DIRECTORATE GENERAL BORDER ROADS

TECHNICAL INSTRUCTION NO 3
(REVISION – 2022)

GENERAL INVESTIGATION AND SURVEY OF PERMANENT BRIDGE PROJECT

अजय भट्ट
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सत्यमेव जयते

आज़ादी का अमृत महोत्सव

रक्षा एवं
पर्यटन राज्य मंत्री
भारत सरकार
Minister of State for
Defence and Tourism
Government of India

MESSAGE

The revised DGBR Technical Instructions are unique as they combine technical content and codes with practical advice on practice of specific subjects. These Technical Instructions have definite data/content which explicitly bring out tools, process and methodology to be followed for various road construction and infrastructure development associated activities.

The literature is a repository of technical and ground experience amassed by the BRO, working over six decades in inhospitable terrain with harsh climatic conditions as well as latest technical advancements in the field of road communication infrastructure development. I personally find these technical instructors informative, exhaustive and practical in approach. These will mitigate the need for ground executers to refer various books/codes where working on various aspects of road construction and will go a long way in assisting the coming generations of BRO executives.

Jai Hind !

Ajay Bhatt

(Ajay Bhatt)

Dated : 20 Dec, 2021

New Delhi

डा. अजय कुमार
रक्षा सचिव
Dr. Ajay Kumar
Defence Secretary

सत्यमेव जयते

आज़ादी का अमृत महोत्सव

भारत सरकार
रक्षा मंत्रालय
Government of India
Ministry of Defence

FOREWORD

1. I am pleased to note that the Border Roads Organisation (BRO) has revised its twenty seven Technical Instruction, after a gap of 10 years having updated technical content and IRC codes. These Technical Instructions will positively prove to be very useful and ready reckoner for the BRO ground executives while steering them towards the correct methodology and processes to be followed for diverse road construction and associated activities.

2. Since the past six decades, BRO has been developing road infrastructure in the remote regions of the nation. It has contributed immensely in nation building and ushered in prosperity and development in the border areas. A robust mechanism to channelize the road construction activities is an essential planning process and therefore, the revised Technical Instructions will facilitate in dissemination and application of engineering knowledge with updated codes and provisions, to enable the executives to construct roads with the latest specifications as laid down by IRC.

3. I congratulate Team BRO for their stupendous efforts put in for revision of the twenty seven Technical Instructions which will further strengthen their technical proficiency.

(Ajay Kumar)

New Delhi,

March 3, 2022.

श्रमेण सर्वम साध्यम्

ले. जनरल राजीव चौधरी, वी एस एम
महानिदेशक सीमा सड़क एवं कर्नल कमांडेंट
सीमा सड़क संगठन

Lt Gen Rajeev Chaudhry, VSM
Director General Border Roads &
Colonel Commandant
Border Roads Organisation

FOREWORD

1. DGBR Technical Instruction Number 3 (Revision 2022) lays down the guidelines for General Investigation and Survey of Permanent Bridge Projects in BRO.

2. The Technical Instruction Number 3 has now been updated and revised incorporating the current standards and specifications laid down by Ministry of Road Transport & Highways (MoRT&H) and Indian Road Congress. The specific requirement of roads under BRO, also have been kept in view while formulating the Technical Instruction.

3. Proper general investigation and survey of permanent bridge is of utmost importance not only for preservation of assets but also for their optimal utilization and traffic safety. The guidelines contained in this Technical Instruction will achieve these objectives with better user satisfaction.

4. This Technical Instruction will come into force with immediate effect.

Station: New Delhi

Dated: Mar 2022

(**Rajeev Chaudhry**)
Lt Gen
Director General Border Roads

INDEX

TECHNICAL INSTRUCTION NO 3

GENERAL INVESTIGATION AND SURVEY OF PERMANENT BRIDGE PROJECT

1. INTRODUCTION

1.1 Permanent bridges of spans more than 30 m fall under the category of major bridges. The efficacy of these bridges is vital to the maintenance of the line of communication and uninterrupted movement of traffic. To ensure the trouble free performance of these bridges, detailed investigation, survey, data collection and data computation and its compilation will be required for proper siting, designing and planning of the bridge scheme. The extent, nature and quality of investigations and analysis of data help in ensuring safety and cost-effectiveness of the structure. The best design and technologically superior option emerges only if investigations have been concluded with the utmost accuracy and completeness.

1.2 DGBR Technical Instruction No.3 "Bridge Survey and Project Report" was issued on this subject and same was subsequently revised in 1967 and in 1993. Since then BRO has gained much experience in this field of bridge activity by constructing many bridges all over the border areas. New publications of IRC and MoRT&H have been issued on various aspects covering or relating to the investigation and survey of bridge projects which leads to upgrade the TI-3 by revising it to incorporate the new guidelines. In view of this DGBR T.I. No 3 (revision-2022) is prepared for application in BRO. It supersedes the earlier DGBR T.I. No 3, DGBR T.I. No 3 (Revision-1967) T.I. No 3 (Revision-1993).

1.3 DGBR T.I. No 3 (Revision-2022) will be read in conjunction with other revised and new T.I.s for supplementary references and elaboration.

2. PLANNING OF OPERATIONS

2.1 **Aim.** The aim is to decide the final location of the bridge and to collect ground data for the proposed location for the preparation of the bridge scheme and subsequent detailed design.

2.2 General Considerations in Bridge Siting

2.2.1 In General, the merits of the site will decide the exact location / position of the bridge.

2.2.2 Hill roads are constructed much ahead of the construction of the permanent bridges. Though the alignment of the road broadly takes into account the suitability of the location of river crossing, but each situation will be subject to technical survey, investigation, examination and treatment of safe, suitable and economical bridge siting and subsequent designing.

2.2.3 The safety, suitability and cost of the alignment of approaches will also be considered in the final location of the bridge.

2.2.4 The total cost of the bridge and the approaches will be considered.

2.2.5 The consideration of the approaches to alignment and the bridge siting will be guided on the following general principles:-

(a) The location of the bridge upto a total length of 60 meters shall be governed by the alignment of the approaches unless there are some special problems in bridge design. In case of bridges on hill roads, both approaches and good site will have equal consideration.

(b) For major bridges of total length between 60 to 300 meters, both proper alignment of approaches and requirements of good bridge site should be considered together in ascertaining the most suitable site.

(c) For major bridges with total length above 300 meters, the requirement of good site should be of paramount importance and therefore it will govern the approach road design.

2.3 **Sequence of Operations**

2.3.1 The survey and investigation of bridge project will be conducted in a planned manner in the following sequence operations:-

(a) Map study for tentative feasible sites.

(b) Preliminary survey and investigation for site selection.

(c) Decision of Final Bridge site.

(d) Detailed Engineering of site selected with minimum 3 alternatives.

2.3.2 The sequence of operations may be suitably rehashed for different categories mentioned in para 2.2.5 above.

2.4 **Board of Officers for Site Selection.** A team comprising of three officers with SE(C)/Col, Lt. Col/EE(C)/Maj. and AEE(C)/ AE(C) level with Civil Engg background and should have knowledge of bridges, will be detailed by HQ CE (P) for selection of site. In case of bridges of longer span say more than 150 m and or problematic cases, HQ DGBR/RBAT Dte may consider associating its representative with Board.

3. MAP STUDY

3.1 **Toposheets.** Toposheets in the following scales will be used :-

(a) 1 : 2,50,000

(b) 1 : 50,000

3.2 **Methodology**

(a) Consider the topography of the longitudinal reach u/s and d/s of river.

(b) Mark problem areas.

(c) Reject stretches where possibility of findings suitable site is not possible.

(d) Site after rejection is delineated for ground survey.

(e) Mark 2-3 tentative/alternate sites in the delineated/possible areas. Care should be taken to see that alternatives are not sought for the sake alternatives i.e. the alternatives should be meaningful and sufficiently distinct from one another. The location of Temporary Bench Marks to be erected on all alternate sites for ready reference during site inspection.

(f) The help of google map or satellite image is also taken for all possible sites.

4. PRELIMINARY SURVEY AND INVESTIGATION FOR SITE SELECTION

4.1 **Reconnaissance and data collection.** Preliminary survey and investigation of the site, identified in the map study will be carried out to help the process of selection of site. In this stage, the broad features of the bridge will be identified. The possible locations, nature of crossing traffic dispersal system for different alternatives are identified. The reconnaissance

visi to the area of the intended bridge site is sufficient at this stage. The list of site data is given in Appendix- I – Data of alternate bridge site.

4.2 **Consideration of Site Selection**

4.2.1 Some points for consideration in the analysis of the alternative sites are given here under:-

(a) As far as possible, the bridge be sited across the narrowest width of the river.

(b) Stream to have stable and well-defined banks and having no history of being out-flanked.

(c) As far as possible, reach upstream and downstream of the site be straight. A bridge should not be sited across meandering stretches of rivers unless it is established that the banks at the bridge site are the nodal points of the river (i.e. the river has a history of touching these points year after year regardless of change in its course elsewhere).

(d) Bridge shall be at right angles to the direction of flow.

(e) 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 as per IRC:5-2015.

(f) The site shall be located away from the confluence region of large tributaries especially in its upstream.

(g) The sites shall be at a minimum clear distance of 300 meters from any existing railway bridge on the same river.

(h) The site to avoid costly approaches.

(j) It shall be free from outflanking attack of the river to avoid costly protective river training works.

(k) It is to avoid excessive under water construction.

(l) It shall be not located near the land-slide or unstable zone and /or avalanche prone area.

(m) The comparative economics of using the existing temporary bridge as a diversion and constructing permanent bridge at a new

site vis-à-vis constructing the permanent bridge at the existing bridge site and constructing a diversion to regulate the traffic during construction be studied.

(n) Site should be away from abrupt change in slope of stream bed and whirl/eroding area.

4.3 **Rough Cost Assessment.** The rough cost estimate of bridge, approach, false work for staging, Sub-Soil Investigation and protective works for all alternative sites will be prepared based on per meter price or on earlier estimate of similar work in that region.

4.4 **Comparative study of Alternative sites.** It includes the merits/ demerits and the total cost of alternative sites. It will include the bridge, approach, false work for staging, Sub-Soil investigation and protective works for each site.

4.5 **Preparation of Report on Site Selection.** Report on site selection will be prepared by the Task Force and will contain the following :-

Part I	:	Statement of Case.
	:	Recommendation of TF Commander.
Part II	:	Appendices :
	-	Detailed Data of existing bridge.
	-	Data for Alternative Bridge sites (Para 4.1).
	-	Rough Cost Assessment of Alternative sites (Para 4.3).
	-	Comparative study of Alternative sites (Para 4.4).
	-	Abstract of Field book.
Part III	:	Sketches and Plans:
	-	Toposheet marked with Alternative Sites.
	-	Sketch map of each site.
	-	Sketch plan showing rough alignment of the approaches with all required levels at each alternative sites

5. DECISION OF FINAL BRIDGE SITE

5.1 The report on Site selection will be considered by the Chief Engineer of the Project who will give his approval after inspection of site.

5.2 Report on Site selection and approval of Chief Engineer will be considered by the HQ DGBR(RBAT Dte) and acceptance will be conveyed to the HQ CE (P) after their satisfaction of the observations, if any, and/or inspection of site.

6. DETAILED ENGINEERING OF SITE SELECTED

6.1 Detailed survey and investigation will be undertaken in respect of the site selected for collection of general or topographic, climatic and hydraulic data. The normal methods of survey and investigation will be applied with modifications required, if any. The ground survey is to be done by Total Station only and fix the points by constructing the permanent structure with reference to Northing and Easting so that all the sites selected can be re-identified at the time of finalization of site and for future reference as and when required. The all alternate sites are to be properly marked with distance from existing bridge if any on layout. Some elements are covered in Appendix-I but will be again checked and confirmed before incorporating the same in the data sheet against the particular selected site. The details of the data for the proposed bridge will be compiled as per Appendix-II. For convenience of the functional staff, this Appendix will be termed as Appendix-II: Hydraulic Data for selected Bridge site. It will be authenticated/signed by the Commander Task Force after due scrutiny and verification.

6.2 Supplementary information will be furnished and incorporated on the basis of the detailed study of existing bridge if any, geological information, previous site reports, geological maps, air photographs, etc. and surface geological examination. For large and important structures, the information may be supplemented by geophysical methods.

6.3 The above information (Paras 6.1 and 6.2) will be examined and scrutinised by HQ CE (P) and accepted by Chief Engineer(P) for accuracy and adequacy, and submitted to HQ DGBR (RBAT Dte.).

6.4 HQ DGBR (RBAT Dte.) will conduct their scrutiny of the data and interact with HQ (P), if required, to confirm the accuracy and adequacy of the same. HQ DGBR (RBAT Dte.) may consider the requirement of following aspects:-

6.4.1 Geophysical Investigation such as:-

(a) **Electrical Resistivity**. The electrical resistivity method is based on the measurement and recording of changes in the mean resistivity or apparent specific resistance of various soils strata at site. The resistivity is defined as the resistance between opposite faces of a unit cube(Cm cube) of the soil. Each soil has its own resistivity depending upon water content, compaction and composition. Thus it is possible to know the nature and thickness of different strata of soils based on electrical resistivity values

(b) **Seismic Refraction Test**.

(i) In this method shock waves are created into soil a ground level or a certain depth below it by exploding small charges in the soil or striking a plate on the soil with hammer. The radiation shock waves are picked by the vibration detector where time of travel is recorded. The different velocity of waves indicates the different layers of the soil strata and its density. In a denser layer the waves travel much faster. This method is used for differentiating the various soil strata based on the velocity values.

(ii) In addition to above the detail report of Sub Soil Investigation of existing bridge if any or the geological map of the area to be investigated in detail to get the idea about the geology of the site under consideration.

6.4.2 Hydraulic model studies are carried out for determination of river behavior with particular reference to:-

(a) Changing of river course
(b) Angle of bridge axis
(c) Adequacy and water way
(d) Maximum dept of scour at critical locations
(e) Requirement of protection works including guide bunds

6.5 HQ DGBR (RBAT Dte) will prepare tentative bridge scheme covering the bridge site, the type of structure with span arrangement and the location and type of foundations , deck level, the program of sub soil investigation and the instructions for any further investigation, if the situation demands.

6.6 HQ DGBR (RBAT Dte) will clearly indicate the extent of exploration, number of bore holes and type of soundings, type of tests, number of

tests, etc. so that the adequate data for detailed design and execution are obtained. Sub Surface Investigation (SSI) will cover the entire length of the bridge and will also extend at either end for a distance of about twice the depth below the bed of the last main foundation.

6.7 The sub-surface data will be compiled in the format placed at Appendix-III: Sub-Surface Data for Bridges. Plate Nos. 1, 2 and 3 will be applied for presentation of the bore hole data.

6.8 The general guidelines for sub-soil data collection are as given below :-

(i) The engineering properties of the soil/rock.

(ii) The location and extent of soft layers and gas pockets, if any, under the hard founding strata.

(iii) The Geological condition like type of rock, faults, fissures or subsidence due to mining, porosity, etc.

(iv) The ground water level.

(v) Artesian conditions, if any.

(vi) Quality of water in contact with the foundation.

(vii) The depth and extent of scour.

(viii) Suitable depth of foundation.

(ix) The probable bearing capacity of the foundation.

(x) Probable settlement and probable differential settlement of the foundations.

(xi) Likely sinking or driving effort.

(xii) Likely construction difficulties.

6.9 The Commander Task Force as well as HQ(P) will scrutinize Sub-Soil Investigaion (SSI) data for the accuracy and will record where appreciable variation is noticed and suggest additional data, bores/ soundings to establish a complete profile of the underlying strata. Regarding additional bores/soundings can also be suggested and conveyed by the HQ DGBR(RBAT Dte).

7. SPECIAL CASES

7.1 The above instructions will be applied in general. For major bridges on turbulent rivers of longer spans and having variable foundation conditions, the HQ DGBR (RBAT Dte) may consider and lay down the detailed instructions of survey, investigation, tests and exploration and specify the thrust areas/activities on case to case basis.

Appendix – I

DATA OF ALTERNATIVE BRIDGE SITES

(a) Name of the river and Highway.

(b) Name of the state, district and nearest identifiable town or village in relation to the location of the sites under consideration.

(c) Map reference of the crossing or the approximate latitude and longitude.

(d) Location of the nearest G.T.S Bench Mark with their levels, exact location of all the alternate sites with co-ordinates (Northing and Easting).

(e) Nature of the river-perennial, tidal, snowfed, rainfed or flashy.

(f) All Details of existing bridge or causeway or ferry site on the same river in the vicinity. Distances of all alternate sites from existing bridge if any.

(g) North line and direction of flow of the stream.

(h) Index map of the catchment area (Scale 1:50,000).

(j) The catchment area for the river at the tentative site worked out in square km from G.T.S maps and same will be counter checked and marked on Google Map.

(k) Exact marking of H.F.L. on all alternate location.

(l) Information about velocity of flow in the stream, presence of floating debris, etc.

(m) Where the site is on straight or curved reach? If on straight reach, the length of the straight reach available on the u/s and d/s of the proposed bridge on all alternate sites be given.

(n) Extent and effect of afflux in case of existing bridge.

(o) Angle of skew.

(p) Name and approximate discharges of all tributary streams joining the river within a reasonable distance u/s of the site under consideration.

(q) The approximate depth of the deepest scour hole below HFL.

(r) Details of meandering alluvial rivers.

(s) Sketch of rough cross section of river to the scale.

(t) The bed material on the surface and a little below it as ascertained by probing with an iron rod.

(u) Material of the banks, whether any bank has been seriously eroded or silted at any point, rock outcrop or hard material jetting out from bank causing deflection of the current, its position, etc.

(v) A sketch map showing the rough alignment and condition of approaches on either side with topographical and built-up details.

(w) General notes about the availability of construction materials.

(x) If available, include at least three existing control stations in establishing any control points on all alternate sites.

(y) GPS co-ordinates of starting and end of bridge is must to mention and should be observed at any time shall be four or more satellite at a time.

(z) Every start and end point of all the alternate sites shall be connected with two or more permanent stations/points to relocate the bridge sites at any point of time.

Appendix – II

HYDRAULIC DATA FOR SELECTED BRIDGE SITE

1. **Location (Preferably Supported by Index Map)**

(a) Name of Road

(b) Name of river/stream on which bridge is to be constructed.

(c) Map reference of the crossing and year of its publication.

(d) Location of the nearest G.T.S Bench Marks with their levels.

(e) Name of the state, District and nearest inhabited identifiable locality on either end of the crossing on the roads leading to the site. Give approximate distance.

(f) Nearest rail head and its distance to the start of the road. Also indicate condition of the access road.

2. **Climatic Data**

(a) Temperature

(i) Annual Temperature.

(ii) Temperature range of the region (maximum and minimum)

(b) Rain Fall (To be supported by Indian Meteorological department data).

(i) Maximum in one hour in severest storm.

(ii) Maximum in 24 hours.

(iii) Monthly and annual rainfall characteristics (appended relevant meteorological records).

(iv) Duration and frequency of a storm with average intensity.

(c) Snow fall (Append with Meteorological department data).

(i) Monthly and annual snow fall characteristics (appended relevant records).

(ii) Maximum snow falls in 24 hours and total snow deposit height to be considered for design.

(iii) Maximum intensity of snow melting (mm/hr).

(iv) Whether site is affected by avalanches, if so, give details.

(d) Wind velocity to be considered for design (Ref Fig :10 of IRC:6-2017).

3. **Hydrology**

(a) **Catchment Characteristics**. An index map of catchment area for the river at the proposed bridge site by tracing the ridge line of the watershed from Topographical Survey of India Maps to a scale of 1:50,000 indicating following details to be attached :-

(i) Area in sq/Km/hectares computed by planimeter or tracing paper graphs.

(ii) Shapes (viz fan, pear, long, narrow, etc.).

(iii) Longitudinal Slope of river.

(iv) Surface Characteristics (SMB, Ordinary soil, rocky, sandy, clayey, etc.).

(v) Land use (afforestation, deforestation, urban areas, cultivate areas, etc.).

(vi) Storage areas (Lakes, Swamps, Tanks, Reservoirs, etc.).

(vii) Distance from critical point to bridge to bridge site (L) in Kms.

(viii) Names and approximate discharge of all tributaries joining within a reasonable distance on U/S of the site under consideration.

(ix) Fall in level from critical points to bridge site (H) in Mtrs.

(x) Details if any of future work that may affect the stream hydraulics should be collected.

All the above also to be cross checked and supported by Google Map.

4. **Topography**

(a) Index map to a scale of 1:50,000 (1 cm =500 mtrs) showing the proposed location and alternative sites investigated, existing communication, proposed road, topography, physical features and towns, etc. in the vicinity and local sources of materials like stone, timber, gravel, sand and suitable camping areas.

(b) A contour survey plan of the stream to be attached indicating following details:-

(i) The distance upstream and downstream of the proposed bridge site to be covered and scales to be adopted shall be as follows :-

(aa) 100 mtrs for catchment areas less than 3 sq km : Scale 1:1,000.

(bb) 300 mtrs for catchment areas 3 to 15 sq km : Scale 1:1,000.

(cc) 1500 mtrs for catchment areas of more than 15 sq km: Scale 1:5,000.

(ii) Two bench marks on either banks showing bearings and distances from distinguished reference points.

(iii) Details of all tributaries merging on u/s of the proposed bridge site up to reasonable distance.

(iv) All possible sites demarcated.

(v) North Line.

(vi) Suitable contour intervals (usually 2 m).

(vii) Outline of low bank, high bank, water edges, island, etc.

(viii) GPS co-ordinates of starting and end of bridge is must to mention and should be observed at any time shall be four or more satellite at a time.

(ix) Every start and end point of all the alternate sites shall be connected with two or more permanent stations/points to relocate the bridge sites at any point of time.

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

(i) Name of the stream and road.

(ii) Approximate outlines of the bank and channel HFL and LWL.

(iii) Direction of flow of water at maximum discharge.

(iv) The alignment of the proposed and existing approaches, if any, to the bridge site.

(v) The angle and direction of skew, if any.

(vi) The names of nearest inhabited identifiable localities at either end of the crossing on the roads leading to the site (Distance in Kilometer to be mentioned).

(vii) Mark the Location and Position of RLs' of the bench marks used as datum supported and taken from GTS bench mark.

(viii) Location of the longitudinal section and cross-section of the road and stream taken within the area of the plan.

(ix) Location of intermediate pier/ well foundation, trial pits and boring with their identification marks.

(x) Location of all Nallahs, temples, buildings, wells, rocky outcrops and other obstruction which may affect the approach alignments.

5. **Stream/Channel Characteristics**

(a) Type of River

(i) Seasonal or perennial.

(ii) Braided, meandering, or straight.

(iii) Other classification e.g. bouldery, flashy, tidal, well defined, etc.

(b) Water level (To be marked with different colors of cross sections)

(i) Highest flood level (H.F.L) and its year of occurrence, delimiting the areas flooded.

(aa) State if the flood level is affected by back water.

(ab) A chart of period of HFL for as many years at the relevant data is available.

(ii) Record of gauging stations.

(iii) In case of tidal rivers include high tide level, low tide level, spring and neap tide levels, wave heights.

(iv) Ordinary flood level (O.F.L.).

(v) Low water level (L.W.L.): Indicate the period of the LWL to determine the feasibility of construction of intermediate piers and to examine provision of diversion during construction.

(vi) Afflux and its nature and depth, if observed (not calculated value).

6. **Bed Material Characteristics (To Be Supported By Photographs)**

(a) Nature of bed material(Sandy, Silty, Clayey, Bouldery, Rockey, etc.).

(b) Rugosity coefficient (n). (As per IRC:SP:13-2004 Page 18, Table 5.1).

(c) Average size of material in erodible depth with the recommended value of silt factor (f).

7. Maximum surface velocity observed at proposed bridge site and corresponding water level (observations on velocity of flow can be made by noting the time taken by floats to pass two fixed points at a known distance apart).

8. Observed maximum depth of scour with scour level, indicating obstructions if any (Not Calculated) of existing bridge if any.

9. Whether floods carry floating debris such as big boulders and trees, if so, give size.

10. The linear water way/effective linear waterway of channels shall be determined as per clause 106.5.1 of IRC : 5-2015.

11. The formula for calculation of discharge and silt factor as adopted by HQ DGBR(RBAT Dte) is given in Appx-IV. The design discharge of the river at the proposed bridge site shall be taken as maximum of the following :-

(a) Calculated from observed maximum surface velocity.

(b) Determined as per clause 106.3 of IRC : 5-2015 in conjunction with article 7 of SP: 13-2004.

12. The compilation of scour depth and foundation adopted by HQ DGBR (Br. Dte) is given in Appx-IV. The anticipated maximum scour depth shall be adopted as the greater of the following :-

(a) Observed scour depth at proposed bridge site.

(b) Determined as per clause 703.2 and 703.3 of IRC:78:2014 as applicable.

(Note : Appended calculation sheets, if any, in respect of Srl No 10, 11 and 12 above).

13. A cross section of the river at the proposed site to a scale of about 1:1,000 horizontally and 1:100 vertically giving following informations:-

(a) Name of river, road and chainages.

(b) The river bed levels upto the top of banks and ground levels to a sufficient distance beyond the edge of the channel.

(c) Nature of sub-soil in bed, bank, approaches and location of trial bores.

(d) LWL, OFL and HFL(to be marked with different colors).

(e) Low and high tide levels in case of tidal rivers.

14. Additional cross-sections of the stream at approximately six times the gap both upstream and downstream of the proposed site from the bridge along the stream.(for smaller stream two additional cross-sections one upstream and the other downstream may be sufficient but for large rivers at least two on the upstream and two on the downstream should be taken)

15. A longitudinal cross section of the stream, showing the proposed site, HFL, OFL, LWL (to be marked with different colors) and bed levels at suitable intervals along the approximate center line of the deep water channel must be drawn. The horizontal scale shall be same as for survey plan and vertical scale not less than 1:1000.

16. **Details for Proposed Bridge**

(a) Proposed length/span of the bridge (With GPS coordinates of starting and end of proposed bridge.)

(b) Recommended deck level with the minimum vertical clearance required (as per article 12, IRC:SP:13:2004), depth of the structure, etc, and also minimum work in approaches.

(c) Type and depth of foundation recommended.

(d) Possibility of constructing intermediate piers.

(e) Dewatering required or otherwise, and the quantum of dewatering effort required in foundations.

(f) Possibility of sinking well and driving piles.

(g) **Details of approach road alignment**. A longitudinal section of rod in the approaches upto a distance of 300 m or more, if necessary, showing clearly the distances, ground levels and proposed approach road levels shall be furnished.

(h) If the bridge is skew, give the angle of skew.

(j) Possibility of diversion of traffic on the river crossing during construction, roughly mention the type of diversion Hume pipe or temporary Bailey Bridge required.

(k) Possibility of land/water routes for transportation of construction machineries and materials if required.

(l) Availability, location and distance chart from proposed bridge site of suitable constructional materials such as sand and aggregate for concrete work and stone for masonry work (give details of approach road quarries).

17. **Details of Existing Bridge.** Details of existing Road/Railway bridges or causeways, if any, on the same river in the vicinity of proposed bridge site :-

(a) **For existing bridges (Road/Railway) :-**

(i) Year of construction and agency.

(ii) Clear water way.

(iii) Type and depth of foundations.

(iv) Type of sub structure.

(v) Type of super structure.

(aa) Carriageway width.

(bb) Load classification.

(vi) Length of bridge with details of span.

(vii) Type of bearings.

(viii) Cross section along the centerline of bridge showing deck level, highest flood level and clearance above highest flood level.

(ix) Brief details along with sketches for protective works, if any.

(x) Any other useful information collected or observed regarding silting or scouring under bridge and damage to protective works.

(xi) Characteristics of soil in foundation and any other design data.

(b) **For existing causeways:-**

(i) Maximum depth of submergence.

(ii) Details of vents with sizes.

(iii) Frequency and duration of traffic interruptions during its submergence.

18. **Other Particulars**

(a) Is the proposed site located in seismic zone? If so, specify name of the zone and the seismic coefficient for design. Also information/ guidelines mentioned in clause 219.1.2 of IRC:6-2017 be adhered to regarding seismic details of proposed bridge site.

(b) Is the proposed site safe from landslides and rolling stones? If not, give details.

(c) Mention the period of working season available in a year.

(d) In case the proposed waterway is substantially more than that of existing temporary bridge, is it possible to construct a permanent bridge of a shorter/longer span in the vicinity of the existing one? If so, justify your proposal with the following supporting details:

(i) For Shorter Span Bridge

(aa) Complete ground data including availability of rock or hard un yielding strata for suitable formation at reasonable depth both in bed and banks.

(ab) Approximate length of the bridge and waterway.

(ac) Approximate cost of works in approaches.

(ad) Approximate cost of river training works.

(ae) Period of traffic held up during construction, if any

(ii) For Proposed site(Longer Span)

(aa) Approximate cost of works in approaches.

(ab) Approximate cost of river training works.

(e) Requirement of False work and its tentative proposal / arrangements, considering the topography and cross-section of the stream.

Appendix – III

Sub-Surface Data for Bridges. The sub-surface exploration shall generally be carried out as explained in clause No 704 of IRC:78-2014 and its Appendix-2. The following data are required to be given sub-surface zone wise as under : (this will be done if possible by visual inspection or after Sub-Soil Investigation(SSI) to get the clear idea of the nature of the Sub-Soil).

1. **For Erodible Strata**

(a) From bed levels to anticipated maximum scour depth levels.

(i) Soil classification.

(ii) Particle size distribution.

(iii) Density (Bulk, Dry, Saturated and submerged density).

(iv) Shear strength parameters: Angle of internal friction (ϕ), cohesion (C).

(v) Permeability where dewatering is expected.

(vi) Silt factor (f).

(b) From anticipated maximum scour depth level to foundation level.

(i) Soil classification.

(ii) Shear strength parameters: Angle of internal friction (ϕ), cohesion (C).

(iii) Coefficient of sliding friction with concrete and masonry.

(iv) Compressibility.

(v) Permeability where dewatering is expected.

(vi) Density (Bulk, Dry, Saturated and submerged).

(c) From foundation level to about 1.5 times the width of foundation below it.

(i) Soil classification.

(ii) Shear strength parameters: Angle of internal friction (ϕ), cohesion (C).

(iii) Compressibility.

2. **For Non-Erodible/Rocky Strata**

(a) Rock classification. (Viz, Hard igneous and gneiss rocks, Hard limestone and hard sand stone, schists and slates, hard slates, hard mud stones, and soft sand stones, soft shales and soft mud stones, soft lime stones, heavily shattered rocks, conglomerates and literates).

(b) Characteristics of rock

(i) Extent of weathering.

(ii) Hardness.

(iii) Joint spacing and bedding.

(iv) Rock Quality Designation (RQD) in %

$$\text{RQD in \%} = \frac{\text{100 x length of the core pieces Of 100 mm and longer}}{\text{Length of Run}}$$

3. The data of Bore Log shall be presented in the format as given in plate No 2, shown with illustration.

Appendix – IV

Formula for Discharge, Scour Depth and Silt Factor Calculation

1. **Estimating Design Discharge**

(a) Empirical Formula

(i) Dicken's formula. $Q = CM^{3/4}$

Q = the peak run-off in m^3/s and M is the catchment area in sq.km

C =11 – 14 where annual rainfall is 60 - 120 cm

= 14 – 19 where the annual rainfall is more than 120 cm

= 22 in Western Ghat

(ii) Ryve's formula $Q = CM^{2/3}$

Q = the peak run-off in m^3/s and M is the catchment area in sq.km

C = 6.8 for areas within 25 Km of the coast.

= 8.50 for areas between 25 and 160 Km of the coast.

= 10.0 for limited areas near the hills.

(b) Rational Formula (Run-off formula)

$$Q = 0.028\ P\ f A\ lc$$

$$lc = \frac{2\ \ lo}{(1 + tc)}$$

$$tc = 0.87\left[\frac{L^3}{H}\right]^{0.385}$$

For values of 'f' and 'P' Figure-4.2 on page 14 and table-4.1 on page 13 of IRC:SP:13-2004 may be referred.

(c) Area Velocity Method

$$Q = AV$$

$$V = \frac{R^{2/3}\ S^{1/2}}{n} \qquad \text{(Manning's Formula)}$$

$$R = \frac{A}{P} = \frac{\text{Area of flow}}{\text{Wetted perimeter}}$$

Where

V = The velocity in m/s considered uniform throughout the cross-section

R = the hydraulic mean depth

S = the energy slope which may be taken equal to the bed slope, measured over a reasonably long reach

n = the rugosity co-efficient

For valus of 'n' use Table-5.1 on page 18 of IRC:SP:13-2004 may be referred.

2. **Selecting Design Discharge.**

(a) Calculate discharge by using three different methods as mentioned above and make comparison.

(b) If Ist highest > 1.5 x 2nd highest, select design discharge as 1.5 x 2nd highest.

(c) If Ist highest < 1.5 x 2nd highest, select design discharge as Ist highest.

Note : To apply above procedure, specially 2(b), sometimes selected design discharge may be considerably lower than highest discharge. In such cases, reason of such wide variation should be verified by re-examining various data to avoid any possible mistakes and design discharge may be fixed after critical examination of data.

3. **Computation of Scour depth**

(a) Mean depth of scour, 'd_{sm}' in meters (below the H.F.L).

$$d_{sm} = 1.34 \left[\frac{D_b^{\,2}}{K_f} \right]^{1/3}$$

Where,

K_f = Silt Factor

= 1.76 x $d_m^{\,½}$ for particles having size between 0.04 mm to 2.00 mm (Refer clause 106.9.3.1 at page no. 24-25 of IRC:5-2015)

d_m = Weighted mean diameter of the bed material in mm

D_b = the discharge in Cumecs per metre width.

$$D_b = \frac{Q + X\% \text{ of } Q}{L}$$

X = 30 % for catchment areas upto 3000 sq Km.

= 30 to 20 % for catchment areas of 3000 to 10000 sq Km.

= 20 to 10 % for catchment areas of 10000 to 40000 sq Km.

= 10 % for catchment areas above 40000 sq Km.

Bridge located across streams having gravel or boulder beds (normally having weighted diameter more than 2 mm), there is yet no rational formula for determining scour depth. However, the formula given in Clause 106.9.3.1 may be applied with the following silt factors, for particle size more than 2.00 mm.

Bed Materials	**Mean size of particle (D_b)**	**Silt factor (K_f)**
Sand (Coarse)(2.0 mm to 4.75 mm)	1.29	2.00
Gravel (fine)(4.75 mm to 20 mm)	5.16	4.00
Gravel (Coarse)(20 to 80 mm)	26.00	9.00
Cobbles and Boulder (> 80 mm)	26.00	9.00

The result may be compared with actual observations at the site or from experiences on similar structure nearby and their performance and decisions taken on the basis of sound engineering judegment.

Notes:

(i) For intermediate values of catchment area, linear interpolation may be adopted.

(ii) The minimum vertical clearance above the HFL already determined as per IRC:5 need not be increased due to larger discharge calculated above.

(iii) In hilly areas keeping in view large amount of flow of debris, minimum vertical clearance shall be 2.0 m as per Para 2 (h) of HQ DGBR letter No. 90107/DGBR/Inspn/Brs/T-Coord/ 41/RBAT Dte dated 26 Aug 2021.

(b) Maximum scour depth, D_m (Page 11 & 12 of IRC : 78 -2014 may be referred)

(i) In the vicinity of piers - 2.00 d_{sm}

(ii) Near abutments

- Approach retained - 1.27 d_{sm}
- Scour allround - 2.00 d_{sm}

4. **Depth of Foundations, D_f.** (Page 13 & 14 of IRC : 78 -2014 be referred before finalizing the Depth of foundation). Following points to be kept in mind at the time of finalizing Depth of Foundation:-

(a) **In Soil.** The embedment of foundation in soil shall be based on assessment of anticipated scour considering the values given in Clause 703 of IRC:78-2014. Foundation may be taken down to a comparatively shallow depth below the bed surface provided good bearing stratum is available, and the foundation is protected against scour. The minimum depth of open foundation shall be upto stratum having safe bearing capacity but not less than 2.0 m below the scour level or the protected bed level.

(b) **In Rocks.**

$D_f = D_m + 1/3\ D_m$ Subject to condition that minimum $1/3\ D_m$ is 2.00 m for arched bridges and 1.20 m for other bridges.

(c) **Hard beds.**

(i) $D_f = D_m$ + 0.6 m anchored into rock having ultimate crushing strength (UCS) of 12.5 MPA and above and extrapolated SPT N value is more than 500.

(ii) $D_f = D_m$ + 1.5 m anchored into rock having ultimate crushing strength (UCS) < 12.5 MPA but e" 2.5 MPA and extrapolated SPT N Value is more than 100 but not less than 500.

(d) For well foundation minimum grip of $1/3^{rd}$ of the maximum depth of scour below the designed scour level be considered to decide the founding level (Ref clause 705.3 of IRC:78-2014)

Note : Scour depth and depth of foundation as calculated above will be measured from the H.F.L.

5. **Typical Example of Determination of Weighted Mean Diameter (d_m) of Particles.** (Adopted from IRC:5-2015 and IRC:13-2004, Plate No. 2,) Representative disturbed samples of bed materials shall be taken at every change of strata upto the maximum anticipated scour depth. The sampling should start from 300 mm below the existing bed. About 500 gms of each of the representative samples so collected shall be sieved by a set of standard sieves and the weight of soil retained in each sieve is taken. The results thereof are then tabulated. A typical test result is shown below (Table I & II).

Table-I

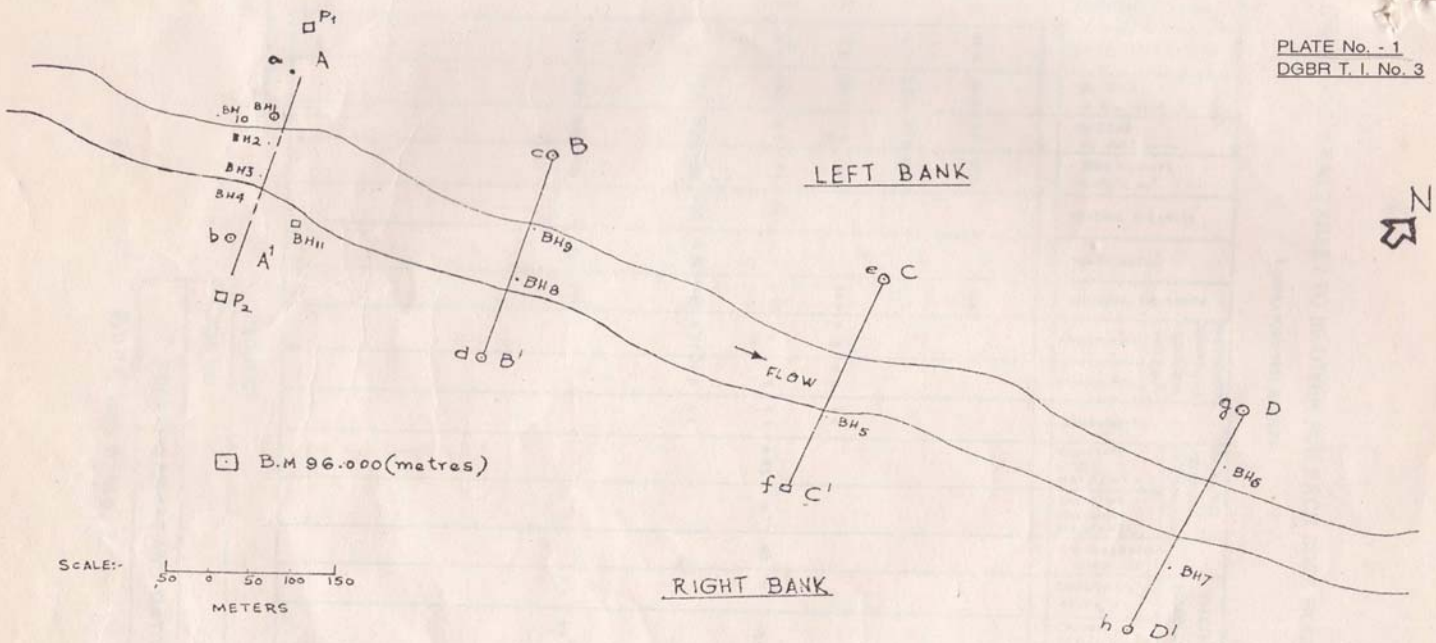
Sieve Designation	Sieve Opening (mm)	Weight of Soilretained (gm)	Percent retained
5.60 mm	5.60	0	0
4.00 mm	4.00	0	0
2.80 mm	2.80	16.90	4.03
1.00 mm	1.00	76.50	18.24
425 micron	0.425	79.20	18.88
180 micron	0.180	150.40	35.86
75 micron	0.75	41.00	9.78
Pan -	55.40	13.21	
Total:		419.40	

Table-II

Sieve No.	Average Size (mm)	Percentage of Weight retained	Percent retained (Col 2 x Col 3)
(1)	(2)	(3)	(4)
4.00 to 2.80 mm	3.40	4.03	13.70
2.80 to 1.00 mm	1.90	18.24	34.66
1.00 to 425 micron	0.712	18.88	13.44
425 to 180 micron	0.302	35.86	10.83
180 to 75 micron	0.127	9.78	1.24
75 micron and below	0.0375	13.21	0.495
			74.365

Weighted Mean Diameter (dm) = $\frac{74.365}{100}$ = 0.74365 Say 0.74

PLATE No. - 1
DGBR T. I. No. 3



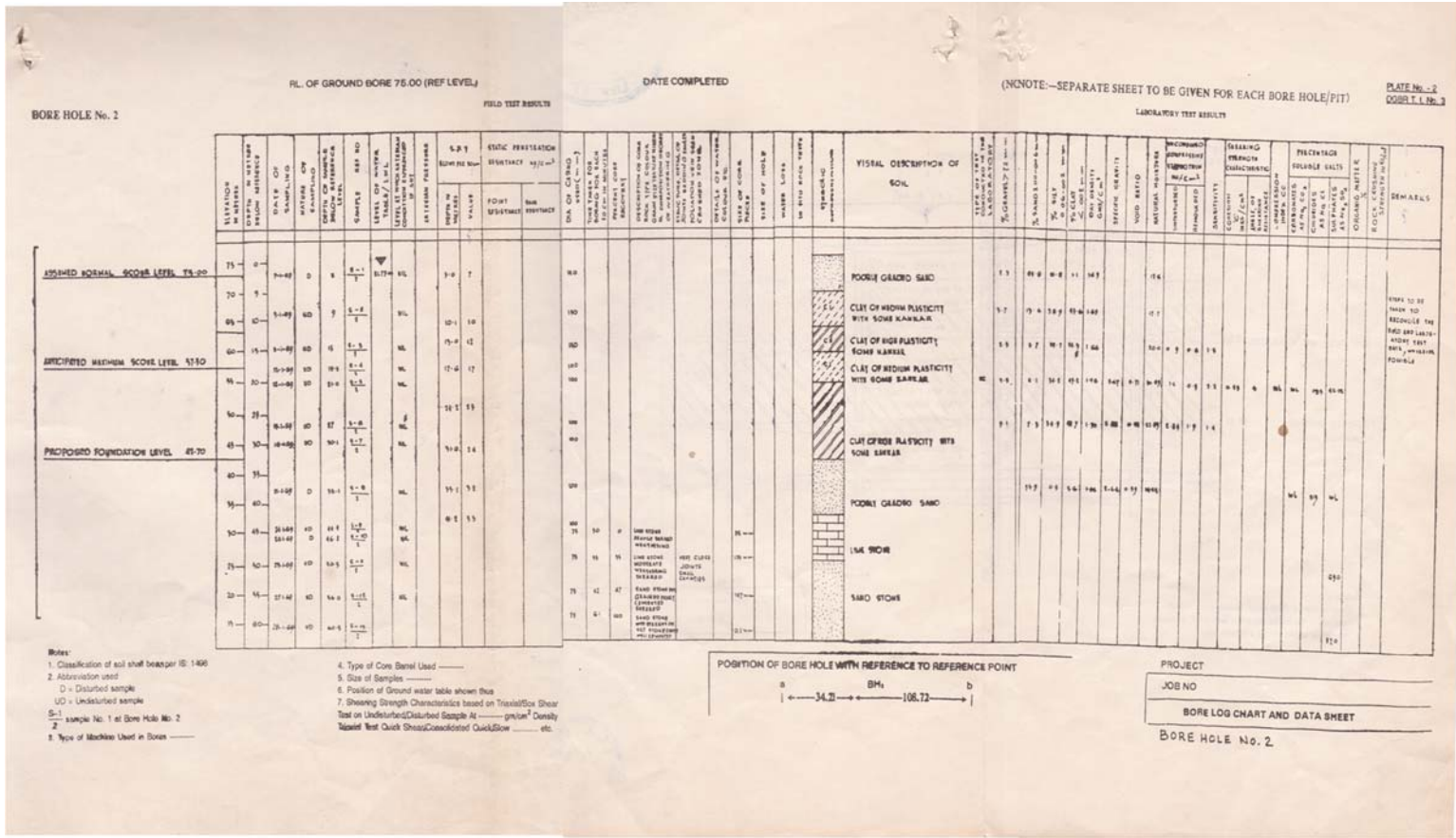
Notes:

1. The position of alternative sites marked AA', BB', CC', DD', etc.
2. The position of reference points marked a, b, c, d etc. be given with references to a permanent location/bench mark by giving the bearing and distances so as to locate the position of bore holes independently.
3. Position of bore hole marked BH_1, etc.
4. Position of pits marked P_1, etc.
5. The details are shown as a sample only.

PROJECT———————

SITE PLAN

SHOWING POSITION OF BORE HOLES, PITS ETC.


BORE HOLE No. 2
RL. OF GROUND BORE 75.00 (REF LEVEL)
DATE COMPLETED
(NOTE:—SEPARATE SHEET TO BE GIVEN FOR EACH BORE HOLE/PIT)
PLATE No. - 2
DGBR T. I. No. 3
FIELD TEST RESULTS
LABORATORY TEST RESULTS
ASSUMED NORMAL SCOUR LEVEL 73·20
ANTICIPATED MAXIMUM SCOUR LEVEL 57·50
PROPOSED FOUNDATION LEVEL 45·70
VISUAL DESCRIPTION OF SOIL
POORLY GRADED SAND
CLAY OF BROWN PLASTICITY WITH SOME KANKAR
CLAY OF HIGH PLASTICITY SOME KANKAR
CLAY OF MEDIUM PLASTICITY WITH SOME SAND AND
CLAY OF HIGH PLASTICITY WITH SOME SAND AND
POORLY GRADED SAND
LIME STONE
SAND STONE
REMARKS
Notes:
1. Classification of soil shall be as per IS: 1498
2. Abbreviation used
D = Disturbed sample
UD = Undisturbed sample
S-1/2 sample No. 1 at Bore Hole No. 2
3. Type of Machines Used in Bores ——
4. Type of Core Barrel Used ——
5. Size of Samples ——
6. Position of Ground water table shown thus
7. Shearing Strength Characteristics based on Triaxial/Box Shear Test on Undisturbed/Disturbed Sample At —— gm/cm² Density Triaxial Test Quick Shear/Consolidated Quick/Slow ——— etc.
POSITION OF BORE HOLE WITH REFERENCE TO REFERENCE POINT
a
BH2
b
34.21
108.72
PROJECT
JOB NO
BORE LOG CHART AND DATA SHEET
BORE HOLE No. 2