in specific zones within the bridge, transitions between sections with different Design Speeds shall be designed as per relevant IRC codes.

105.5 Longitudinal Gradient and Cross Slope

105.5.1 The maximum longitudinal gradient on bridge shall be consistent with the gradient of the approach roads as per relevant IRC codes.

105.5.2 The cross slope on bridge deck shall be consistent with the cross slope of the adjoining roadway.

105.5.3 During exiting a bridge, consideration shall be given to stopping sight distance, especially where bridge approaches are constructed close to intersections.

105.6 Super-Elevation

105.6.1 The super elevation and additional widening on the deck of a bridge on a horizontal curve shall be provided in accordance with the relevant IRC code.

105.6.2 Transition from normal cross slope to full super elevation shall be avoided over a bridge as far as possible.

105.7 Approaches to Bridge

105.7.1 The approaches on either side of the bridge for a length of at least 15 m shall continue to have the same horizontal profile as that provided for the bridge. This length may be suitably increased where necessary to provide for the minimum sight distance for the design speed. However, in difficult geometric situations, the minimum length of approaches with same horizontal profile may not be insisted upon, provided user's safety concerns are not compromised.

105.7.2 Where horizontal curves have to be provided on the approaches, beyond the straight portion on either side, the minimum radius of curvature, the super elevation and transition length for various speed and curve radii shall be provided in accordance with stipulations contained in relevant IRC Codes.

105.7.3 If there is a change of gradient in the approaches, suitable vertical curves shall be introduced conforming to stipulations contained in relevant IRC Codes.

106 HYDROLOGY AND HYDRAULIC DESIGN

106.1 Data collection for hydraulic design shall be made in accordance with Clause 104.2 of the Code.

106.2 Determination of Design Highest Flood Level

106.2.1 The design flood level shall be decided on the basis of data collected during reconnaissance survey, aerial survey, satellite maps, detailed survey and hydrological and hydraulic studies and analyses made.

106.2.2 *Design Highest Flood Level shall be the Highest of the following :*

a) The highest of flood levels as obtained from local enquiries from aged persons. Such local enquiries should be made at 3 different locations at site.

b) Level of the highest watermarks, left on different old structures or the erosion marks on the banks

c) Highest flood level that will be able to pass the design discharge as determined from other sources as per clause 106.3

d) The highest of the levels after considering the effects of confluence, backwater and HFL because of merger of or into any other river in the influence zone upstream or downstream of site.

e) The highest level as corroborated from the records of HFL available for existing bridges, other structures like dams and spillways and gauge stations etc. on the river in upstream or downstream direction.

f) Effect of any new structure planned for future in the influence zone of the stream.

106.3 **Determination of Design Discharge**

106.3.1 The design discharge for which the waterway of the bridge is to be provided, shall be based on maximum flood discharge of return period of 100 years. In case where the requisite information is not available, the design discharge shall be the maximum estimated discharge determined by consideration of the following or any other rational method.

106.3.1.1 From the records of discharge observed in the stream at the site of the bridge, or at any other site in its vicinity i.e., the discharge taken for design at any other bridge site and any other irrigation structures like dam or spillway or Gauge Station on this river in the upstream direction.

106.3.1.2 From the rainfall and other characteristics of the catchment:

i) By the use of an empirical formula, applicable to that region, provided that empirical formula can predict the maximum discharge for given return period.

ii) By a recognized method, provided it is possible to evaluate, for the region concerned, the various factors employed in that method.

106.3.1.3 From stage discharge curves, if available

106.3.1.4 By the area velocity method with the help of hydraulic characteristics of the channel. In case of the river not confined within banks and flowing in larger widths, the flow width should be divided into suitable zones i.e., main flow channel, side flow channel, slow channel and stagnant or no flow channel depending upon the characteristics and various parameters which should also be considered accordingly for calculation of discharge from that zone.

5.6.2 *Topographic Survey*

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

Ground surveys conducted at site help in preparation of site map and river cross sections. Keeping in mind that these maps are to be used in the identification of alternative locations and alignments, the surveys should be planned to be sufficiently exhaustive. Establishment of permanent bench marks at site linked to GIS levels which are to be used during detailed survey construction and maintenance must precede such survey.

5.6.3 *Hydrological Survey*

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

5.6.4 *Traffic Survey*

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

5.6.5 *Sub-soil Investigation*

In the feasibility stage, for minor bridge the sub-soil investigation on two locations, one in river bed and one in approach should be carried out. For major bridge, the sub-soil investigation at every 100 m or part thereof in river bed and one in approach should be carried out. The investigation carried out should give sufficient details for various alternatives under consideration.

5.6.6 *Geophysical Investigation*

Geophysical investigation by any or combination of the following methods suitable to site requirement, should be carried out for identifying the a) subsurface characterization for depth of bed rock, type of rock, layers and fractures in rock, water table etc. b) locating buried utilities c) for indicative engineering properties of soil and d) for selecting borehole locations. Geophysical Investigation is also suitable for obtaining subsurface information in environmentally sensitive areas, on contaminated ground or where the drilling is either not possible or extremely cumbersome.

5.7 Preliminary Engineering

5.7.1 *Design Philosophy*

Design philosophy of criterion is a clear, comprehensive and precise elucidation of the general principles to be adopted and the significant parameters to be used in the actual design of a highway bridge structure. Design philosophy forms the basis of design and also serves as a reference for the design procedure. Design philosophy flows from design requirements as per codes; nature of data base; the extent of available data; special requirements specified for the particular bridge structure by the client viz. special loads, increased clearances for navigational