities, should preferably be adopted. Lighting levels in subways/underpasses should be critically examined under day light conditions to achieve acceptable gradient between the bright outside and the relatively dark inside. The design philosophy for electrical system should also indicate the type of wiring, provision of standby supply, etc.

The design philosophy, insofar it is developed at the feasibility report stage, should be agreed upon by all concerned parties before proceeding to the next phase.

5.7.4. **Approach alignment and siting of bridges** : Selection of various alternative alignments involve only preliminary engineering. These alternatives are usually based on subjective judgement. Care should be taken to see that alternatives are not sought for the sake of alternatives, i.e., the alternatives should be meaningful and sufficiently distinct from one another.

Preliminary investigation of siting and alignment alternatives are usually required for major bridges where different approach alignment, and economy of construction are influencing factors.

Alternatives may be grouped into two categories : (i) siting and approach-alignment alternatives, (ii) alternatives in the structural systems.

Identification of feasible alternative sites and approach alignments may be made with the aid of topographical maps, road project maps, field survey maps etc. as available. Factors affecting the choice of structural forms are enumerated in clause 5.7.7. herein

5.7.5. **Identification of feasible alternative alignment** : Preliminary bridge-site location and, along with it, alignment alternatives need to be decided upon at the start of feasibility study to enable planning relevant data collection efforts. At least some basic data in the form of broad topographic survey maps are needed at this stage. At various stages of project development, alternatives could be progressively shortlisted based on more data and its analysis keeping in view the influence of geometric requirements of road alignment. Guidelines for bridge alignment given in Pocket Book for Bridge Engineers published by IRC for Ministry of Shipping & Transport may be referred.

Review of alternatives may include field inspection as well as scrutiny of data.

For selection of alternatives, a decision matrix could be made as in the case of pre-feasibility study stage.

For minor bridges (upto a total length of 60 m), alignment of approaches takes precedence over the bridge site, whereas for a major bridge (with total length of over 300 m) the requirement of a good bridge site is given priority. For bridges, within these two extremes a choice shall be made on the relative merits between the two viz. bridge site and alignment of approaches. Final choice shall require discussions with the concerned authorities such as PWD, MOST, City Corporation and/or any other client before preparation of feasibility Report.

5.7.6. **Geometric design** : For every feasible site and alignment, a geometric design which includes vertical curves, horizontal curves, superelevation etc. need to be carried out.

5.7.7. **Span configuration** : Each site has its own unique conditions affecting the choice for the type of a bridge structure for optimum performance, economy and maintenance free design life service. Choice of a particular span arrangement and the type of structure depends upon several factors such as site characteristics, type of sub-soil strata, height and length of the bridge, design and construction aspects, availability of construction materials, construction technology and time-frame of construction etc.. In case of urban flyovers, the practical and economic viability of viaduct span vis-a-vis retaining walls for approaches may be examined without affecting the aesthetics and other requirements.

Design effort is an important parameter in selecting the span arrangement and so also is the availability of specialised centering and shuttering, launching equipment etc. These factors often dictate an alternative span arrangement to be adopted. Successful tenderer's suggestions regarding an alternative span arrangement are governed by the design and construction resources under his control. Such tender data from previous projects should be made use of in updating the feasibility analysis for the project at hand. This would greatly help in limiting the number of economically feasible alternatives.

The ranges of span length within which a particular type of superstructure can be economical alongwith other considerations like type of foundation etc. are given below :

Type of superstructure		Span length
(i) R.C.C. single or multiple boxes	-	1.5 to 15 m
(ii) Simply supported RCC slabs	-	3 to 10 m
(iii) Simply supported RCC T-Beam	-	10 to 25 m
(iv) Simply supported PSC girder bridges	-	25 to 45 m
(v) Simply supported RCC voided slabs	-	10 to 15 m
(vi) Continuous RCC voided slabs	-	10 to 20 m
(vii) Continuous PSC voided slabs	-	15 to 30 m
(viii) RCC box sections; simply supported/ balanced cantilever continuous	-	25 to 50 m
(ix) PSC Box sections, simply supported balanced cantilever	-	35 to 75 m
(x) PSC cantilever construction/continuous	-	75 to 150 m
(xi) Cable stayed bridges	-	200 to 500 m
(xii) Suspension bridges	-	500 m onwards

However, whenever an economical span arrangement and type of structure is decided, it has to be ensured that the required infrastructural facilities, design and construction capabilities, specialised materials etc. are available.

5.7.8. **Aesthetic considerations** : For aesthetics, attention should be focussed on producing a clean, simple, well proportioned structural form. In most cases, achieving the desired visual quality may add little to the overall cost of the structure. Aesthetic considerations should play an important part in minor bridges also. Bridge parapets, are the most visible parts and should harmonise with the surroundings.

Landscaping the site to achieve visual agreement between the structure and the environment should be considered especially in case of urban locations and grade separation structures.

5.7.9. **Preliminary design** : Preliminary designs should be carried out for all alternatives.

The design should provide the following: the approach road alignment, siting, geometric design: type, depth and preliminary design of foundations and substructures, type and preliminary design of the superstructure including bearings.

5.7.10. **General arrangement drawings** : Based on the preliminary design, General Arrangement Drawings should be produced for all alternatives. These drawings should be detailed enough in all respects so that a considered judgement of the relative merits of the various alternatives can be made.

5.7.11. **Preliminary cost estimates** : Preliminary cost estimates are prepared after the preliminary design for various alternatives has been completed. Such cost estimates are necessary for feasibility studies and project evaluation. Rates adopted for the cost estimates should be those as per schedule of rates based on MOST Data Book. For items not covered by Data Book, proper analysis of rates may be prepared.

5.7.12. **Initial environmental examination** : Initial environmental examination should be carried out for all alternatives. Construction of a large bridge may have an adverse impact on the environment. The most likely impacts are as under.

a) Increase in floodability
b) Likelihood of river bank erosion
c) Possibility of siltation
d) Relocation and rehabilitation of people/communities
e) Traffic and transportation effects on the surrounding areas
f) Effects on historic site/monuments
g) Likelihood of the bridge structure not harmonising with the surroundings.

Floodability can increase if the waterway is inadequate and the afflux is large. This may raise the level of water upstream in the nearby settlements.

The siting of the bridge and the waterway provided may change the course of the river and erode the river banks, affecting the land and settlements.

The level of the river bed may rise due to siltation that may be caused due to interference with the natural regime of the flow. Inadequate waterway too causes flooding and consequent deposition of silt on the agricultural land.

For major bridges, there is a distinct possibility of relocation of people communities. Efforts should be made to keep the impact of the bridge in this regard to a minimum. The proposed bridge might also attract or generate additional traffic affecting adversely the capacity of roads in the vicinity. The proposed bridge may also adversely affect the quality and nature of historic sites/monuments. Aspects of such environmental impacts of the proposed bridge need to be studied in detail.

In addition, approaches to a major bridge may traverse through forest land, unstable hill faces, natural lakes, historical landmarks or architectural/archaeological relics. The Archaeological Survey of India and the State Archaeological Departments should be consulted. The department of culture will be able to throw light on the historical resources.

When bridges and their approaches are to be constructed adjacent to inhabited areas, the vibration, noise and dust caused by construction activity will adversely affect the environment. Necessary mitigatory measures will need to be undertaken to safeguard the interests of the surrounding environment.

5.8. Economic Evaluation

5.8.1. **General principles** : Though the construction of a bridge brings about a variety of benefits enjoyed by practically all sectors of the economy, the prevailing conditions of resource scarcity necessitates an economic evaluation of projects so that only worthwhile projects are taken up for implementation. The Indian Roads Congress Special Publication No. 30 (Manual on Economic Evaluation of Highway Projects) contains detailed procedure for economic evaluation and may be referred to for guidance.

While for very large bridge project a separate economic evaluation is necessary, smaller projects are usually included as part of the overall highway projects for economic analysis.

Economic evaluation exercise for large bridge projects should include approaches as a part of the project. The cost and benefits of both bridge and its approaches are to be considered together.

5.8.2. **Period of analysis** : A bridge has a long design life of many years (say in the range of 50-100 years). But it is not necessary to carry out economic evaluation for such a long period because of difficulties of forecasting and because of the insignificant contribution of discounted future benefits. It is customary to cover a period of 15-30 years after throwing open the facility to traffic.

5.8.3. **Traffic projection** : Three types of traffic are to be considered :

1. Normal traffic, which includes the present traffic growing at a projected rate.
2. Diverted traffic, i.e. the traffic which would get diverted to the new facility after its construction.
3. Generated traffic, the traffic that gets generated or induced because of the new improved facility.

The rate of growth of traffic is estimated on the basis of (i) past trends with suitable modifications to account for the future, and (ii) economic models which establish the elasticity of traffic with respect to economic indicators such as GNP, growth in population, agricultural and industrial outputs.

5.8.4. **Project cost and scheduling** : Cost of the project is split into yearly cost inputs over the expected period of completion. The cost of maintaining the structure over the period of analysis is also considered. Since economic costs, exclusive of taxes and subsidies are to be considered, they should be worked out after studying the tax element in the various items of work. As an approximation, the economic cost can be taken to be 80-85 per cent of the financial cost.

5.8.5. **Project benefits** : The benefits from the construction of a bridge fall under the following heads :

a) Savings in vehicle operating costs due to reduced travel distance and/or superior road conditions;

b) Savings due to value of reduction in time of travel of passengers and commodities in transit;

c) Savings due to reduction in accident costs;

d) Expected increase in agricultural, industrial or mining output.

Travel time savings of passengers are not generally considered in highway project evaluation in India. However, if the project results in very substantial travel time savings, the EIRR may be presented with and without travel time savings, e.g. in the case of an urban route.

The VOC elements may be taken from the IRC Special Publication No. 30.

5.8.6. **Sensitivity analysis** : The estimation of project costs and benefits is dependent on various factors which may vary from the assumptions made at the time of project formulation. In order to assess how sensitive the economic evaluation is to uncertainties, a sensitivity analysis is carried out. Normally, three cases are considered :

i) Base benefits reduced by 15 per cent
ii) Base cost increased by 15 per cent
iii) Base (i) and (ii) above together.

5.8.7. **Economically/Financially low return projects** : In some projects, particularly for subways, underpasses, flyover etc. adequate economic/financial return may not be associated. These are needed from the considerations of special benefits under compelling circumstances.

5.9. Feasibility Study Report

Feasibility Study of a project should be carried out and a report prepared to cover the following aspects wherever relevant and applicable. These are for general guidance only and any other relevant subject shall be studied and suitably incorporated in the report.

a) **Socio-economic profile of the State :**

Population, state income, land use, economic sector (agriculture, forestry, fishery, industry, etc. as relevant), prevalent transport services.

b) **Socio-economic Profile of the Project Influence Area :**

Role of similar other facilities in the vicinity, delineation of the influence area, demographic characteristics, influence area economy (district income, per capital income), economic sector, transport profile.

c) **Study Methodology**

Reconnaissance survey, preliminary data collection, alternative alignments study report, further data collection, model study, traffic layout plan. Preliminary design and cost estimate, environmental impact assessment, economic viability appraisal and sensitivity analysis.

d) **Traffic Survey and Analysis**

Surveys and studies undertaken, classified directional volume count. Origin-Destination (O-D) survey, speed and delay surveys, pavement roughness survey, axle load survey, past traffic data, assignment of project traffic, diverted traffic, base year traffic, average annual daily traffic, traffic growth forecast.

e) **Project Description**

Project alignment, project elements geometric design, land acquisition, various components/parts of the project (such as main bridge, viaduct service road etc.), area drawings scheme, obligatory improvements, design standards, preliminary design drawings and cost estimates, construction programme, equipment and foreign exchange requirements.

f) **Preliminary Design**

(i) Project corridor inventory - Existing bridge and culvert inventory and condition, inventory of existing river bank protection etc. as applicable.
(ii) Engineering survey and investigation - Topographic survey, hydrological survey, soil investigation, etc.
(iii) Survey for environmental impact assessment study - Ambient air quality monitoring, water quality monitoring, noise monitoring, etc.
(iv) Design standards and specification-Geometric design standards, standards for design of various components of project, specifications, etc.
(v) Bridge and pavement design - Design alternatives and construction methodology, standards for design of various components of project such as main bridge, approach viaduct etc. embankment design, pavement design, etc.

(g) Project Cost Estimate

Basis of cost estimate, basic cost of materials, bill of quantities and cost estimates, land acquisition cost, abstract of cost estimate.

(h) Economic Evaluation

Economic analysis, project cost and scheduling, project benefits. Vehicle Operating Cost (VOC), savings, time savings, economic cost of vehicle hold-up, economic cost and productivity, cost benefit analysis, sensitivity analysis.

(i) Initial Environmental Examination for alternatives

(j) Conclusion and Recommendation

5.10. Acceptance of Feasibility Study Report

The feasibility study report is generally required to be presented in draft form called draft Feasibility Study Report to the employer for their comments. After receipt of comments of the employer, the feasibility study report is finalised duly incorporating the comments of the employer. After submission of final feasibility study report, the employer is required to take decision about final bridge site, approach alignment, design parameters including type of bridge and span arrangement.

6. PREPARATION OF DETAILED PROJECT REPORT

6.1. Detailed Investigation

Upon finalisation of alignment and bridge site, detailed investigations are carried out with respect to topographic survey, subsoil investigations and environmental impact assessment. Model study (if required) has to be carried out immediately after acceptance of approach alignment and bridge site.

6.1.1. **Final location survey** : The purpose of final location survey is to lay out final centre line of the road in field based on the alignment selected in the design office and to collect necessary data for preparation of working drawings. The completeness and accuracy of the project drawings and estimate of quantities depends a great deal on the precision with which this survey is carried out. As far as possible, for survey of major bridges, modern survey equipment such as total station should be used.

On finalisation of bridge alignment, the same is to be set-out on site on the basis of actual geometry. The initial topographical survey is required to be updated on the basis of actual setting out at site. Such a detailed survey is more important where there is a substantial time gap between execution of topographical survey at preliminary investigation stage and settlement of the alignment.

6.1.2. **Sub-soil investigation** : On finalisation of layout, it is necessary to carry out a detailed sub-soil investigation based on the actual layout. It is at this stage that the requirement of various tests to be conducted as well as their location at site becomes evident. At least one bore hole on each foundation location should be made in case of major bridges. When founding strata is rock, the number of bore holes may be suitably increased depending upon the dip of rocky strata. The number of bore holes in case of minor bridges may be decided in consultation with the employer. The tests should provide adequate information required to carry out engineering design. Sub-soil investigation should be carried out as per IRC:78 and relevant IS Codes or as decided by the concerned departments. Before the final investigation is taken up, it is necessary to review the extent of usefulness and reliability of the data obtained from preliminary investigations. No further investigations are required in case preliminary investigations provide adequate information/data to carry out detailed engineering design.

6.1.3. **Environmental impact assessment** : Environmental Impact Assessment on the selected alignment should be carried out as per the guidelines of Ministry of Environment & Forests. The mitigation measures of adverse impact should be outlined by an Environmental Management Plan.

6.2. Detailed Design

After detailed investigations have been completed, detailed design is taken up and has to be carried out for various components of the crossing as per the design philosophy developed and finalised at feasibility stage. Based on detailed design, working drawings are required to be prepared. Constructability of structure has to be considered in the design stage. Special care may be taken to examine easy concreting of structure by avoiding congestion of reinforcement and proper dimensioning.

6.2.1. **Superstructure** : The detailed design of superstructure is to be carried out using the most appropriate methods. Computer aided methods of analysis may be used but care should be taken in the modelling of the structure and interpretation of the results. Results so obtained should preferably be checked by other simpler methods wherever relevant.

For specialised structures such as cable-stayed or suspension bridges, dynamic analysis is required. Wind tunnel testing may also be required in certain cases.

6.2.2. **Bearings, expansion joints, railing, wearing coat and appurtenances** : The type of bearings is dependent on the structural system for the superstructure and the support conditions. The detailed design of bearing is carried out depending upon the type of superstructure, support condition and bearing type. Details of expansion joints, railing, wearing coat and other appurtenances should also be given.

6.2.3. **Substructure** : The detailed design of substructure will be carried out in accordance with the hydraulic and structural requirement. In addition, as the substructure is one of the two visible parts of the crossing. Its aesthetics require special consideration.

6.2.4. **Foundations** : The type and size of foundations depends on the soil conditions and river flow pattern as determined from the investigations. The detailed design should be carried out following the guidelines given in the design philosophy.

6.2.5. **Approaches, river protection, river training works, etc.**: Detailed drawings of approaches, river protection and training works (where provided) should also be given.

6.2.6. **Software application** : For speedy and accurate analysis/ design, 'computer aided design' methods are often resorted to. Where standard proven softwares are used, with approval of the client, the design may be carried out straight away giving a brief of the software adopted, alongwith input data and output. If designers' own programmes are used, their validity should be proved to the satisfaction of the client giving the logic adopted and comparing the results obtained with long hand method for few typical cases.

6.3. Detailed Cost Estimates

6.3.1. **Cost estimates and its content** : The detailed cost estimate of the project should give a clear picture of the financial commitments involved and should be complete in all respects. It should give a realistic idea of the cost involved. This is possible only if all the items of work are carefully listed, the quantities are determined to a reasonable degree of accuracy and the rates are provided on a realistic basis.

The estimate should have the following components presented in a logical sequence :

1. General Abstract of Cost under Major Heads
2. Details of Cost for Each Major Head
3. Details of Quantities
4. Justification for Rates
5. Quarry/Material Source Charts
6. Foreign Exchange Component
7. Tools and Plants

6.3.2. **General abstract of cost** : The General Abstract of cost should be one-page summary of estimated cost under each major head. Considering that a bridge project invariably involves its approaches, the following major heads are suggested:

1. Site clearance
2. Earthwork
3. Shoulder, sub-base and base course
4. Bituminous/cement concrete courses

5. a) Bridges
   i) Superstructure
   ii) Substructure
   b) Culverts
6. Road Junctions
7. Drainage and protection works
8. Miscellaneous items including cost of traffic diversion during construction and cost for mitigation measures for environment protection.
9. Land Acquisition including rehabilitation/resettlement of project affected persons.

Provision should be made for contingencies, work-charged establishment costs, quality control and supervision charges.

Contingencies are intended to cover minor variations in quantities and rates. The normal practice is to provide 3-5 per cent contingencies.

Work-charged establishment costs are intended to cover the wages of casual staff employed in connection with execution of the work. The normal practice is to provide 1.5 - 2 per cent.

Quantity of following items should be given in the report for working out factors for escalation formula :

i) Cement
ii) Reinforced steel
iii) Prestressing steel (high tensile steel)
iv) Bitumen
v) Coarse Aggregate
vi) Fine Aggregate

Provision for quality control is made separately. The provision should cover the cost of field and central laboratory and the testing charges. In modern contracts, it is usual to specify that all quality control tests are made by the contractor at his cost, and the rates are expected to reflect this. In that case, it may be more appropriate to include this item in the Analysis of Rate of individual item of work.

Project Management charges are intended to cover the cost of office establishment and that of the supervisory staff For National Highway works which are executed by the State Public Works Department, Agency Charges at 9 per cent are currently paid by the Central Government to cover the supervision charges incurred by the States. If the supervision is to be done by the Indian Consultants, Foreign Consultants or a combination of these and the Public Works Department, the supervision charges should be estimated accordingly.

The addition of centage charges should follow a logical pattern. The format given in clause 6.3.3 is recommended.

6.3.3. **Details of cost of each major head** : Items that are involved under each of the major heads of work are to be listed, the quantities and rates entered against each and the cost derived and entered.

In order to ensure that no items are missed, it is desirable that each department prepares its own standard list of items based on M.O.S.T. data book and specifications, This standard list can be used for all estimates, marking 'nil' entries against those that are not needed for a particular project.

General Abstract of Cost

1.	Site Clearance	
2.	Earthwork	
3.	Shoulder, sub-base and base courses	
4.	Bituminous/cement concrete courses	
5.	Culverts and Bridges	
6.	Road Junctions	
7.	Drainage and protection works	
8.	Miscellaneous items	
	Total 1-8	--------------------
9.	Contingencies @------- per cent of items 1-8	
	Total 1-9	--------------------
10.	Work-changed Establishment @-------- per cent of items 1-9.	
11.	Quality Control @-------- per cent of (items 2-8 including-------- per cent contingencies thereof)	
	Total 1-11	--------------------
12.	Supervision charges @-------- per cent of items 1-11	
	Total 1-12	------------------
13.	Land Acquisition i.e. rehabilitation and re-settlement	--------------------
	Grand Total =	

6.3.4. **Details of quantities** : The quantities entered in the cost estimate are to be well supported by detailed calculations. It should be possible for anybody to check the calculations independently.

6.3.5. **Justification of rates** : The rates adopted must be realistic and should reflect truly the cost likely to be incurred in carrying out the work as per the specifications stipulated.

Most of the State Public Works Departments have Basic Schedule of Rates for different Districts/Zones in the state and they are regularly updated. If the Basic Schedule of Rates is valid for the year in which the estimate is prepared, and it reflects the Specifications truly, the rates can be adopted. Otherwise, the rates have to be analysed. The Report should contain the analysis which should account for all items of cost, over heads and profit on realistic basis.

The quarry and material source charts should accompany the analysis of rates.

6.3.6. **Foreign exchange component** : Where a work involves the use of foreign exchange, the estimates should give details of this component. It should comprise material and equipment costs and personnel costs.

6.4. Specifications

The Detailed Project Report should clearly make a reference to the Specifications which is intended to govern the work. These could be the State Public Works Department Specifications or the Ministry of Surface Transport Specifications.

6.5. Special Specifications

If the Standard Specifications does not fully cover the scope of certain items of work in the project, it is necessary to mention broadly the additions and alterations that would be made to the Specifications. Any special item not covered by the clauses in the Specifications may have to be governed by special clauses issued by the Ministry of Surface Transport or the State Public Works Departments. If the Specifications are to be borrowed from A.S.T.M. or other foreign bodies or Bureau of Indian Standards or the Indian Roads Congress, mention should be made accordingly.

6.6. Preparation of Detailed Drawings

6.6.1. **General** : The drawings for a bridge project should depict the proposed works in relation to the existing features, besides other information necessary for accurate transformation of the proposals in the field. For easy understanding and interpretation, it is desirable that the drawings should follow a uniform practice with regard to size, scales and details to be incorporated.

6.6.2. **Drawings sizes** : Drawings should be of adequate size to accommodate a reasonable length of the approach road, the bridge site, or a structural unit in full detail. At the same time, these should not be inconveniently large necessitating several folds. It is recommended that the size may be 594 x 420 mm, corresponding to the size A2 of IS : 696-1960. A margin of 40 mm may be kept on the left hand side of the drawing for stitching into a folio. For making drawing folder A-3 size after reducing the original tracing in A-2 size may be used for convenience of handling.

6.6.3. **Component parts of bridge project drawings** : The drawing required for a bridge project include the following:

i) Index Map

The index map should show the exact location of the bridge on the roads on which it falls, and should show details of the immediate neighbourhood covering important physical features like rivers, lakes, railway lines, other roads etc. and should show about 20-25 km of the road on which the bridge falls with the kilometerage marked.

ii) Contour Plan

A contour survey plan of the stream and its neighbourhood showing all topographical features for a sufficient distance on either side of the site should be given. It should give clear indication of the features that would influence the location and designs of the bridge; its protective works and its approaches. All the sites under consideration should be indicated on this plan.

iii) Site Plan

A site plan should be given to a suitable scale showing details of the site selected and the details of the stream upto a distance of at least 100 meters on upstream and downstream of the proposed bridge site and covering the approaches to a sufficient distance, which in the case of a large bridge should not be less than 500 meters on either side of the channel. The plan should include the following :

a) Name of the stream and road;
b) Approximate outlines of the banks and channels of HFL and LWL;
c) Direction of flow of water at maximum discharges, and if possible, the extent of deviation at lower discharges;
d) The alignment of the proposed and existing approaches, if any, to the bridge site;
e) The angle and direction of skew, if any;
f) The names of the nearest inhabited localities at either end of the crossing on the roads leading to the site;
g) The location and R.L. of the Bench Mark used as datums :
h) The location of traverse survey points to facilitate the alignment of the bridge during construction;
i) Location of the L.S. and C.S. of road and stream taken within the area of the plan;
j) Location of trial pit and boring with their identification numbers; and
k) Location of all nallahs, temples, buildings, wells, rock outcrops and other features which may affect siting of the bridge and alignment of the approaches.

iv) Catchment Area Map

The catchment area map for the river at the proposed site should be prepared by tracing the ridge line of the watershed from topographic Survey of India Maps to a scale of 1/50,000. The area may be measured and indicated.

v) Longitudinal Section of the Stream

A longitudinal section of the stream should be provided, showing the proposed site, HFL, OFL, LWL and bed levels at suitably placed intervals along the approximate centre line of the deep water channel. The horizontal scale should be the same as for the site plan and the vertical scale should not be less than 1/1000.

vi) Cross-Section

A cross-section of the river at the proposed bridge site should be furnished to a scale of 1/1000 horizontally and 1/100 vertically giving the following information :

a) Name of the river, road and chainages;
b) The river bed levels upto the top of the banks and ground levels to a sufficient distance beyond the edge of the channel;
c) Nature of sub-soil in bed, bank, approaches and location of trial bores;
d) LWL, OFL, and HFL; and
e) Low and high tide levels in case of tidal rivers.

Additional cross-sections of the streams at suitable distances both upstream and downstream of the proposed site along the stream should be supplied. For smaller streams, two additional cross-sections, one upstream and one downstream may be sufficient. But for larger rivers, at least two cross sections on the upstream and two cross-sections on the downstream should be supplied. These cross-section should also show the details mentioned earlier for the cross-section at the bridge site.

vii) Bore Log Data

The bore log data should be supplied, showing the location of bore holes and the R.L. of the top of bore hole. The strata encountered at various levels should be indicated therein.

viii) Drawings of the Bridge

The following drawings should be supplied :

a) General Arrangement Drawing, containing the cross sectional view of the stream and the bridge, the plan of the bridge and the cross section of the bridge at right angles to the direction of traffic. The scale should be approximately selected so that the full bridge arrangement can be accommodated in one sheet.
b) Details of substructure and foundations drawn to a suitable scale.
c) Superstructure details drawn to a suitable scale.
d) Details of protective works drawn to a suitable scale.
e) Drawings of miscellaneous items like bearings, expansion joints, wearing coat, railing, approach slab etc.
f) Details of the existing bridge, if any.

6.7. Detailed Project Report

6.7.1. **General** : The Detailed Project Report is the final stage in project preparation. The report must be comprehensive, cogent and contain all basic information relevant to the project.

6.7.2. **Contents of the report** : The report should contain the following items in the year in which they appear

1. Introduction
2. Site selection
3. Topographical survey
4. Hydraulic data and waterway fixation
5. Environmental Impact Assessment
6. a) Design of bridge elements
   b) Design of protective works
7. Materials and Resources
8. Estimate
9. Construction arrangement
10. Drawings
11. Economic Viability Analysis
12. Quality Assurance System
13. Maintenance Manual (where required)

6.7.3. **Introduction to the report** : The introduction to the Report should give a complete picture of the project and should include the following information :

i) Reference to the authority calling for the Project Report.
ii) Bridge location, road (NH, SH or any other category of road along with the designated number), road kilometerage, and name of the river.
iii) Existing condition - A brief description of the existing mode of crossing; details of existing bridge, if any, with load carrying capacity; road width; type of foundations; substructure and superstructure; general condition of the structure and an appraisal of the existing alignment and whether it needs any improvement/change.
iv) The need for a new bridge, supported by existing and projected traffic data and any other justification.

6.7.4. **Site selection** : Various alternative sites considered should be discussed critically with their merits and demerits and finally details of selected alignment be included. Reference should be given to the authority approving the site, and site inspections if any, carried out by the approving authority.

6.7.5. **Topographical survey** : Details of the topographic surveys carried out, and reference to the Bench mark used for conducting the survey should be given.

6.7.6. **Hydraulic data and waterway fixation** : The hydraulic data collected should be given. These include :

i) Catchment area and nature of catchment
ii) Rainfall intensity
iii) River bed slope and LWC slope
iv) LWL (LTL in case of tidal river)
v) HFL (HTL in case of tidal river)
vi) Cross-sectional area of the stream

The hydraulic calculations in support of the design discharge and waterway should be given. These shall include :

i) Discharge by various methods, and the justification for selection of constants in different formulae
ii) Design discharge adopted with justification
iii) Waterway required for different considerations and waterway adopted.
iv) Scour calculations and the determination of foundation depth.

6.7.7. **Design of bridge elements** :

i) Design of foundation elements :

In case of well foundation, well diameter, steining thickness, curb details, cutting edge details, bottom plug, sand filling, top plug, well cap, curtain walls, floor protection works etc. should be given.

In case of pile foundation, type of pile (precast, cast in situ), bored or driven, material of pile, pile length, pile diameter, pile cap, pile cut-off level, nature of stratum, pile capacity, pile test requirement etc. should be given.

ii) Design of substructure elements like pier, abutment, wing walls, pier cap, abutment cap, pedestals etc.
iii) Design of superstructure

iv) Design of bearings
v) Design of approach slab
vi) Wearing coat
vii) Railings
viii) Expansion Joints
ix) Design of protective works like guide bund, bank pitching, and details of any model studies carried out.
x) Design of high approach embankment in the approaches
xi) Design of horizontal and vertical alignment of the approaches
xii) Design of pavement in the approaches

Reference to Codes and Design Criteria adopted and to Standard Drawings adopted should be given.

6.7.8. **Materials and resources** : The list and quantities of construction materials like cement, steel, high tensile steel, deformed bars, boulders, coarse aggregate, sand, bricks etc. required for the project should be given and their sources of supply indicated. Sources of water for mixing and curing concrete and its suitability on the basis of tests conducted should be mentioned. Leads involved for materials should be indicated.

6.7.9. **Specifications** : Specifications adopted for the work and any special specifications that have been adopted should be discussed.

6.7.10. **Estimate** : The estimate to be prepared should be based on the detailed drawing, corresponding bill of quantities and work specification.

The estimate for the project should comprise :

i) General Abstract of Cost
ii) Abstract of cost for each major head
iii) Details of quantities
iv) Rates adopted and analysis of rates
v) Foreign Exchange component, if any;

6.7.11. **Construction programme** : The arrangement for construction should be discussed here, whether it is through departmental agency or through contract.

It is desirable that a tentative list of equipment with type and number required to be deployed in the project is indicated. The CPM

Chart for the project should be based on the suggested list of equipment as mentioned above. In addition to the CPM Chart, bar chart should also be prepared to highlight the broad activities alongwith their targets.

If through contract, the Report should briefly give the procedure of pre-qualification of tenderers. It should mention whether the tenders will be through Local Competitive bidding or International Competitive bidding.

6.7.12. **Working drawings** : The report should list out the drawings prepared for the project. The drawings should be in a separate folio.

6.7.13. **Economic analysis** : The economic analysis carried out during the feasibility stage may be revised based on detailed estimated cost of the project and revised rate of return worked out are given.

6.7.14. **Financial forecast and budget provision** : Detailed Project Report should clearly indicate the financial forecast and budget provision for the project.

6.7.15. **Environment impact assessment** : Details of EIA and mitigating efforts should be given in the report.

6.8. Quality Assurance System

For laying quality assurance system the Guidelines on 'Quality System for Road Bridges (Plain, Reinforced Prestressed & Composite Concrete)' brought out by the Indian Roads Congress may be followed.

6.9. Maintenance Manual

Maintenance manual should be prepared with an aim of upkeeping of various components of the project in sound condition throughout the life of the structure. Maintenance manual should contain technical data and details of various components of the project. The manual should incorporate the salient features of the project including details of superstructure, substructure, foundations, loading, temperature provision, soil parameters etc. considered in the design.

The manual should indicate detailed inspection requirements including status and qualification of inspection officer, requirement of routine inspection, intensive and detailed inspection, requirement of special inspection, if any. It should highlight the procedure to be adopted for inspection including any pre-requisite for inspection activities (such as familiarity with the structure, etc.), inspection sequence, methods of inspection, cleaning, remedy, repair or replacement (partial or total) of various components of the project including bearings, expansion joints, wearing course etc.

As-built drawings of the project should form a part of the maintenance manual. The contractor of the project should be responsible for the preparation of the maintenance manual.

6.10. Executive Summary

A concise summary in the form of 'Executive Summary' with key diagrams and figures should be prepared for distribution among the key decision makers, financiers etc. Executive summary should highlight the input parameters, findings, decisions etc. for ready reference. This may incorporate site appreciation, surveys and investigations involved, design and planning aspects, service systems, phasing of projects and provision for future expansion, alternative proposals considered, cost estimate and recommendations.