



**GOVT. OF RAJASTHAN**

**RAJASTHAN URBAN INFRASTRUCTURE  
DEVELOPMENT PROJECT**

HAND BOOK FOR  
BRIDGE WORKS

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# 1. INTRODUCTION

A bridge project from its conception to completion involves various stages of planning, design, approval/sanction, tendering and execution. Also inspections, maintenance and repairs are continuing activities for enhancing the service life of the structure. This pocket book has been specifically aimed at giving the practicing engineers the basic information on these aspects.

A bridge project from conception to construction and final completion of the bridge involves a number of major activities which can be summarized as follows:-

**Start** - administrative decision for constructing a bridge.

## **Feasibility studies**

**Preliminary Project preparation** – site selection, Preliminary survey and investigation including hydraulic survey, subsoil investigation, fixation of span arrangements and selection of type of structure. Preliminary design of various components of bridge, preliminary cost estimates.

**Detailed project preparation** – detailed survey, hydraulic design, subsurface investigation, detailed structural designs, detailed estimate and detailed project report.

**Technical approval and financial sanction** –

**Decision to take up work from plan funds or to invite private entrepreneurs.**

**Approval of Tenders and Revised cost if necessary and start of construction work**

**Construction** – Project scheduling and monitoring of quantity and progress of work.

## **Inspection and maintenance of bridges**

**Note:** Bridges are usually designed for at least 50 years life and should cater to the projected traffic demands. Utmost care should be exercised in site investigations by following the procedures outlined in the subsequent chapters ensuring only preparation of thoroughly investigated projects which will ultimately facilitate speedy construction and maintenance costs.

# 2. PROJECT PREPARATION

Preparation of a detailed project report is a pre-requisite for proper evaluation of the project, its approval by competent authority and finally its execution. Properly prepared project report is very helpful in ensuring timely completion of project thereby ensuring fullest advantage of the project avoiding time and cost overruns. Project preparation activity can be divided into the following three broad stages:-

(1) Feasibility Study

(2) Preliminary Project Report

(3) Detailed Project Report

For detailed guidelines reference may be made to Special Publication No.54-“Project Preparation Manual for Bridges” published by Indian Congress.

## ***2.1. Feasibility Study***

2.1.1. The project preparation for a bridge work starts with the identification of the project. This phase is known as the pre feasibility stage. For this stage, 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 of the project on the traffic scenario in immediate vicinity is also considered. This reconnaissance visit to the area of the intended site is sufficient at this stage.

2.1.2. In the feasibility stage, preliminary surveys, data collection and investigations are carried out. Alternative site are investigated, design and rough cost estimates for various alternatives are made. The feasibility report covering the recommended alignment including alternative considered, span arrangement, preliminary cost estimates, economic and financial viability is prepare. Feasibility study should also cover the following aspects.

- i. the main purpose of the bridge project i.e. the trunk route, economic or interstate importance, access to ports, tourism, agriculture development etc. the place of the project in the road development programme and the priority assigned to.
- ii. The geographic features of the area such as size, economic (industrial and agricultural), other traffic generated activates in the area, main population centers, their size projections and growth rates, and government’s economic programme for the developments.
- iii. Measurable and non measurable benefits should be listed. The former may consider reduction in operation costs, reduction in travel time for goods and passengers, reduction in maintenance cost in case a old bridge is replaced. The latter may include social and economic development of the adjacent area consequent to the construction of the bridge.
- iv. A cost benefit analysis should be enclosed and results critically discussed. For calculation of cost benefit analysis, a reference may be made to IRC SP -30: 1993. “Manual on Economic Evaluation of Highway Projects in India (First Revision)”

## ***2.2 Preliminary Project Preparation***

Preliminary project preparation involves various stages like recognition of the need, study of maps, reconnaissance survey leading to selection of alternative site, preliminary survey and investigation including subsoil investigation and collection of hydraulic data leading to final site selection and all these activities has to be systematically planned and carried out in their logical sequence.

### 2.2.1. Bridge sitting and road alignment:

The considerations which decide the inter se priority between a suitable bridge site and suitable road alignment will be guided by the following principles: -

- (i) The location of a bridge upto a length of 60 meter shall be governed by the suitability of alignment of the road unless there are some special problems at the crossing with regard to design / maintenance of the bridge.
- (ii) For bridges having a length between 60 and 300 meters both suitability of site of the bridge that of the alignment of the approaches shall be considered together.
- (iii) For bridges having total length more than 300 meters, there requirement of good site for the bridge shall have the precedence and the alignment of the approaches will have to confirm to the selected bridge site.
- (iv) Where existing two lane highway is proposed to be widened to four lane width, the location of the additional tow lane bridge shall be governed by factors mention in para 2.2.3.1 (ix) below

### 2.2.2 Reconnaissance survey:

In case of an entirely new alignment. The site selection may have to start with the study of available maps before starting the reconnaissance. Usually, topo sheet in the scales 1:2,50,000 and 1: 50, 000 are available for the Survey of India. In case of bridges upto 300 m length, two or three possible road alignment should be marked on the topo sheets considering the topography of the land, land use, soil type, waste bodies, marshes, control points, river profile, straightness of the reach, width of crossing, presence of high banks etc. the two or three possible alignments may have to be considered for reconnaissance. Some landmarks for easy identification during reconnaissance may also have to be marked on topo sheets.

### 2.2.3 Factors deciding site selection.

**2.2.3.1** Adequate efforts made in selection of good site for locating a bridge will be amply rewarded in the form of reduced cost of the project and trouble free performance of the bridge. The factors that have to be considered in the selection of a site are indicated below. Though it may not be feasible to satisfy all desirable attributes simultaneously, the selected site should represent the most desirable mix of the attributes consistent with overall economy, including the cost of approaches.

- (i) **Permanency of the channel:** it has to be ascertained from different maps prepared over a long period of time that the river does not have any tendency to meander at the proposed site.
- (ii) **Presence of high and stable banks:** the presence of high and stable bank generally offers an ideal site, which reduces the cost of approach embankments and their protection work.
- (iii) **Narrowness of the channel and large average depth compared to maximum depth:** this ensure large average depth

of flow compared to maximum depth of flow and reduced water way which greatly reduces the overall cost of the bridge structure.

- (iv) **Straight reach of the river u/s and d/s of the proposed site:** straightness of the reach both u/s and d/s ensures uniform distribution of discharge/velocity. Curvature in the stream especially on the u/s leads to obliquity and concentration of the flow on the convex side leading to higher scour, and consequent cost of foundation and protection works. If the bank on the convex side is erodible it may lead to heavy recurring expenditure in protecting the abutment and the embankment on that side.
- (v) **Freedom from islands or any form of obstruction both u/s and d/s** any shoal formation disturbs flow characteristics. Gradual silting of one or more channels results in increased concentration of flow in other channels leading to higher scour or bank erosion, channels leading to higher scour or bank erosion, outflanking of the bridge etc. the site should also be away from confluence of tributaries where turbulence and obliquity of flow can be expected which results in higher unpredictable scour and water current forces on substructure.
- (vi) **Possibility of right angled crossings:** Right angled crossing offer minimum possible bridge length and reduces chances of obliquity of flow with respect to the substructure.
- (vii) It is preferable to site the bridge on u/s of the existing cause way, if any.
- (viii) **Possibility of good approach alignment:** curves except gentle ones are preferable to be avoided on approaches and bridge proper form visibility and safety considerations.
- (ix) Where existing two lane highway is proposed to be widened to four lane width, the additional tow lane bridge shall be sited as close to existing bridge as possible. However, in case of bridges having well foundations, distance sufficient for generation of passive resistance of soil shall be provided.

Some typical example of satisfactory and unsatisfactory sitting of bridge is indicated in fig. 2.2.1 in pocket book for bridge engineers.

**2.2.3.2 Sitting of grade separators:** Sitting of bridges which act as rail/road grade separators will be largely decided by good alignment of the approaches, availability of land and other constraints imposed by rail lines, services etc. at skew crossings, skew of more than 45 should generally be avoided.

**2.2.3.3 Distance between rail and road bridges:** the distance between rail and Road Bridge should be as large as possible but not less than 400 m in any case.

## **2.2.4 Preliminary survey, subsoil investigations and hydraulic survey:**

Once the possible alternative sites are selected on the basis of reconnaissance survey and the criteria for site selection enumerated in para 2.2.3 above, the next step is to conduct the preliminary survey, subsoil **investigations and hydraulic survey at each of the alternative sites:**

### **2.2.4.1 Preliminary Survey:**

The data to be collected during the preliminary survey are:-

- (i) The names of the states, district, nearest town/village, and river across which the bridge is proposed.
- (ii) The chainage of the highway, location of nearest GTS bench mark with level, and latitude and longitude of the site as measured from the survey of India maps.
- (iii) Details of the existing bridges or causeways on the same river in the vicinity which should include:-
  - description with sketches showing relevant dimensions.
  - length and depth of submergence, number and sizes of vents, and frequency (including duration) of interruptions to traffic in case of causeways.
  - Number and length of spans, clear waterway, adequacy or otherwise of waterway with special reference to silted up spans or signs of undue scour or attacks on abutments" and approaches in case of bridges.
- (iv) An index map of the site on a scale of 150000 indicating the name and chainage of the highway. The name of the river, name of the nearest town/village marking of the alternative sites, location of the nearest GTS benchmark if possible, name of district and state, direction of flow, nature of land-use, general topography of the area and north line.
- (v) Site plans of the bridge for the alternative sites indicating the north line, alignment of the road and the river, the angle of crossing, water spread at LWL'HFL. Chainage of the proposed bridge at crossing of the river, the direction of flow at maximum discharge, private land boundaries, services, location of deep channels, ponds, places of worship, graveyards, if any, near to the proposed site. Location and reduced level of the temporary bench mark used as datum, location of the L.S. and C.S. of the road and the stream taken within the area of the plan, location of trial pits/borings with their identification number and location of nallahs wells, buildings, rock out crops etc. which may affect the approach alignments.

### **2.2.4.2. Hydraulic Survey:**

Hydraulic data collected for the purpose of the preliminary project report (PPR) has to be good enough for the detailed engineering also. No separate hydraulic data collection is envisaged for detailed engineering except that for



model studies, if any, conducted for bridges across major rivers. The hydraulic data collected at PPR stage should include:-

- (i) A catchments area map on a scale of 1:50,000 indicating the drainage channels and the land-use pattern including built up areas, barren land, cultivated land, forests, hilly areas etc. and its area in square kilometers. For preparation of the catchment area GTS maps of largest available scale may also be referred for tracing the ridge line.
- (ii) HFL ascertained from watermarks, if any, on the permanent objects on the banks supplemented by local enquiry from nearby inhabitant as to the highest flood levels reached during their living memory'.
- (iii) Information about velocity of flow and presence of floating debris etc. from local enquiry. Velocity of flow is best ascertained during floods by the use of floats by determining the time to traverse two fixed points at measured distance apart.
- (iv) In case a causeway or the existing bridge is of insufficient waterway resulting in afflux, the extent of such afflux is ascertained for arriving at the rough assessment of discharge.
- (v) Names and approximate discharges of all tributaries joining the river within a reasonable distance u/s of the site under consideration.
- (vi) Skew angle of crossing, if any, should be ascertained correctly. Skew angle should be measured in relation to the direction of flow at/near HFL and not in relation to the direction of flow at/near HFL and not in relation to the bank line.
- (vii) The approximate depth of the deep scour hole below HFL mentioning its location, whether general or localized near any hard obstruction or caused by whirlpool. Information about scour around piers and abutments of any other bridge across the same river in the vicinity from records or by soundings taken near the proposed site during receding floods will be very useful in cross checking the calculated scour and thereby avoiding gross errors.
- (viii) The khadir width in case of wide/meandering alluvial rivers. The width and depth of the channel during dry weather flow, OFL and HFL should be noted, as well as the radii of the larger meanders scaled from the map.
- (ix) Cross section of the river on a vertical scale of about 1/100 and horizontal scale of 1/10000. at the proposed sites indicating.
  - (a) Name of the river and the site

- (b) The (road) chainages and bed levels with reference to the temporary benchmark and ground levels for sufficient distance beyond the edge of the channel
- (c) Nature of the subsoil in the bed, bank approaches and location of the trial bores.
- (d) LWL, OFL and HFL
- (e) Low and high tide levels where applicable.

It should also include one or two additional cross sections at 300 to 300 m u/s and d/s for small and large rivers respectively.

- (x) A longitudinal section of the stream 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 shall be same as for survey plan and vertical scale not less than 1:1000.
- (xi) Rainfall data indicating
  - (a) Maximum precipitation in one hour and 24 hours
  - (b) Rainfall distribution in catchment
  - (c) Duration, frequency of floods
  - (d) Rain gauge data of storms for which corresponding stream gauge data is available (data for unit hydrograph)
  - (e) Average annual rainfall characteristics (append relevant meteorological records).
- (xii) Stream/channel characteristics Seasonal or perennial
  - (a) Braided, meandering or straight
  - (b) Other classifications like bouldery, flashy, well defined, presence of pools, weeds etc.
  - (c) Highest flood and other major floods and their year of occurrence delineating the areas flooded
  - (d) Afflux if observed

#### **2.2.4.3. Preliminary subsoil investigation**

- (i) Preliminary subsoil investigations should include adequate number of trial bores/trial pits for obtaining realistic data for deciding the span arrangement, type of foundation and scour level as specified in 1RC:78 for making the preliminary design of the bridge. The exploration shall cover the entire length of the bridge and also extend at either side for a distance of about twice the depth below bed of the last main foundations. It should also include study of available information on the

geological formations from geological maps, site reports of existing bridges, aerial photography etc. If significant difference in the foundation strata is anticipated, few bores at alternative sites may also be required sometimes, so as to help in the final selection of the site.

- (ii) **Depth of exploration:** The depth of exploration should be at least  $1 \frac{1}{2}$  times the minimum width of the foundation below the proposed foundation level in case of open foundations and deep well foundation. Where such investigation end in any unsuitable or questionable foundation material, the exploration shall be extended to a sufficient depth into firm and stable soil or rock but not less than four times the minimum depth of foundation below the earlier contemplated foundation level. In case of good sound rock the stipulation of minimum depth may be decreased based on difficulty to conduct core drilling however minimum depth should not be less than 3 meters.
- (iii) Depth of exploration for pile foundation should be as per Section 1100 of MORT&H Specifications for Road and Bridge Works.

## **2.2.5. Design discharge and linear waterway**

### **2.2.5.1. Design discharge**

(i) Usually bridges are required to be designed for a discharge corresponding to a flood with a 50 year return period, and only in case of very important bridges that they are to be designed for a flood of 100 year return period. Normally, in the absence of reliable data for "statistical analysis of floods, design discharge may be fixed on the basis of any rational method. Empirical methods are less reliable and may be used with caution. Various methods for calculating discharge are given in *IRC-SP-13*.

## **2.2.6. Clearance**

### **2.2.6.1. Clearance for traffic**

- (i) The minimum vertical and horizontal clearances (clear height and width respectively available for passage of traffic) to be provided on bridges shall be as specified in IRC-5.
- (ii) For bridges constructed on horizontal curve with super ; elevated road surface, the horizontal clearance shall be increased on the side of the inner kerb by a margin equal to 5 meters multiplied by the super elevation; the maximum vertical clearance being measured from the super elevated level of the roadway. The above extra horizontal clearance required is over and above the increase in width required for the design of road on curve.

- (iii) For footways and cycle tracks, the minimum vertical clearance shall be 2.25 meters.
- (iv) For vertical and horizontal clearances at under passes and / rail over bridges the essential provisions are given below. IRC: 5 may be referred to for details.

## **2.2.7. Width of carriageway, footpath and median**

### **2.2.7.1. General (for all roads except national highways):**

The provisions given in clause 1 12 of IRC:5 may be applied for all bridges except for National Highways for which para 2.2.9.2 may be referred to.

### **2.2.7.2. For bridges on National Highways:**

All bridges should have width between outer most faces of the railing kerbs equal to the roadway width of the approaches irrespective of their length or location. For details. Ministry's Circular No. RW/NH-33044/2/S8-DO.II dated 09/05/2000 may be referred to<sup>94</sup>.

**Footpaths:** In urban areas, minimum footpath width of 1.5<sup>m</sup> may be provided. In case of divided carriageways, footpath shall be provided only on the left side of the carriageway for each direction of traffic, wherever footpath is not provided, safety kerb of 750 mm width has to be provided as per Clause 1.1.3 of IRC:5. In case of very high volume of pedestrian traffic, the provision of footpaths of more than 1.5 m width or a separate pedestrian bridge may be considered depending on site conditions.

**Crash Barriers:** Crash barriers shall be provided for all bridges on National Highways to safeguard against errant vehicles. For bridges with footpath, crash barrier "shall be so located as to separate the main carriageway from the footpath for the safety of pedestrians. For further details, IRC-5 "General Features of Design" may be referred to.

**Extra width on curves:** In case of bridges lying on a curve or a horizontal profile, extra width on bridge shall be" provided as per IRC codal provisions applicable for road section.

## **2.2.8. Fixation of span arrangement and selection of the type of structure**

### **2.2.8.1. General consideration in selection of type of bridges and span arrangement:**

Specific site characteristics like width of crossing, nature of stream, depth of flow during different seasons, subsoil characteristics, and the capabilities of contracting agencies who would be interested in building the structure including availability of skilled and unskilled labor are mostly the major considerations in selecting the type of structure and span arrangement in specialized structures like long span bridges. The attempt of the engineers should be towards minimizing the overall cost of the total structure including approaches within the site specific constraints as obtained. For normal simply supported structures, it has been observed that the total cost of the bridge proper tends to

be the minimum, when. the cost of superstructure approaches to that of foundation and substructure put together which may be applied as a thumb rule for initial trial.

**2.2.8.2. Economical range of span lengths for different types of superstructures:** Apart from the estimated cost based on schedule of rates, costs as quoted during tendering may be used for constantly updating the cost analysis data. The ranges of span length within which a particular type of superstructure can be economical along with other considerations Rice type of foundation etc. are given be low:-

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 24 m
iv	Simply supported PSC girder bridges	25 to 45 m
v	Simply supported RCC voided slabs	10 lo 15 m
vi	Simply supported/continuous PSC voided slabs	1 5 to 30 m
vii	Continuous RCC voided slabs	10 to 20 m 25 to 50 m
viii	RCC box sections simply supported / Balanced cantilever continuous	35 to 75 m
ix	PSC box sections; simply supported / Balanced cantilever	75 to 150 m
x	PSC cantilever construction / continuous	100 to 800 m
xi	Cable stayed bridges	300 to 1500 m
xii	Suspension bridges	

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

**2.2.8.3. Type of foundations:** The subsoil characteristics obtained at a particular site and consequently "file "type of foundations feasible, is one of the major "considerations- in selector of type of structure and span arrangement as already mentioned:

(i) Shallow foundations: Isolated open foundations are feasible where an SBC of about 15 t/m<sup>2</sup> or more is available at shallow depths with in-redouble substratum. Here again, open excavation is feasible only upto a depth of 3 to 4 m where the subsoil is porous and water table is high. In cases, where the SBC is still less and where ~ smaller spans arc economical from other considerations, raft foundations or box structures with floor' protection arid curtain walls are the other options.

(ii) Deep foundations : Where suitable founding strata is available at a depth of 6 m or more with substantial depth of standing water, highly pervious substratum and large scour depth/it may be "advisable to go for deep foundation like (a) well, or (b) piles.

- (a) Well foundations: This is one of the most popular types of up foundations in our Country, due various reasons like its simplicity, requirement of very little of equipment's for its execution, adaptability to different subsoil conditions and difficult site conditions like deep standing water and large depths to good founding strata. Caissons are an adaptation of well foundations to sites with deep standing water/"
- (b) Pile foundations: Pile foundations are another type of deep foundations which are suited for adoption in the following situations:-Availability of good founding strata below large deep soft soil Need to have very deep foundations beyond the limit of pneumatic operations usually depth beyond 35 meters or so. In some cases of strata underlying deep standing water and the strata being very hard not permitting easy sinking of wells or based on economic factors deciding the use of piles as compared to wells. However, pile foundations are not preferred within the flood zone of the river with deep scour.

(jii) Classification of piles

- (a) Precast driven piles
- (b) Driven cast-in-situ piles
- (c) Bored cast-in-situ piles
- (d) Bored recast piles and
- (c) Driven steel piles

Further guidance on the design and construction aspects of pile foundations can be obtained from IRC: 78.

### **2.2.9 Preliminary design of various components of bridge**

The Preliminary design should include all calculations needed for finalizing the cross section of the superstructure including the checks for the maximum bending stress and shear stress. It should also include preliminary design of the critical abutment and pier on the basis of preliminary subsoil investigations.

**2.2.9.2 Minimum depth of foundations:** The following minimum depths may be ensured:

- (i) **Shallow foundations in erodible strata:** Such foundations may be taken to a minimum depth of 2.0 m if they support an arch superstructure or 1.20 m in other cases provided adequate SBC is available at that depth to support a individual foundation or rafts as the case may be and the foundations are protected against undermining by suitably designed flooring, cut off walls and launching aprons.

- (ii) **Deep foundations in erodible strata:** Such foundations shall be taken to such depth where the base pressures calculated based on any rational design method is less than the available S.B.C. and a minimum grip length of 1/3rd of the maximum anticipated scour depth below HFL (i.e.  $\frac{1}{3} \times 2d$ ) is ensured.

(jii) **Shallow foundations in rock:** A minimum embedment of 0.6 m in case of hard rocks having a crushing strength of 100 kg/cm<sup>2</sup> or more may be provided considering the overall characteristics such as fissures, bedding planes, cavities etc. Higher embedment may be provided for softer varieties considering the above mentioned characteristic? And strengthening measure: if any, proposed.

- (iv) **Deep foundations in rock:** If hard rocky strata is met with at depths below the maximum scour level, and if deep foundations are resorted to, it shall be ensured that such foundations are evenly seated all along the periphery on sound rocky strata (devoid of fissures, cavities, weathered zones etc). On sloping rock surfaces, the foundations shall be properly seated by benching and the extent of seating and embedment in each case shall be decided by Engineer-in-charge.

**2.2.9.3. Substructure :** Substructure include those portions of a bridge which are above the foundation which include piers, abutments, abutments and pier caps, dirt walls, returns, wing wall etc. but excludes bearings and superstructure. It can be built of brick/ stone masonry, plain/reinforce prestresses concrete, steel. Selection of a particular type of substructure depends upon the span and type of superstructure, the height of substructure, availability of construction material and construction equipments, period and time of construction and above all on overall economy. The shape of piers and abutments in general, should be such as to cause minimum obstruction to flow of water.

Substructure shall be designed to withstand the loads and forces as specified in IRC: 6, the worst combination of forces and factors of safety shall be as specified in IRC: 78. For allowable stresses and other design requirements relevant IRC Codes depending upon the type of construction material shall be followed.

#### **2.2.9.4. Bearings**

- (i) Bearings are vital components of a bridge which while allowing of longitudinal and/or transverse rotations and/ or movements of the superstructure with respect to the substructure (thus relieving stresses due to expansion and contraction), effectively transfer loads and forces from superstructure to substructure. Adequate care shall be exercised in selecting the right type of bearings based on the guidelines given below:
- (a) For solid/voided- slab superstructure resting on unyielding supports, no bearings are generally provided if the span length is less than 10m. The top of piers/abutments caps are however rubbed smooth with carborandum stone.

- (b) For girder and slab spans more than 10m length and resting on unyielding supports, neoprene bearings may be considered. For spans larger than 25m roller and rocker bearings or PTFE bearings could be considered.
  - (d) For very large spans and where multidirectional freedom of movement and rotation are to be allowed provision of pot bearings may be considered.
- (ii) The design of metallic bearings and neoprene bearings shall be in conformity with IRC: 8: Parts I & II respectively.
  - (iii) In case of roller-cum-rocker bearings only full circular rollers are to be provided.
  - (iv) In order to cater for any possible relative undue movement of bearings over the abutment resulting in girder ends jamming against the dirt wall preferably a larger gap may be provided between the girder end and the dirt wall.
  - (v) All bearings assemblies shall be installed in accordance with the instructions contained in the codes and specifications and on the approved drawings. In particular the following important points shall not be lost sight of:
    - (a) All bearings shall be set truly level so as to have full and even seating. Thin mortar pads (not exceeding 12mm) may be used to meet this requirement.
    - (b) The bottoms of girders resting on the bearing shall be plane and truly horizontal.
    - (c) In case of rockers and roller bearings, necessary adjustment for temperature at the time of placement, shrinkage, creep and elastic shortening shall be made, such that the line of bearing is as central as possible on the bearing plates at the normal temperature taken in design.
    - (d) For elastomeric bearing pads, the concrete surface shall be level such that the variation is not more than 1.5mm from a straight edge placed in any direction across the area.
    - (e) For spans in grade, the bearings shall be placed horizontal by using sole plates or suitably designed R.C.C. pedestals.
    - (f) Bearings of different sizes must not be placed next to each other to support a span.
    - (g) Installation of multiple bearings one behind the other on a single line of support is not permitted.
    - (h) The bearings shall be so protected while concreting the deck in situ that there is no flow of mortar or any other extraneous matter into the bearing assembly and particularly on to the bearing surfaces. The protection shall be such that it can be dismantled after the construction is over without disturbing the bearing assembly.



- (i) Special attention should be given to the temporary fixtures to be provided for the bearings during the concreting of superstructure in order to ensure that they do not get displaced during the initial installation itself. The temporary fixtures should be removed as soon as the superstructure has attained its required strength
- (vi) Bearings provided at any end of superstructure shall be along a single line of support and of identical dimensions.
- (vii) Ministry of Road Transport and Highways, Govt. of India carries out pre-qualification of the manufacturers of bearings from time to time. The pre-qualification is valid for a certain period. It is advisable to procure bearings from stiff manufacturers only.

#### **2.2.9.5. Superstructure**

- (i) It is the superstructure of a bridge that directly supports the traffic and facilitates its smooth uninterrupted passage over natural/man made barriers like rivers, creeks, railways, roads etc. by transmitting the loads and forces coming over it to the foundation through the bearings and substructure.
- (ii) The minimum functional requirement of superstructure are specified in IRC: 5 and IRC: 21. In case of box girder superstructure, the minimum clear height inside the box girders shall be 1.5 m to facilitate inspection.
- (iii) Aesthetic aspects already specified in para 2.10.2 will be one of the major considerations while deciding on the type of superstructure of a bridge keeping in view the criteria mentioned therein.
- (iv) Consistent with economy and local availability of the materials, labour and technology for a particular type of superstructure selection may have to be made out of the following material options:
  - (a) Masonry
  - (b) Reinforced cement concrete
  - (c) Pre stressed concrete
  - (d) Steel or
  - (e) Composite construction which is a combination, of the any of the above.
- (v) **Reinforced cement concrete superstructure:** These are the most popular type of superstructure in the present day which may take the form of solid slab, voided slab. T-beam and slab, box girder, rigid frame, arch, balanced cantilever or bow-string girder.
- (vi) **Prestressed concrete superstructure:** This may also take any of the above forms referred in the previous Para.

- (vii) **Steel superstructure:** With increasing availability of quality steel at international prices in recent years the use of steel for superstructure is becoming an attractive option. The forms, these may take are steel beam, plate girder, box girder, steel truss, arch, cantilever suspension bridges and cable stayed bridges.
- (viii) **Composite Superstructure** any combination of above materials considering their distinct advantages for particular elements may be adopted. Most common types of composite construction are cast in situ or precast girder in prestressed concrete with R.C.C. deck or steel beam/plate girders with RCC deck or cable stayed bridges with RCC or PSC deck.
- (ix) **Design:** Relevant IRC Codes which have to be complied in the design of superstructure are IRC: 4 (IRC: 21, IRC: 18, IRC: 24, IRC: 22 for Masonry, Reinforced Cement Concrete, Prestressed Concrete and Composite Superstructures respectively. Other codes applicable for all types of superstructures are IRC: 5 and IRC: 6. Other major guidelines also include IRC: 85. In case IRC codes are silent about some design aspects, provisions, in the IS/International Codes may be followed.
- (x) **Provision for future pre-stressing:** In case of prestressed concrete superstructure, provision for future prestressing to the extent of 20 per cent of total prestress force may be made. For this purpose, dummy cables may be laid in the structure which can be used for further prestressing if the need arises afterwards.
- (xi) **Standard plans for highway bridges:** Ministry of Road Transport & Highways gives preference to item rate contracts except in case of special problems, very large projects involving novel design/construction methods, and have brought out various standard plans which include standard plans for (i) RCC Solid Slab Superstructure, with and without footpaths for 3m to 10m spans with Unum overall width, (ii) I-Beam and Slab Superstructure of 12m to 24m spans of overall width 12.00 m, (iii) PSC Girder with RCC Deck Composite Superstructure for 30 m span with and without footpath, 35m span with footpaths and 40m span without footpaths and (iv) RCC Solid Slab Superstructures of 15, 22.5, 30 and 35° skew for span 4m to 10m with and without footpaths. These plans are published by M/O RT&H / IRC and are listed in Appendix 1.

**2.2.9.6. Expansion joints:** Expansion joints are provided at the end of deck and cater for movement of deck due to temperature, shrinkage, creep etc. Expansion joints make the deck joint leak proof, protect the edges of slab/girder and also allow smooth passage of loads from one span to other by bridging the gap. Depending upon the gap width to be bridged, there are various types of expansion joints in use at present as detailed below.

- (a) **Buried joints:** Where the gap is 20mm or less, bituminous/asphalted

surfacing is laid over a 12mm thick 200mm wide steel plate resting freely over the top surface of deck concrete. To keep the plate in position 8mm dia 100 mm long nails spaced at 300mm c/c along the center line of the plate are welded to the bottom surface of the plate and protrude into the gap.

- (b) **Filler joint:** This type of joint is suitable for fixed ends of simply supported spans with insignificant movements or simply supported spans not exceeding 10 meters. It can cater for horizontal movement upto 20mm.
- (c) **Asphaltic plug joint:** It is of asphaltic concrete made from polymer modified bitumen binder and selected single size aggregate. It rests over a 6mm thick and 200mm wide steel plate placed over the gap. The width of the plug varies from 500 to 750mm and its depth varies from 75 to 100mm. It caters for a horizontal movement upto 25mm and vertical movement upto 2mm.
- (d) **Compression seal joint:** It consists of steel armored nosing at two edges of the joint gap suitably anchored to the deck concrete and a joint sealer performed multiweb cellular section of chloroprene elastomer compressed and fixed into the joint gap with special adhesive binder. The seal shall cater for a horizontal movement upto 40mm and vertical movement of 3mm.
- (e) **Elastomeric slab seal joint:** It comprises of reinforced elastomeric seal fixed on either side to deck concrete of adjacent spans through bolts. It can cater to a maximum
- (f) **Strip seal expansion joint:** It comprises of an extruded section of chloroprene held in position by edge beams made of either expanded or hot rolled steel section or cold rolled cellular steel sections with suitable profile to mechanically lock the sealing element. The edge beams are anchored to deck by reinforcing bars, headed studs or bolts or anchor plates. The working movement range of the sealing element shall be 70mm.
- (g) **Modular Strip Seal/Box Seal Joint:** A modular expansion joint consists of two or more modules so as to cater to a horizontal movement in excess of 70mm. It allows movement in all the three directions and rotation about all the three axes as per design requirement. During all movement cycles of the joint, opening or closing of all modules are equal.
- (h) **Special Joints:** For bridges having wide deck or span length of more than 120m or/and involving complex movements/rotations in different directions/planes provision of special type of modular expansion joints such as swivel joints may be made.
- (i) **Ministry of Road Transport & Highways, Govt. of India** vide their letters No.RW/NH-34059/1/96 S&R dated 31.3.97 and 17.7.97 have issued interim specifications for expansion joints and subsequent modifications in the list of manufacturers / suppliers which may be followed. Supply of new type of expansion joints may be obtained on the basis of competitive bidding from amongst the manufacturers/suppliers listed at Annexure-II to the above referred letter. Further, a warranty of 10 years of trouble free

performance may be insisted upon from the contractors/suppliers for all type of joints except for buried joints and filler joints.

### **2.2.10. Corrosion protection measures:**

Reinforced concrete | has generally been considered to be a durable construction material. f However, of late distress has been observed in several bridges | primarily due to corrosion of embedded reinforcement. The cause of occurrence of corrosion is observed due to (1) hot and aggressive environment, (2) defective workmanship and (3) presence of chloride both in ingredients and/or atmosphere.

It is generally agreed that corrosion does not occur when adequate cover is provided on rebars, aided by well compacted concrete, since both water and oxygen are required in free state to initiate corrosion which will not occur in dry concrete or totally [ submerged condition. It is, therefore, imperative to use design mix j concrete as cited in the Ministry's specification and strict quality control may be observed especially in severe marine conditions. Many approaches are available to inhibit or delay the onset of corrosion in rebars such as (i) usage of inhibitors in concrete, (ii) application of surface sealant (on concrete), (iii) metallurgical improvements in steel, (iv) cathodic protection, and (v) protective coatings on reinforcement. Ministry has brought out a circular vide No. RW/NH-34041/44/91 -S&R dated 21.3.2000 giving detailed guidelines on use of fusion bonded epoxy coated reinforcement and other coatings for bridges on National Highways and other centrally sponsored bridges to be constructed in marine environment susceptible to severe corrosion which may be followed to reduce the chances of corrosion.

### **2.2.11. Design of river training and protective works**

**2.2.11.1** River training and protective works is required for ensuring the safety of bridges and their approaches on either side. The selection of the type of river training or protective work will depend upon terrain, overall behavior of the river, location of the bridge vis-à-vis the areas of attack of the river, span arrangement nearness of the approaches from the influence zone of the river, etc. The types of river training and protective works generally being used are as follows:

- (i) Guide bunds
- (ii) Spurs or groynes
- (iii) River bank protection
- (iv) Approach road protection
- (v) River bed protection

The special features along with the broad design principles for each type are described in IRC:89-1987. "The Guidelines for Design and Construction of River Training and Protective Works for Road Bridges", which may be referred to for details.

## **2.2.12. Preliminary cost estimate**

**2.2.12.1** Preliminary cost estimate shall be a reasonably firm cost estimate on the basis of which administrative approval can be accorded. It shall be based on quantities worked out during preliminary design and current schedule of rates from which no major changes either in quantities or in rates shall normally occur except under totally unforeseen circumstances.

**2.2.12.2** While preparing detailed project estimate, following additional points should also be kept in view:

- (I) Structural elements like light posts and cable ducts for electrification of new bridges of lengths 300 m or more on National Highways may be provided, if required, and the cost thereof included in the estimate for the bridge proper provided that the Municipal Board/ concerned local authority is prepared to meet the initial cost as well as subsequent maintenance charges of electrical installations including cost of wiring, lamps etc. and also to bear the electricity charges. Accordingly, the estimate should be accompanied by a clear certificate from the local authority that is prepared to meet the cost of electric installations and maintenance charges.
- (II) All proposals for reconstruction of existing weak bridges in National Highways should be accompanied with the rating of the bridges based on detailed provisions contained in IRC Special Publication No. 9 "Report on rating of bridges" for proper appreciation. Further, the inspection of existing structure should be done for collection of data in accordance with the provisions contained in Chapter R-3 of the aforesaid publication and the required information furnished.

## ***2.3. Detailed Project Preparation***

### **2.3.1 Survey:**

Detailed Survey of the area, final selection of site, type of structure, type of foundations, span arrangement and alignment of approaches would have been completed at. Preliminary project Report stage. A further topographic survey may be required along the final alignment to verify the changes, levels etc. and to fill in the gaps in the survey carried out during preliminary project Report stage.

### **2.2.2 Hydraulic designs:**

Hydraulic designs done at the preliminary project report stage may be considered adequate unless special circumstances warrant updation of the same.

### **2.3.3 Detailed subsurface investigation and testing**

- 2.3.3.1. All subsurface data necessary for detailed design of all the foundations separately, if necessary, have to be obtained during detailed subsurface investigations to be carried out in accordance with relevant IRC code provisions and MOST's specifications..
- 2.3.3.2. For minor bridges at least one bore at each of the abutment locations and one in the bed of the stream shall be taken.
- 2.3.3.3. In case of major bridges at least one bore shall be taken at each of the foundation locations.
- 2.3.3.4. The depth of subsurface exploration shall be based on the anticipated foundation level as per the Preliminary' Project Report or from the details of foundations of existing bridges nearby, type of structure, span arrangements etc. and the bores shall extend at least 1-1/2 times the width of foundation for open and well foundation. In case of pile foundation, reference may be made to para 2.4.3.3.
- 2.3.3.5. For the portion of the approaches having embankment heights of 6.00m or more bore holes may be taken in the approach alignment to obtain data for the design of embankment as per IRO75 "Guidelines for the Design of High Embankments".
- 2.3.3.6. Disturbed/undisturbed soil samples shall be taken at every 1.5m intervals. Also SPT or static penetration tests shall be conducted at these intervals. Efforts shall be made to obtain undisturbed samples at least at alternate levels except in purely cohesion less soils. Data that are expected to be collected by the sampling and testing are: Soil classification, Particle size distribution, Shear strength characteristics. Permeability where dewatering is expected, Compressibility, Density, Void ratio, Moisture content, Nature and type of rock where met with and bearing capacity.
- 2.3.3.7. Subsoil investigations shall also determine the depth of water table, artesian conditions, if any, and the quality of ground water.

### **2.3.4 Detailed structural design**

- 2.3.4.1. Preferably detailed design should be done top downwards, i.e. superstructure to be finalized first, bearings next and so on, though it is started from foundation onwards in design and build contracts. Detailed structural design of all the components of parameters.

#### **2.3.4.2. Superstructure**

- (a) Detailed design and detailing of each of the elements of the superstructure have to be done during this phase.
- (b) In case computer programmers' are used for the analysis

and/or detailing, it has to be ensured that the programmer has been adequately validated. Also listing of input data and input values needs to be thoroughly checked and indicated for verification by approving authority.

**2.3.4.3. Bearings:** Detailed design of bearings shall conform to IRC: S3 Parts I & II for metallic and neoprene bearings and in case of special type of bearings like pot/PTFE bearings, specialized literature and codes and Ministry's Specifications for Roads & Bridge Works Section 2000 clause 2006 may be referred and complied with.

**2.3.4.4. Substructures:** Unlike the typical design in preliminary stage, while preparing detailed design all individual piers, abutments, return walls etc. which have any difference with regard to the forces acting, height of substructure etc. have to be separately analyzed and designed individually if economy/safety demands so.

**2.3.4.5. Foundation:** In the case of foundations also each individual foundation has to be designed separately during the detailed design stage taking into account difference in founding levels and the subsoil data as obtained at each of the individual foundation locations during detailed subsurface investigations.

**2.3.4.6. Secondary elements:** Detailed design of secondary elements like railings/crash barriers, expansion joints, kerbs, footpaths, approach slab etc. have also to be included in the D.P.R.

### **2.3.5 Detailed estimate**

**2.3.5.1.** Detailed Estimate shall be based on finalized bill of out have to be firm unless under unforeseen circumstances. The items of the estimate may be arranged systematically in the following order.

- (i) Preparatory works
- (ii) Foundation
- (iii) Substructure
- (iv) Superstructure
- (v) Protective Works
- (vi) Miscellaneous items
- (vii) Sub-estimate for approaches
- (viii) Centage charges like quality control contingencies work charged establishment and agency charges.

**2.3.5.2.** The bill of quantities have to be based on detailed quantity estimates which again have to be based on detailed design and dimensions so arrived at for all the elements of the bridge.

**2.3.5.3.** The rates adopted shall be the current schedule of rates applicable for the region and wherever same items arc not covered by the schedule, the rate for the same shall be based on detailed analysis of rates.

**2.3.5.4.** The agency and other charges applicable for estimates of National Highway Works are indicated under Cl.3.2.

**2.3.5.5.** The abstract of cost estimate containing the complete nomenclature of each item of works, final quantities as worked out in the detailed estimate, rates as in para 2.3.5.3 cost of each item and remarks, if any, shall invariably form part of the detailed estimate.

### **2.3.6 Detailed project report:**

Detailed Project Report should contain the following five volumes namely:

- (i) Final Report
- (ii) Detailed Designs
- (iii) Detailed Estimate
- (iv) Detailed Bill of Quantities and Specifications
- (v) Detailed Drawings.

**2.3.6.1. Final report:** The final Report should contain:

- (i) An introductory report indicating the location of the bridge, the need for the same, the population and economic activities likely to be served by the bridge, alternative sites considered and the aspects in favour of the site finally selected.
- (ii) Design data for the bridge including survey data, hydraulic data and subsoil data.
- (iii) Detailed information on the general arrangement selected for the bridge and the factors favoring the choice.
- (iv) Economic analysis of various options including the do nothing option in case of very major projects and at least of the finally selected option in case of other projects.
- (v) Report on the environmental impact assessment, and
- (vi) A schedule of construction including a CPM chart in case of major projects; and at least a Bar chart indicating important mile stones in other cases.

**2.3.6.2. Detailed designs :** Detailed design sheets of all components of the bridge have to be included in this volume.

**2.3.6.3. Detailed estimate:** This volume should contain all the items covered under Para 2.3.5.

**2.3.6.4 Detailed bill of quantities and specifications:** The detailed bill of quantities should contain the:



- (i) Reasonably firm quantities of each item of work forming part of the project worked out on the basis of detailed drawings.
- (ii) The detailed specifications of each of the items of the project.

**2.3.6.5 Detailed drawings:** This volume should contain the following:-

- (i) Index plan
- (ii) Site plan
- (iii) at least three cross sections of the river as-specified in Para 2.2.4.2(ix)
- (iv) a longitudinal section connecting the cross section points.
- (v) A contour survey plan
- (vi) Bore log data
- (vii) A general arrangement drawing of the bridge superimposed on the cross section of the river at the proposed site also indicating the bore details
- (viii) Detailed drawings of all the components of the bridge
- (ix) Complete details of existing bridges, if any
- (x) Plan and L section of approaches
- (xi) Cross section of approaches
- (xii) Detailed drawings of CD. Works
- (xiii) Miscellaneous drawings

## **3. CONSTRUCTION**

### **3.1 General**

**3.1.1** The execution of a bridge may be taken up departmental or through a contracting agency. Before start of construction work care must be taken to ensure that the following documents are available:

- (i) Sanction letter and technical note, if any.
- (ii) Bill of quantities.
- (iii) Copy of contract document along with any special conditions thereof.
- (iv) Copy of approved set of plans and detailed working drawings.
- (v) Standards, specifications, guidelines, codes of practices etc., according to which the work must be executed as per contract.
- (vi) Survey, investigation and sub-soil test reports.

**3.1.2** Finalize the site and decide location of site office, storage sheds, batching plant, casting yard, labour camp etc.

**3.1.3** Identify sources of construction materials like sand, coarse aggregate and boulders etc. and supply of cement and steel including the time required in transportation of these materials to the site of work.

**3.1.4** Draw a detailed work programme (CPM) on the basis of availability of plant, equipment, material, manpower etc. Refer IRC Special Publication No. 14 - A manual for application of the critical path method.

- 3.1.5** Identify major milestones to serve as important dates for reviewing the progress of work.
- 3.1.6.** After having cleared the site, transfer the alignment of the bridge and ground with the help of reference pillars fixed at site during the location survey. Fix up permanent bench marks, reference pillars. Use Auto levels, accurate theodolite and other precision electronic instrument.
- 3.1.7.** The construction of various components of bridge works protective work shall conform to ministry's Specification for Road and Bridge Works and relevant IRC Bridge Codes/Standards.

## **3.2 *Formwork and Staging***

For form work and staging IRC: 87 may be followed.

## **3.3 *Placing of Reinforcement***

Reinforcing steel shall conform to the dimensions and shapes given in the approved Bar Bending Schedules.

Reinforcement bars shall be placed accurately in position as shown on the drawings. The bars, crossing one another shall be tied together at every intersection with binding wire (annealed) to make the skeleton of the reinforcement rigid such that the reinforcement does not get displaced during placing of concrete, or any other operation. The diameter of binding wire shall not be less than 1 mm.

Layers of reinforcement shall be separated by spacer bars at approximately one meter intervals. The minimum diameter of spacer bars shall be 12 mm or equal to maximum size of main reinforcement or maximum size of coarse aggregate, whichever is greater. No person shall be allowed to walk directly over the reinforcement placed in position.

Necessary stays, concrete/polymer cover blocks, metal chairs, metal hangers, supporting wires etc or other subsidiary reinforcement shall be provided to fix the reinforcement firmly in its correct position.

Placing and fixing of reinforcement shall be inspected and approved by the Engineer before concrete is deposited.

## **3.4 *Foundations***

### **3.4.1 *Open foundation:***

Excavation for laying the foundation shall be carried out in accordance with Section 300 of Ministry's Specifications. Any depth excavated below the specified level shall be made good with M 15 concrete in case of

foundation resting on soil and foundation grade concrete for foundations in rock.

Open foundation shall be constructed in dry conditions. When the bearing surface is earth, a layer of M 15 concrete shall be provided below foundation concrete. The thickness of this layer shall be 100mm minimum unless otherwise specified.

Where water is met with an excavation, adequate measures such as bailing out, pumping, constructing diversion channels etc shall be taken to keep the foundation trenches dry and to protect the green concrete against damage.

All spaces excavated and not occupied by the foundation, shall be refilled with earth upto surface of surrounding ground. In case of excavation in rock, the annular space around foundation shall be filled with M 15 concrete upto the top of rock.

### **3.4.2 Well foundations**

**3.4.2.1.** The construction procedure shall conform to the provisions contained in Section 1200 of Ministry's Specifications.

7.5.2.2 Well sinking: Sinking of well can be accomplished by the following methods:-

- (i) Open grabbing with / without kentledge
- (ii) Jackdown methods
- (vii) Pneumatic sinking of wells
- (viii) Blasting

**3.4.2.2 Blasting:** Blasting may be employed with prior approval of competent authority to help sinking of well for breaking obstacles such as boulders or for leveling the rock layers for square setting of wells. Blasting may be resorted to only when methods are found ineffective.

### **3.4.3 Pile Foundation:**

The piles may be either pre-cast concrete piles or cast in situ driven or bored piles. The detailed procedure for construction of pile foundation shall conform to the specification given in section 1100 of m RT&H's specifications and Clause 711 of IRC: 78.

## **3.5 Substructure**

**3.5.1** Materials shall conform to section 1000 of Ministry's Specifications.

**3.5.2 Piers and abutments:** Masonry form work concrete and reinforcement for piers and abutment shall conform to Section 2200 of Ministry's Specification.

- 3.5.3** Piers cap and abutments cap: The surface of cap shall be finished smooth and shall have a slope for draining of water. For short span slab bridges with continuous support on pier caps the surface shall be cast horizontal. The top surface of the pedestal on which bearing are to be placed shall also be cast horizontally.

The surface on which elastomeric bearings are to placed shall be wood float finished to a level plane which shall not vary more than 1.5 mm from straight edge placed in any direction across the area. The surface on which other bearings (steel bearings, pot bearings) are to be placed shall be cast about 25 mm below the bottom level of bearings.

- 3.5.4** Dirt/ballast wall, return wall and wing wall: In case of cantilever walls, no construction joint shall be permitted. Wherever, feasible, the concreting in cantilever walls shall be carried out in continuation of the ballast wall.

No horizontal construction joint shall be provided. If shown on drawings or directed by the engineers, vertical construction joints may be provided. Vertical expansion gap of 20 mm shall be provided in return wall/wing wall at every 10 m intervals. Weep holes shall be provided as prescribed for abutments.

The finish of the surface on the earth side shall be rough while the front face shall be smooth finished.

Architectural coping for wing wall/return wall in brick masonry shall conform to Section 1300 of Ministry's specifications.

- 3.5.5** Tolerances in concrete elements shall conform to Section 2208 of Ministry's specifications.

## **3.6 Superstructure**

### **3.6.1 Concreting:**

Concreting shall be done as per Section 2300 of Ministry's specifications.

### **3.6.2 Prestressing:**

Before commencement of the prestressing, it shall be ensured that all the tendons are free to move between the jacking points.

The tendons shall be stressed at a gradual and steady rate and the extension recorded at each increment of jack pressure.

The extension of the tendons at the agreed pre-specified total force shall be within 5 per cent of the agreed calculated extension.

Any appreciable variation between the calculated extension and actual extension should be notified and settled in consultation with the Engineer-in-charge before proceeding with further tensioning.

Stressing shall be done from both ends unless one end prestressing is specified in the drawings.

Prestressing record of all the cables shall be maintained in the format given in Appendix 1800/II of Ministry's Specifications for roads & bridge works (third revision).

Efficiency of prestressing jack should be found before hand and catered for in the extension of cables.

### **3.6.3 Grouting:**

Grouting of cable ducts shall be carried out as per Appendix 1800/III of Ministry's Specifications.

Grouting shall be carried out as early as possible as but not later than 2 weeks of stressing in tendon.

Before grouting, ducts shall be flushed with water for cleaning as well as for wetting the surfaces of the ducts walls. Water used for flushing should be of same quality as used for grouting. It may, however, contain about 1 per cent of slaked lime of quick line. All water should be drained through the lowest vent pipe or by blowing compressed air through the duct.

Water/cement ratio of grout mix should be as low as possible, consistent with workability. This ratio should not normally exceed 0.45.

Mixing time depends upon the type of the mixer, but will normally be between 2 and 3 minutes. However, mixing should be for such duration as to obtain uniform and thoroughly blended grout, without excessive temperature increase or loss of expansive properties of the admixtures. The grout should be continuously agitated until it is injected.

It is essential that the grout is maintained in a homogeneous state and of uniform consistency so that there is no separation of cement. Use of grout mixers to obtain a colloidal grout is essential.

The pump should be a positive displacement type and should be capable of ejecting the grout in a continuous operation and not by way of pulses. The grout pump must be fitted with a pressure gauge to enable pressure of injection to be controlled. The minimum pressure at which the grout should be pumped shall be 0.3 MPa and the grout pump must have a relief arrangement for bypass of the grout in case of build-up of pressure beyond 1 MPa. The capacity of the grout pump should be such as to achieve forward speed of grout of around 5 to 10m per minute. The slow rates are preferable as they reduce the possibility of occurrence of voids.

Pumping of grout should continue till the mix coming out at the other end is of the same consistency.

Grouting record should be maintained in the format given at Appendix 1800/IV of Ministry's Specifications (Third revision) – 1995.

### **3.7 Bearings:**

Bearings shall conform to the provisions contained under Section 200 of Ministry's specifications for Road & Bridge Works published in April 1995 and IRC: 83 – Part I & Part II. However, some of the important points about installation are as follows

### **3.8 Expansion Joints:**

The fabrication and fixing of expansion joints shall be as per approved drawings and in accordance with Section 2600 of Ministry's Specifications and with manufacturers' recommendations and Ministry's interim specifications issued vide letter no. RW/NH/34059/1/96 dated 31/03/97 with amendment issued from time to time.

### **3.9 Materials**

#### **3.9.1 Cement:**

Cements manufactured in the country are covered by the following Indian standards:

(i) Ordinary Portland Cement (33 grade)	:	IS :269
(ii) Rapid Hardening Portland Cement	:	IS 8041
(iii) Blast Furnace Slag Cement	:	IS : 455
(iv) Ordinary Portland Cement (43 grade)	:	IS : 8112
(v) Portland Pozzolana Cement	:	IS : 1489 Part I
(vi) Ordinary Portland Cement (53 grade)	:	IS : 12269
(vii) Sulphate Resistant Portland Cement	:	IS : 12330
(viii) Low Heat Portland Cement	:	IS: 12600

- OPC 43 or 53 grades when used, the minimum cement content mentioned from durability consideration shall be ensured.

- For PSC members cement listed at Sl. No. (i), (iv), (vi) (vii) conforming to IS: 269, IS: 8112, IS: 12269 and IS: 12330,

- Portland pozzolana cement (IS: 1489) may be permitted only in plain concrete members.

- Sulphate resistant cement (IS: 12330) shall be used when Sodium Sulphate and Magnesium Sulphate are present in large concentrations detrimental to concrete.

Before taking any supply, manufacturers' certificate that the cement conforms to the requirements of BIS is to be obtained. BIS certification of all cement supply is mandatory. The distinguishable identification marks put on the cement bags should also be taken

which would help in identifying bags of one type of cement from other type.

It is not sufficient to rely solely on the manufacturers test certificate. Independent testing of every consignment of cement shall be done prior to use.

### 3.9.2 Coarse aggregate:

Coarse aggregates shall consist of clean, hard, strong, dense, non-porous crushed stone, crushed gravel, natural gravel or other approved inert material. These shall not consist pieces of disintegrated stones, soft flaky, elongated particles, salt alkali, vegetable matter or other deleterious material. Coarse aggregates having positive alkali-silica reaction shall not be used. Coarse aggregates shall conform to IS: 383 and tests for conformity shall be carried out as per IS: 2386 parts I to VIII.

### 3.9.3 Sand/ Fine aggregate page:

Fine aggregates shall consist of natural sand or hard pieces of crushed stone or gravel or combination thereof. They shall be clean and should not contain mica or other deleterious materials in such quantities as to reduce the strength and durability of concrete or to attack the embedded steel.

All fine aggregate shall conform to IS: 383 and tests for conformity shall be carried out as per IS: 2386 (Part I to VIII)

### 3.9.4 Steel

#### 3.9.4.1 Reinforcement/untensioned steel shall consist of the following grades:

Grade Designation	Bar type conforming to governing IS Specifications	Characteristic of the following grades	Elastic Modulus Gpa
Fe 240	IS: 432 part I Mild steel bar	240	200
Fe 415	IS: 1786 High Yield Strength Deformed bars(HYSD)	415	200
Fe 500	IS 1786 Deformed bars	500	200

Other grades of bars conforming to IS: 432 and IS: 1786 shall not be permitted. No re-rolled steel shall be permitted.

Fusion-bonded epoxy coated reinforcing bars shall meet the requirements of IS: 13620 and additional requirements as per Clause 1009.3 of Ministry's Specifications. Wire fabric company to IS: 1566 and TMT bars conforming to IS: 1786 can also be used.

**3.9.4.2 Steel for pre-stressing:** The pre-stressing steel shall conform to either of the following:

- (a) Plain hard drawn steel wire conforming to IS: 1785 (Part I) and IS: 1785 (part II).
- (b) Cold drawn indented wire conforming to IS: 6003.
- (c) High tensile steel bar conforming to IS: 2090.
- (d) Uncoated stress relieved strands conforming to IS: 6006.
- (e) Uncoated stress relieved low relaxation strand conforming to IS: 14268.

**3.9.4.3 Cast steel:** Cast steel shall conform to grade 280-520 N of IS: 1030. For grey iron castings, Clause 1009 of Ministry's specification may be referred to.

**3.9.4.4 Structural steel;** All structural steel shall comply with the requirements of the relevant Indian Standards, viz, IS: 226, 961, 2062, 8500, 1148, 1149, 1161, 4923, 11587, 808, 1239, 1730, 1731, 1732 and 1852.

### **3.9.5 Water:**

Water used for mixing and curing shall be clean and free injurious amounts of oils, acids, alkali, salts, sugar organic materials or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for Mixing concrete. Mixing and curing with sea water shall not be permitted. As a guide, the following concentrations represent the maximum permissible values:

- (a) To neutralise 100ml sample of water, using phenolphthalein as an indicator, it should not require more than 5ml of 0.02 normal NAOH.
- (b) To neutralise 100ml sample of water, using methyl orange as an indicator, it should not require more than 25ml of 0.02 normal H<sub>2</sub>SO<sub>4</sub>.
- (c) The permissible limits for solids shall be as follows when tested in accordance with IS: 3025:

Permissible limits (max)	
Organic -	200 mg/lit
Inorganic	3000 mg/lit
Sulphates (SO <sub>3</sub> )	400 mg/lit
Chlorides (Cl)	500 mg/lit"
Suspended matter	2000 mg/lit

\* In case of plain cement concrete, the limit of chlorides may be increased upto 2000 mg/lit.



All samples of water (including potable water) shall be tested and suitable measures taken where necessary to ensure conformity of the water to the requirements stated herein.

(d) The pH value shall not be less than 6.

### 3.9.6 Admixtures:

Admixtures shall conform to the requirements of IS:9103. In addition, the conditions mentioned in clause 1012 of Ministry's Specifications shall be satisfied.

### 3.9.7 Storage of materials

**3.9.7.1 General:** All materials shall be stored in such a manner so as to prevent their deterioration or intrusion by foreign matter to ensure the preservation of their quality and fitness for the work.

**3.9.7.2 Aggregate:** Different sizes of coarse aggregates shall be stored in separate stock piles, sufficiently away from each other to prevent inter-mixing.

Aggregates should be stored on a clean, hard surface and not directly on the ground as material will be wasted and mud and dirt may get mixed with the concrete. When a hard surface is not available, it is advisable to spread a layer of lean concrete (such as one with an aggregate cement ratio of 1:9) over the ground on which the aggregates are to be stored. It should be laid with slopes to the edges so that water drains away from the stockpiles. The use of aggregates from the bottom of a stockpile should be avoided, as this part is usually saturated with water and may also contain an accumulation of dirt washed in from the higher layers.

**3.9.7.3 Cement:** Cement shall be stored above ground in perfectly dry and watertight sheds and shall be stocked not more than 8 bags high. Where storage containers are used, their capacity shall be adequate to cater to requirements at site and should be cleaned once every 3 to 4 months. Cement more than 3-4 months old shall invariably be tested before being used on the work.

The bags should be stocked such that the first batch in can be the first out.

**3.9.7.4 Steel:** The bars should be stored above the surface of the ground preferably in covered shade. If they are to be stored for long periods, some covering should be provided to keep off the rain. Slight rusting cannot usually be avoided but bars that are rusty should be freed from loose rust (brushing with a wire brush is the best means of doing this); otherwise, the concrete will not grip the steel properly and the strength of the unit may be seriously reduced.

The bars should be stacked in such a manner that the lengths and sizes required can be found easily. Bars should be marked with their original

bar list number on a paper covered metal label. In this way, the bar bender can find the correct group of bars without having to move several tons of the wrong type.

**3.9.7.5 Prestressing materials:** All prestressing steel, sheathing, anchorages and sleeves or coupling must be protected during transportation, handling and storage. The pressing steel sheathing and other accessories must be stored under cover from rain or damp ground and protected from the ambient atmosphere if it is likely to be aggressive. Storage at site must be kept to the absolute minimum.

Prestressing steel shall be stacked in a closed store having single door with double locking arrangements and no windows. Also the air inside the store shall be kept dry as far as possible by using various means to the satisfaction of the Engineer. Also instrument measuring the air humidity shall be installed inside the store. This is with a view to eliminating the possibility of initial rusting of prestressing steel during storage.

**3.9.7.6 Water:** Water shall be stored in containers/tanks covered at top and cleaned at regular intervals in order to prevent intrusion of foreign matter or growth of organic matter. Water from shallow, muddy or marshy surface shall not be permitted. The intake pipe shall be enclosed to exclude silt, mud, grass and other solid materials and there shall be minimum depth of 0.60m of water below the intake at all times.

### **3.9.8 Tests and standards of acceptance of material:**

The contractor shall furnish test certificates from the supplier of material along with each batch of material (s) delivered to Site.

The contractor shall set up a field laboratory with necessary equipments.

The testing of all the materials shall be carried out by the Engineer or his representative at site.

Tests which cannot be carried out in the field laboratory have to be got done from recognized laboratory.

#### **Testing at site:**

##### **Sand:**

- (1) Grading by sieve analysis.
- (2) Fineness modulus.
- (3) Silt test - with measuring cylinder filled with salt water solution (one teaspoonful to half liter water). Fill the cylinder up to 50ml, mark and then pour the sand until the level of sand reaches 100 ml mark and the water level higher. Add more salt water till the level reaches 150 ml mark. Then shake the cylinder and keep on a level surface and tap gently until the top of the same layer is level. Allow to settle for 3 hrs and measure the height of the silt layer on top of the sand. This should

not be more than 6 ml or 6 per cent of the height of sand.

- (4) Organic impurities test - take 3 per cent solution of caustic soda (sodium hydroxide) in water in a graduated clear glass bottle of 350 ml. Fill it up with the sand upto 125 ml mark, add the caustic soda solution with shaking until the level comes to 310 ml mark. Shake the bottle vigorously and leave to stand for 24 hrs. Check the colour of the liquid on top, clear and light straw colour is acceptable. Darker colour show organic impurity.
- (5) Moisture content - use any instrument known as 'speedy moisture tester'<sup>1</sup> or by liquid displacement method or by the conventional method of weighing, drying and re-weighing.

Coarse aggregates:

- (1) Grading by sieve analysis.
- (2) Flakiness index.
- (3) Crushing strength.
- (4) Cleanliness i.e. impurities of clay, mud, vegetable matter, etc
- (5) Moisture content

## **4. QUALITY SYSTEMS FOR ROAD BRIDGES**

- 4.1** To ensure building of safe, serviceable, durable and economically viable bridges, it is necessary to have a strategy for management of human skills by way of quality .system defining quality policy, quality assurance and quality audit. Guidelines on quality systems for road bridges have been evolved by IRC vide SP: 47 - 1998 "to facilitate preparation of appropriate quality systems for new bridge projects and application of these guidelines will inculcate in all those involved in this building activity that provide the product or services expected of them consistently. These guidelines cover quality system for activities of bridge structure using concrete elements and include project preparation, design and drawing, construction and supervision, contract management, quality of materials and equipments used in construction and workmanship. The guide line also stipulate organizational requirement for adoption of quality system by suppliers, purchasers, owners, approving authorities and consultants. These guidelines have been made applicable for all the bridge structures on National Highways and centrally financed schemes by the Ministry vide Circular No. RW/NH 34066/5/S&R dated 20th Dec. 1999.

## **5. PROJECT SCHEDULING AND MONITORING OF WORKS**

### **5.1 Scheduling**

For all important bridge projects, it is essential to have a CPM/ PHRT chart for the entire project. Reference may be made to Special Publication No. SP-14 of IRC Construction agency should submit the chart preferably along with the tender, and in any case before commencement of work. For minor bridges, bar charts fixing the targets for the major activities along with the construction schedule may be submitted.

The various activities involved in the completion of the project right from the award of work to its completion shall be identified both in terms of time and money as also the resources like manpower, T&P and materials etc., required for the completion of the activity, the entire purpose being to streamline the construction procedures and take advance action in respect of those activities which affect the subsequent activities and in particular, the activities in critical path, so as to avoid any delay arising in the completion of the project. The inter-dependency of different activities should be correctly shown and the activity durations considered shall be realistic. The CPM chart should be updated regularly as the work progresses.

Availability of resources, viz, manpower, material, plant and machinery and funds shall be clearly identified to enable their mobilization / procurement well in time.

### **5.2 Monitoring**

- 5.2.1** To monitor the progress of the work at various stages, necessary data must be maintained at site showing the position of each activity, targets to be achieved, bottlenecks, if any, expenditure and position of funds, etc.
- 5.2.2** Monthly/quarterly progress reports may be prepared in the Performa prescribed by the RUIDP and submitted regularly to the concerned officers for their information and for keeping a close watch on the progress of the work and the problems encountered in the field with a view to sort them out.
- 5.2.3** It is necessary to ensure simultaneous completion of a bridge work and its approaches. Accordingly, progress made on the approaches may also be indicated.

### **5.3 *Documentation***

Record of design and drawings as approved for construction and completion of drawings as per actual construction should be maintained meticulously at the division / circle office or at Chief Engineer's office. To save storage space micro filming system may be introduced.

## Appendix - I

### CHECKLIST FOR PREPARATION OF GAD

#### A. GENERAL

1	Title block, scales names etc. correctly written	
2	Key plan indicated	
3	North Line indicated	
4	Chainage indicated	
5	In notes, units of dimensions, levels and chainages indicated	
6	In notes, Type of superstructure indicated	
7	In notes, Type of substructure indicated	
8	In notes, Type of foundation indicated	
9	In notes, Type of expansion joints indicated	
10	In notes, Type of bearings indicated	
11	In notes, Type of wearing coat indicated	
12	Grades of concrete for superstructure, substructure, foundation, approach slab, abutment, wing wall / return wall, toe walls, PCC below foundations etc. indicated	
13	Details for arrangements at dirt wall given	
14	Details for arrangements at expansion joints given	
15	Section of abutments given clearly	
16	Section of return wall along with fly wings given	
17	Section of piers and foundations given clearly	
18	All section marks and details numbering are tallying with the actual sections / details	
19	No detail / section numbering is repeated / missed	

## B. PLAN

1	Directions “to___” in both sides indicated	
2	Span arrangements with embankment lengths, viaduct lengths etc indicated	
3	Expansion joints indicated	
4	Crash barrier location shown	
5	Handrails location shown	
6	Piers, abutment, return walls / wing walls shown	
7	Toe walls shown	
8	Length of return wall / wing walls shown	
9	Skew angles indicated and skew / square dimensions indicated	
10	Centre line of bridge axis and piers / abutments indicated along with setout dimensions.	
11	Median indicated and shaded	
12	Median wall and connectivity / dry joint to existing structure shown	
13	Drainage spouts indicated	
14	Tapering of carriageways at approaches indicated	
15	Approach embankment revetment, side slope pitching and bed pitching with toe walls indicated	
16	Indicated the profile of river bed / railway tracks / roads	
17	U /s and D / s sides indicated	
18	Web lines indicated in dotted	
19	Chainages indicated	
20	Approach slab indicated	
21	Hand rails / Crash barrier lines indicated	
22	Railway chainage indicated and railway directions indicated	

### C. ELEVATION

1	Span arrangements with embankment lengths, viaduct lengths etc indicated	
2	Directions "To____" in both sides indicated	
3	Expansion Joints indicated	
4	Crash barrier location shown	
5	Handrails location shown	
6	Piers, abutment, return wall / wing walls shown	
7	Toe walls shown	
8	Length of return wall / wing wall shown	
9	Dimensions in square / skew indicated	
10	Centre line of bridge axis and piers / abutments indicated along with setout dimensions.	
11	HFL indicated	
12	Chainages and FRL at deck level indicated	
13	Bed level indicated	
14	Approach embankment revetment, side slope pitching and bed pitching with toe walls indicated.	
15	Foundations shown and levels indicated	
16	Indicated the clearance from HFL / tracks / highest road level to soffit	



#### D. SECTION

1	Title block, scales nemes etc. Correctly written	
2	Crash barrier location shown	
3	Handrails location shown	
4	Piers, abutment, return walls / wing walls shown	
5	Toe walls shown	
6	Centre line of bridge deck with respect to existing bridge indicated	
7	Drainage spouts indicated	
8	HFL indicated	
9	FRL at deck level indicated	
10	Bed level indicated	
11	Approach embankment revetment, side slope pitching and bed pitching with toe walls indicated	
12	Section of piers indicated	
13	Section of abutment indicated	
14	Foundations shown and levels indicated	
15	Indicated the clearance from HFL / tracks / highest road level to soffit	
16	U / s and D / s indicated	
17	Wearing coat indicated	

## **Appendix - II**

### **CHECKLIST FOR SUBMISSION OF GAD TO RAILWAY DEPARTMENT FOR ROBS**

1. Railway Boundary marked on GAD.
2. Railway track existing and tracks proposed in future marked on GAD.
3. A railway signal detail (if at point) is marked.
4. LC no if level crossing is present marked.
5. Railway chainage marked on drawings.
6. Minimum distance of Pile Cap / Pier Shaft / Abutment shall be minimum of 2360mm from the central line of track.
7. For the distance between top of railway track and soffit level shall be
  - a. The minimum height is 6550mm for ROB
  - b. Where double Decker trains are likely to run height is 7300.

Appendix III

KD  
14/03/10

Government of India  
Ministry of Shipping, Road Transport & Highways  
(Department of Road Transport & Highways)

Transport Bhawan,  
1, Parliament Street,  
New Delhi - 110 001.

No. RW/NH/33044/2/88-S&R(B)

24<sup>th</sup> March, 2009

To

1. Secretaries of all State Governments /UTs dealing with National Highways.
  2. Engineer-in-Chief / Chief Engineer of all States Governments/ UTs dealing with National Highways.
  3. Secretary, Transport of all State Governments and UTs.
  4. Chairman, National Highways Authority of India.
  5. Director General (Border Roads).
  6. *All ROs/ELO*
- Subject: Width of Bridges on 2-lane National Highways (with and without footpath).

Sir,

Instructions were issued vide this Ministry's letter of even number dated 9<sup>th</sup> May, 2000 regarding width of bridges to be provided on National Highways. The matter has been reconsidered in the light of concern for safety of vehicles/pedestrians using the bridges. The following revised guidelines are now issued in supersession of the earlier instructions for bridges on 2-lane NHs. These guidelines are applicable essentially to future cases.

2. GENERAL

The basic approach is that the width of carriageway of all bridges irrespective of their lengths or location / terrain (rural, urban, plain) shall be that:-

- a) ~~for free flow of traffic from approaches to bridge, width of carriageway on bridge shall be~~ equal to the carriageway width of immediate approaches plus paved shoulders even if presently not provided. For bridges on 2-lane NHs the carriageway width shall be 10.50m (paved shoulder and kerb shyness on either side taken as 1.50m and 0.25m respectively).
- b) Overall width of bridges will vary depending upon width of carriageway, footpath, safety kerbs, crash barriers, railings and provision for kerb shyness. Overall width of bridges for 2-lane NHs without footpath and with footpath are given in table in Annexure.
- c) Formation width of the immediate approaches shall be equal to overall width between outermost faces of the railing / crash barrier of the bridge. In case the formation width of approaches is different than the overall width of the bridge as stipulated in (b) above,

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*6.6.4.09*  
*2.2.2009*

formation shall be increased to the overall width of bridge in at least for 90 m on either side of bridge followed by a transition of 1:20.

### 3. Existing Narrow bridges on NHs:

3.1 Narrow Bridges having width of deck less than the width of approaches are potential source of accidents. It is necessary to provide positive guidance so that the drivers have sufficient information to safely negotiate the narrow bridges. For this purpose, the safety measures shall be adopted as per site requirement as spelt out in circular No. RW/NH/33044/2/88-S&R(B dated 31.10.2008.

### 4. FOOTPATHS

4.1 Footpath to bridges located in urban and rural areas may be decided on the basis of expected pedestrian traffic. In case the pedestrian traffic is heavy, the width of the footpath can be suitably increased or a separate pedestrian bridge can be considered depending on site condition. However minimum width of footpath shall be 1.5m.

4.2 Provision of footpath for bridges in rural areas particularly for very long bridges shall be considered on case to case basis.

4.3 Typical cross section of bridges on 2-lane NHs without footpath and with footpath of 1.5 m width are at Figure. 1 and 2 respectively.

4.4 In case provision for ducts for taking telephone wires, gas pipeline and electric cable is to be provided, then the shoulder shall be raised otherwise the footpath shall be at the same level as that of the carriageway on the bridge.

4.5 At the entrance to the footpath on either end of the bridge suitable barrier shall be provided so that two and three wheelers can't enter the footpath.

### 5. CRASH BARRIERS

5.1 Crash barriers shall be provided on all the bridges on National Highways to safeguard against the errant vehicles. The type & design for the concrete crash barrier may be adopted as per IRC: 5-1998 & IRC: 6: 2000.

5.2 For bridges without footpath, crash barriers shall be provided at the riverside.

5.3 For bridges with footpath, crash barrier shall be provided between footpath and carriageway as shown in Figure 2.

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5.4 For bridges with footpath, having length more than 100m, half metre (0.5 m) wide opening in the crash barrier shall be provided at 50 m interval.

**6. EXTRA WIDTH ON BRIDGES LOCATED ON CURVES:**

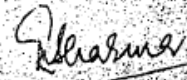
Extra carriageway width of bridge located on curves shall be provided as per IRC code provisions applicable for road section on curves.

**7. Road over bridges on National Highways**

The above provisions shall also generally apply to all road over bridges except where any deviations have to be made due to specific site constraints.

It is requested that the contents of this circular be brought to the notice of all officers in your department concerned with National Highways and other centrally sponsored schemes.

Yours faithfully,



Arun Kumar Sharma  
Chief Engineer (S & R)  
For Director General (Road Development) & S.  
Telephone: 011-237198

Annexure : Width of bridge on two lane National Highway with and without footpath

ANNEXURE

Width of bridge on two lane National Highway without and with footpath  
(Reference para 2 and fig. 1, 2 & 3).

Dimensions in meters

Description	Bridge without footpath	Bridge with footpath (1.5 footpath)
Carriageway	10.00	10.00
Kerb shyness	0.50(2x 0.25)	0.50(2x 0.25)
Footpath		3.00 (2 x 1.50)
Safety Kerbs	1.50 (2 x 0.75)	-
Crash Barrier	0.90 (2 x 0.45)	0.90 (2 x 0.45)
Railings		0.40 (2 x 20)
Overall width	12.90	14.80

**Note:**

(a) Carriageway width of 10.50m on bridges is planned to account for paved shoulders on approaches if provided later. Thus to arrive at the width of carriageway on bridges, the allowance for paved shoulders and kerb shyness has been made.

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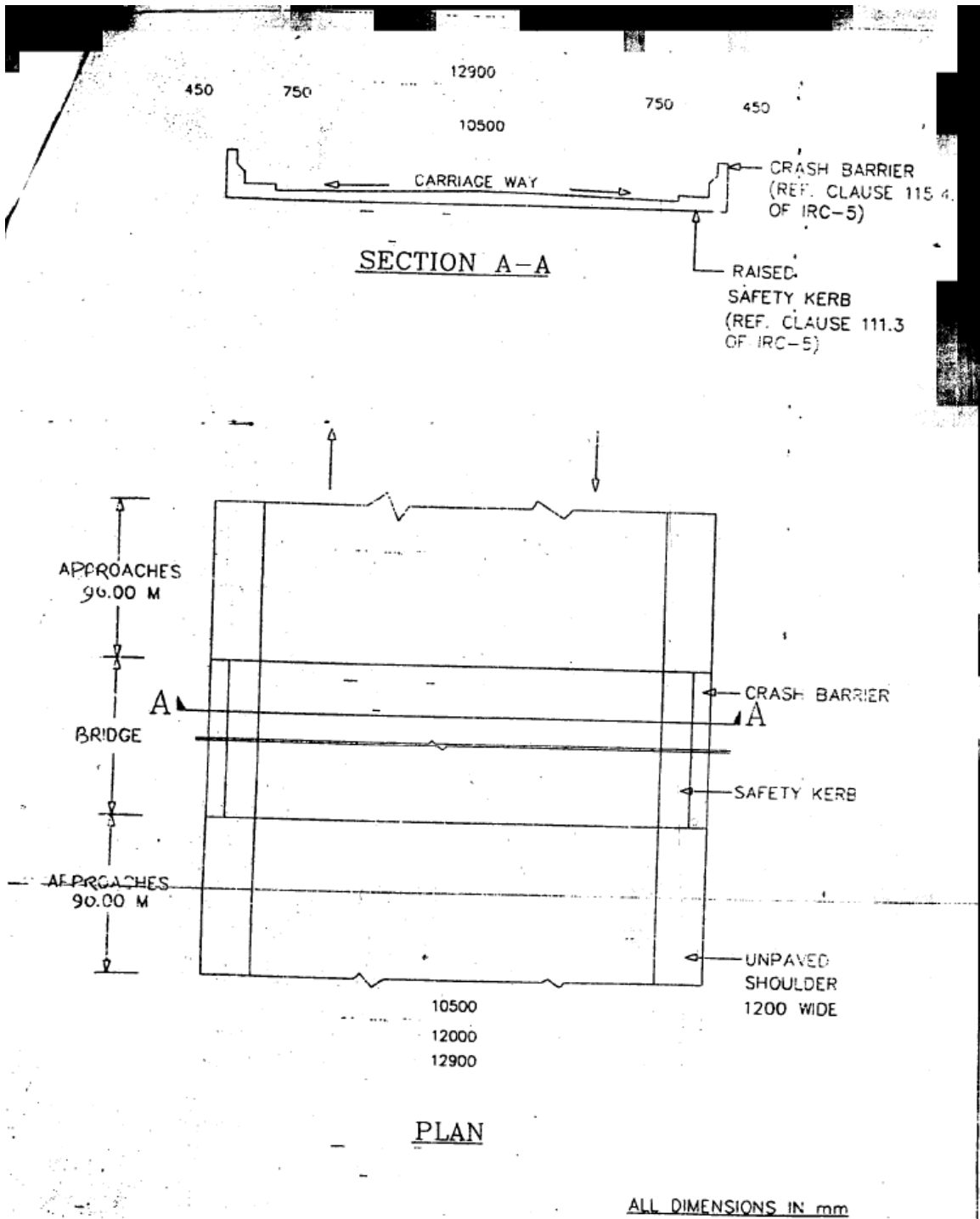
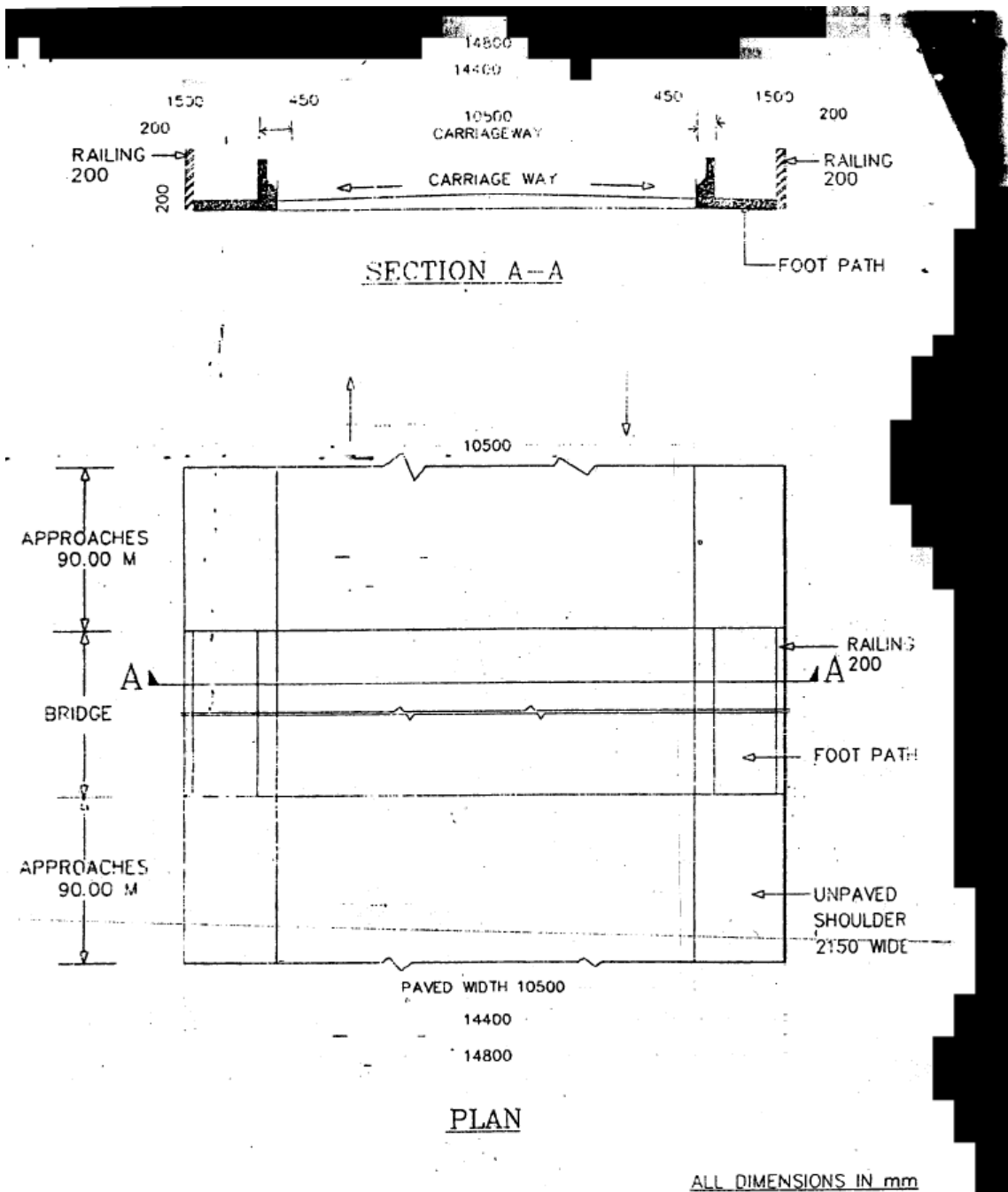


FIG 1:-TWO LANE HIGHWAY BRIDGE WITHOUT FOOTPATHS  
HAVING CRASH BARRIER AT THE EDGES

-5/6-



IG.2:-TWO LANE HIGHWAY BRIDGE WITH FOOTPATHS HAVING  
CRASH BARRIER BETWEEN FOOTPATH AND CARRIAGEWAY

-6/6-



**LIST OF CODES, SPECIAL PUBLICATIONS & BOOKS RELATED TO  
BRIDGE WORK**

S. No.	Code/ Document No.	Title
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**1. IRC SPECIFICATIONS, STANDARDS, DESIGN CODES**

1	IRC:5-1998	Standard Specifications and Code of Practice for Road Bridges, Section I – General Features of Design (Seventh Revision)
2	IRC:6-2000	Standard Specifications and Code of Practice for Road Bridges, Section II – Loads and Stresses (Fifth Revision)
3	IRC:18-2000	Design Criteria for Pre stressed Concrete Road Bridges (Post Tensioned Concrete) (Third Revision)
4	IRC:21-2000	Standard Specifications and Code of Practice for Road Bridges, Section III – Cement Concrete (Plain and Reinforced) (Third Revision)
5	IRC:22-2008	Standard Specifications and Code of Practice for Road Bridges, Section VI – Composite Construction (Limit States Design) (Second Revision)
	IRC:24-2010	Standard Specifications and Code of Practice for Road Bridges, Steel Road Bridges (Limit State Method) (Third Revision).
6	IRC:38-1988	Guidelines for Design of Horizontal Curves for Highways and Design Tables (First Revision)
7	IRC.:45-1972	Recommendations for Estimating the Resistance of Soil Below the Maximum Scour Level in the Design of Well Foundations of Bridges
8	IRC:78-2000	Standard Specifications and Code of Practice for Road Bridges, Section VII – Foundations and Substructure (Second Revision)
9	IRC:83-1999 (Part I)	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part I : Metallic Bearings (First Revision)
10	IRC:83-1987 (Part II)	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part II: Elastomeric Bearings
11	IRC:83-2002 (Part III)	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part III: POT, POTCUMPTFE, PIN and Metallic Guide Bearings
12	IRC:87-1984	Guidelines for the Design and Erection of False work for Road Bridges
13	IRC:89-1997	Guidelines for Design and Construction of River Training & Control Works for Road Bridges (First Revision)

**IRC SPECIAL PUBLICATION**

14	IRC:SP:13-2004	Guidelines for the Design of Small Bridges and Culverts (First Revision)
15	IRC:SP:23-1983	Vertical Curves for Highways
16	IRC:SP:29-1994	Directory of Indigenous Manufacturers of Road/ Bridge Construction Machinery & Important Bridge Components (First Revision)
17	IRC:SP:33-1989	Guidelines on Supplemental Measures for Design, Detailing & Durability of Important Bridge Structures

18	IRC:SP:37-2010	Guidelines for Load Carrying Capacity of Bridges
19	IRC:SP:47-1998	Guidelines on Quality Systems for Road Bridges (Plain, Reinforced, Prestressed and Composite Concrete)
20	IRC:SP:51-1999	Guidelines for Load Testing of Bridges
21	IRC:SP:54-2000	Project Preparation Manual for Bridges
22	IRC:SP:56-2000	Guidelines for Steel Pedestrian Bridges
23	IRC:SP:60-2002	An Approach Document for Assessment of Remaining Life of Concrete Bridges
24	IRC:SP:64-2005	Guidelines for the Analysis and Design of CastinPlace Voided Slab Superstructure
25	IRC:SP:65-2005	Guidelines for Design and Construction of Segmental Bridges
26	IRC:SP:66-2005	Guidelines for Design of Continuous Bridges
27	IRC:SP:67-2005	Guidelines for Use of External and Unbonded Prestressing Tendons in Bridge Structures
28	IRC:SP:69-2005	Guidelines & Specifications for Expansion Joints
29	IRC:SP:70-2005	Guidelines for the Use of High Performance Concrete in Bridges
30	IRC:SP:71-2006	Guidelines for Design and Construction of Pretensioned Girder of Bridges
31	IRC:SP:75-2008	Guidelines for Retrofitting of Steel Bridges by Prestressing
32	IRC:SP:82-2008	Guidelines for Design of Causeways and Submersible bridge
33	MORT&H	Standard Plans for 3.0 m to 10.0 m Span Reinforced Cement Concrete Solid Slab Structure with and without Footpaths for Highways, 1991
34	MORT&H	Standard Plans for Highway Bridges R.C.C. TBeam & Slab Superstructure – Span from 10 m to 24 m with 12 m width, 1991
35	MORT&H	Standard Plans for Highway Bridges PSC Girder and RC Slab Composite Superstructure for 30 m Span with and without Footpaths, 35 m Span with Footpaths and 40 m Span without Footpaths, 1991
36	MORT&H	Standard Drawings for Road Bridges – R.C.C. Solid Slab Superstructure (15° & 30° SKEW) Span 4.0 m to 10.0 m (with and without Footpaths), 1992
37	MORT&H	Standard Drawings for Road Bridges R.C.C. Solid Slab Superstructure (22.5° Skew) R.E. Span 4m to 10m (with and without Footpath), 1996
38	MORT&H	Standard Plan for Highway Bridges – Prestressed Concrete Beam & RCC Slab Type Superstructure Volume - II
39	MORT&H	Standard Plans for Single, Double and Triple Cell Box Culverts with and without Earth Cushion
40	HRB SR No.20, 2004	State of the Art : Development of Bridge Bearings
41	Paper Nos.109 & 112, 1946	Standard Specifications & Code of Practice for Road Bridges, Sections I & II (with Explanatory Notes & Discussions)
42	Paper No.238, 1996	Considerations in the Design and Sinking of Well Foundations for Bridge Piers (B. Bal want Rao & C. Muthuswamy)
43	I.S.: 1893 – 2002 (Part – I)	Criteria for Earthquake Resistant Design of Structures. (Fifth Revision) June 2002
44.	I.S.: 2911 – 1979	Code of practice for Design & construction of Reaffirmed Feb 2002

		Pile Foundation. (First Revision June, 1980)
45.	I.S.: 13920 – 1993	Ductile Detailing of Reinforced (Reaffirmed July 2003) Concrete Structures subjected to Edition 1.2 (2002-03)

#### BOOKS FOR REFERENCE

1	Open Channel Hydraulics – By Ven Te Chow
2	Essentials of Bridge Engineering – By D. Johnson
3	Bridge Engineering – By K.S. Rakshit
4	Concrete Bridge Design & Practice – By Dr. V.K. Raina
5	Foundation Design – By Wayne C Teng
6	The World of Bridges – By Dr. V.K. Raina