Newsletter
Issue-03

CoERBAT

Centre of Excellence for Roads, Bridges, Airfields and Tunnels

This Issue

REVISION IN IRC CODE – SILT FACTOR

In **IRC:5-2015**, there is a detailed procedure for determination of maximum scour depth using the universally accepted Lacey's formula adopted for different terrains in India which had certain shortcomings as far as **silt factor** for bouldery beds was concerned. Based on extensive study carried out on river scour data pattern by BRO, IRC vide their notification No 40, has revised the silt factor, which will be useful for all departments involved in construction of bridges in bouldery bed due to optimization of scour depth and will save govt exchequer.

Indian Highways Issue dated Feb 2022 has also highlighted the important contribution of BRO in this field.

SEGMENTAL CONSTRUCTION OF BRIDGES IN HILLY AREAS : AN OVER VIEW

Construction of bridges in hilly areas has always been a challenging task for the engineers. Deep gorge, bouldery river bed, high velocity of current, flash floods, limited working space and difficulty in diversion of flow, pose serious problems to the construction agencies in these areas. These factors at times, make it impossible to adopt conventional construction techniques, where formwork is supported on staging from the bed level and demand a high level of ingenuity of the engineers to bridge such gaps.

Segmental construction technique, which on the other hand, facilitates construction of longer span bridges, reduces intermediate piers and thus obstruction to flow, and avoid system of erection of staging from river bed level, has been found to be a very effective and economical technique in such situations. Besides least disturbance to the natural flow of water, their appealing aesthetics, speed in construction, reduced efforts in foundation and pier work, make this technique an obvious choice in such situations. Construction of foundations in bouldery river beds, is another tedious problem in hilly areas.

The slow rate of sinking combined with associated problem of tilt and excessive efforts needed on dewatering, at times forces the executives to adopt pneumatic sinking. However, this technique also has a restriction beyond a certain depth. Steel bridges, though offer wide choice to have longer span arrangements than a PSC construction but space restriction, problem in transportation of heavy fabricated components on hill roads and proper matching thereof with the case in situ elements remains a major problem. Border Roads organization, which is primarily engaged in construction of road infrastructure has made many bridges using segmental construction technique. Because of the space restrictions and transportation problem, cast-in situ construction has been adopted in segmental construction.

SEGMENTAL CONSTRUCTION TECHNIQUE

Designer has to take into account suitably, the construction technique in detail including stresses arising during construction and schedule of prestressing of cable at each stage.

Selection of a suitable span arrangement is the first step in design of any bridge project which is mainly governed by the site conditions. For segmental construction either a continuous span or a cantilever span having suspended span in between or a hinge is followed due to obvious advantages in design of pre-stressing system and construction. The connection between pier and the super-structure could either be a monolithic or otherwise supported on bearings depending upon the soil conditions and seismicity of the area.

Once a suitable span arrangement is decided based on the site conditions and characteristics of soil, the following steps are followed to evolve the design:

(a) Finalization of the dimensions of box girder depending upon the width of the carriageway/footpath. Depth at root section however mainly depends upon the span length and is normally equal to 1/8 of span.

(b) Based on the length of the arm, it is then divided into likely construction units. Length of each unit is generally kept in the range of 3.0 m to 4.0 m based on the construction convenience and the gantry parameters.

(c) On finalization of dimensions of the structure, stresses i.e bending, shear and tension, due to various specified loads is analyzed at each section. Attempt is made to remove the imbalance in the moment, if any, by suitable re-adjustment.

(d) Finally, the ultimate moments generated at each section due to dead loads and live loads as per the provisions contained in IRC:18-2020 are calculated. Thereafter, the design of super-structure is done in such a manner that it can resist the ultimate moments at each section. Suitable cable profile is accordingly decided based on the pre-stressing system to be used and the concentration of tensile stresses.

Segmental construction is however a delicate process and needs a fine balance at each stage of casting. Any imbalance at any stage could lead to severe damages and therefore, a thorough and careful approach is needed in casting of each segment. On casting of pier head, the process of segmental construction starts. A proper flow chart of the activities and sequence thereof is drawn for the purpose. In case of cast-in situ segmental construction, usually the following schedule is adopted.

(a) Construction of one unit each on both side of pier Head
(b) Erection of CLC gantry
(c) Casting of each subsequent cantilever units (including prestressing of cables to be anchored at that units)

CASE STUDY : A case study of one of such bridges constructed using segmental construction technique (cast-in-situ) is discussed in subsequent paragraphs.

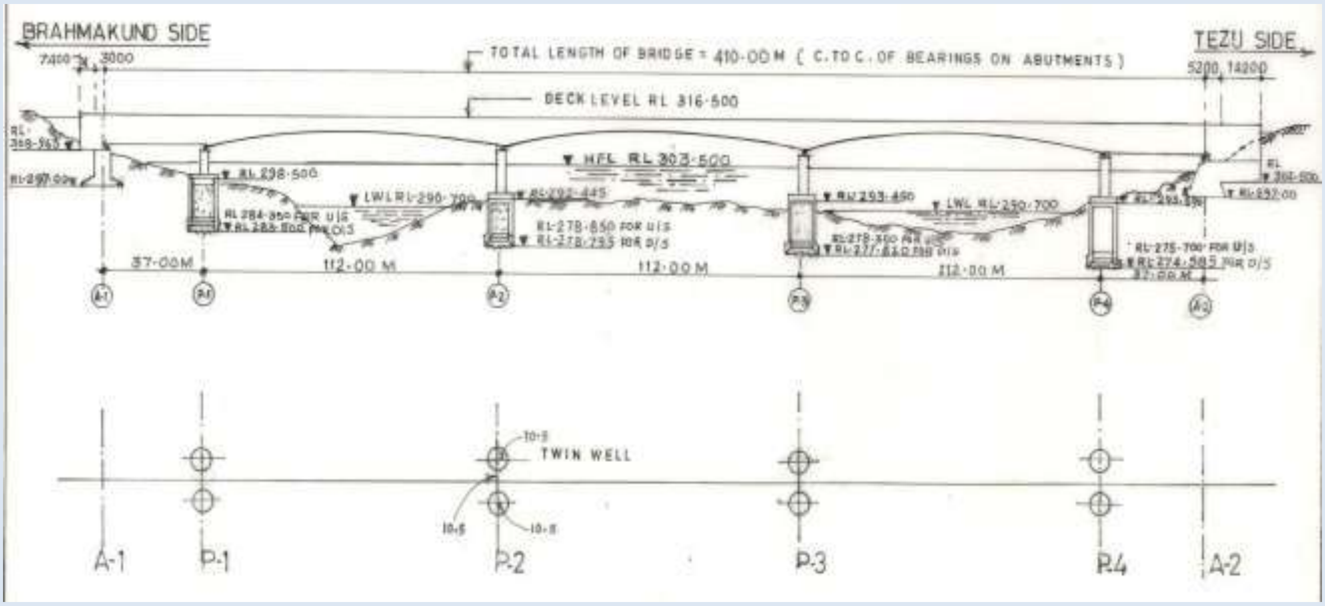


Fig 1 General arrangement drawing

Salient Features :

(i)	Length of bridge	: 410.00m (Fig 1)
(ii)	Span arrangement	: End spans (2x 37 m) & mid spans (3x112m) continuous bridge
(iii)	Overall width	: 11.05 m (2 lanes with footpath)
(iv)	Superstructure	: Continuous structure
(v)	Deck level	: RL 316.500 m
(vi)	HFL	: RL 303.500 m
(vii)	LWL	: RL 290.700 m
(viii)	Design Discharge	: 22000 Cum/ Sec
(ix)	Design Velocity	: 6.00 m/sec
(x)	Silt Factor	: 9
(xi)	Type of Strata	: Soil mixed with boulders/ Hard rock
(xii)	Type of foundation	
	(aa)Abutments	: Both sides - Open foundation
	(bb)Foundation/Pier	:RCC Twin well (circular shape). Distance between wells 5.25m. Outer dia – 10.5 (Fig-2)
(xiii)	Pier	: A – shape pier
(xiv)	Depth of box – girder	: Varies from 2.75m to 6.35m.

SUPERSTRUCTURE

Bridge having total length 410 m, is comprised of 3 spans of 112 m length each and two end spans of 37 m each on both the sides (Fig 1). On completion of foundation work at A1 and P1, the superstructure work was planned using cantilever gantry to cast the segments on each side of the pier. All the pier heads carry pot bearings. Abutment on left side had rocker bearing to cater for the total horizontal force of the structure and right side abutment provided with sliding bearing. To resist the total horizontal force, mass concrete filling has also been done with abutment having rocker bearing.

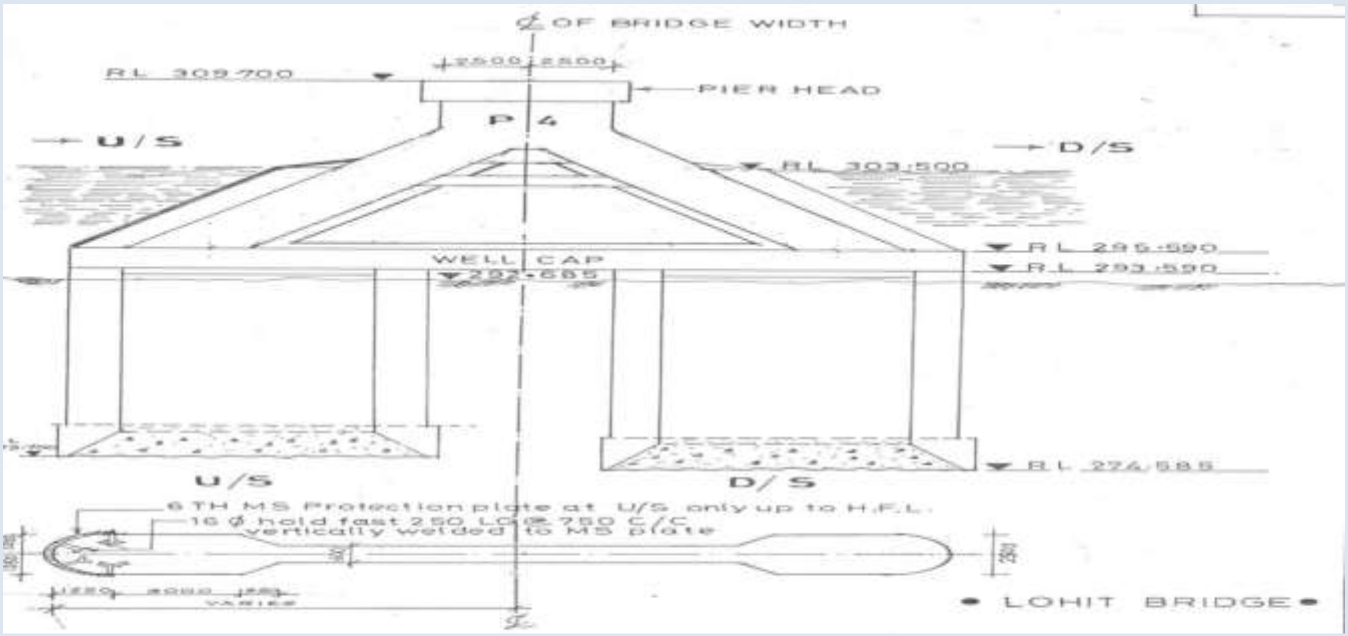


Fig 2 Foundation details

To start the superstructure works, firstly a gantry was fixed to cast the element on the pier head. One element was first cast on both the sides and then lowered and balanced on the bearing with the help of vertical pre-stressing. Details of superstructure are as under (Fig3) :-

(i)	Height of box at pier head	: 6.350 m
(ii)	Height of Box at central portion	: 2.750 m
(iii)	No of cable in one arm	: 62 nos
(iv)	Pre-stressing system	: 12T13

CONSTRUCTION METHODOLOGY

On casting of segment at pier heads (total length 7.80m i.e. 3.90 mtr on each side), the following methodology was then used to proceed with further work. For this purpose, a steel gantry was designed and fabricated for cantilever construction. The main trusses of the Gantry were provided with the arrangements for shuttering of soffit slab, webs and deck.

(i) Gantry consists of two units to facilitate casting of segments on both sides of the pier which was erected over the segment cast over the pier (Fig 4 & 5).

(ii) Thereafter, soffit shuttering, shuttering for web and deck shuttering fixed to the overhanging portion of the Gantry on both the sides is carried out. This was fixed to the desired level as per the design dimension and profile of the super structure (Fig 6 & 7).

(iii) Reinforcement was then tied as per the drawing and profile.

(iv) Concreting of both the units was done simultaneously. Soffit concreting was done first and, then that of web in stages and finally the deck slab.

(v) Required cables were stressed after the concrete attained the strength of M35. Profile of the cable which is most important was maintained effectively by cable hangers of 6 mm dia MS rods.

(vi) After stressing the cable, the segment got united with the previous segment.

(vii) The gantry was then released by loosening the back side bolts and front bolts.

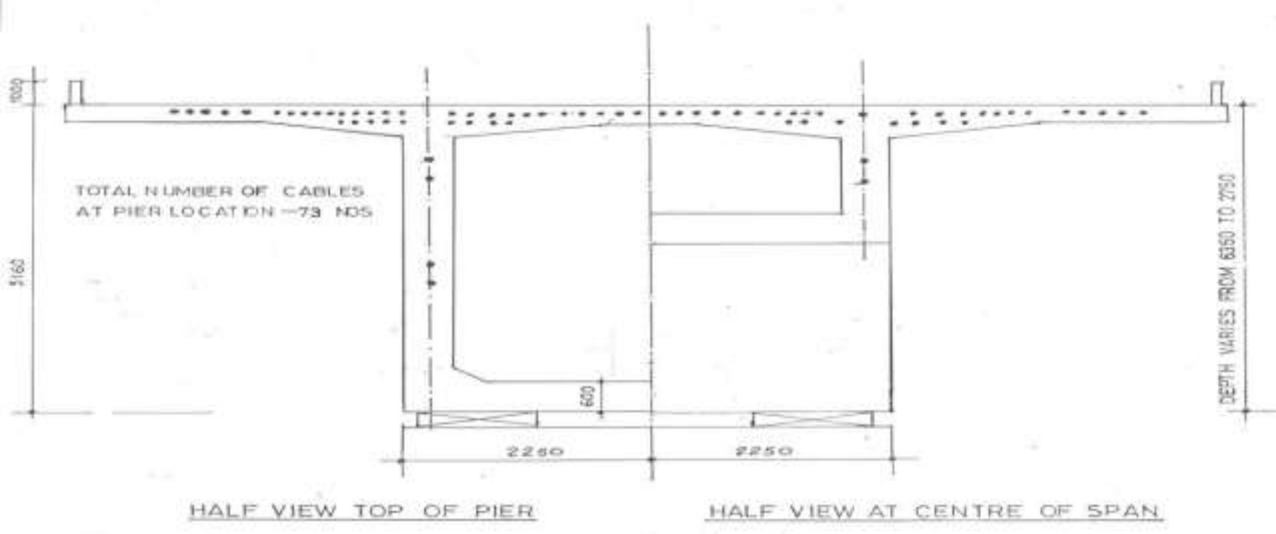


Fig 3 Details of superstructure

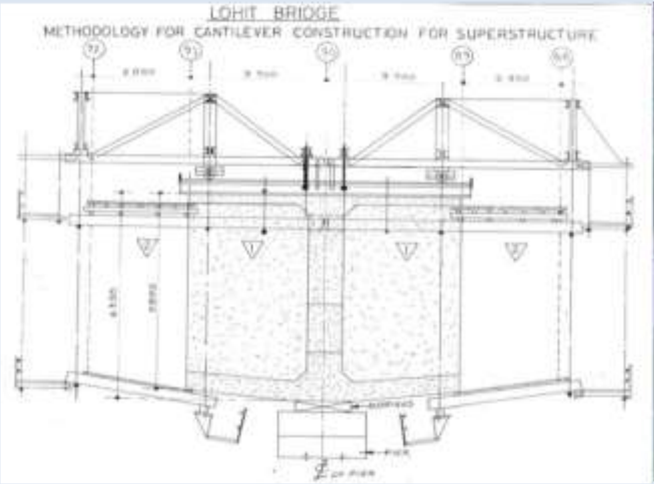


Fig 4 & 5: Casting of Elements on Pier Head Casting

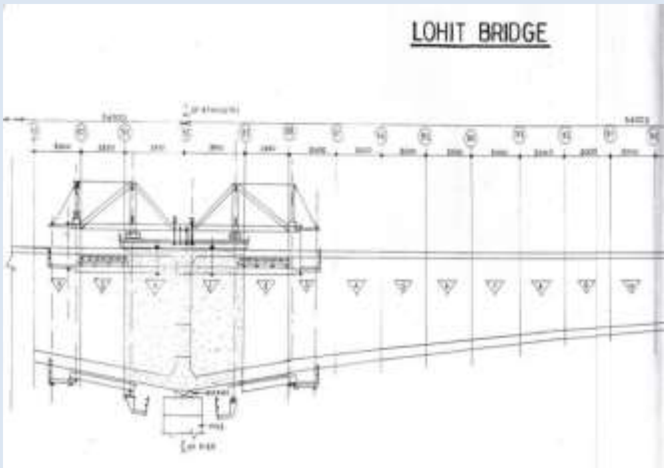
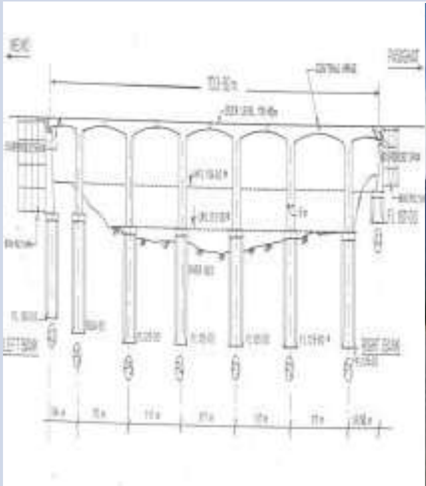


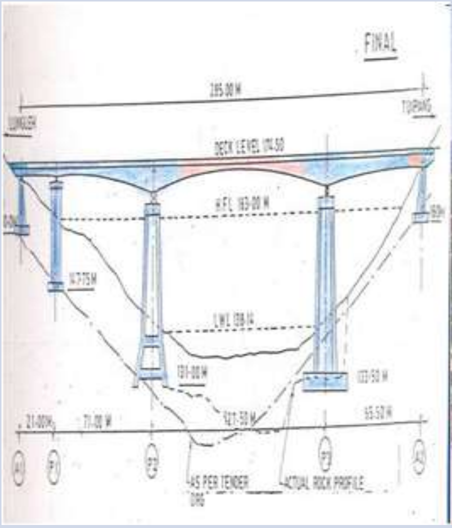
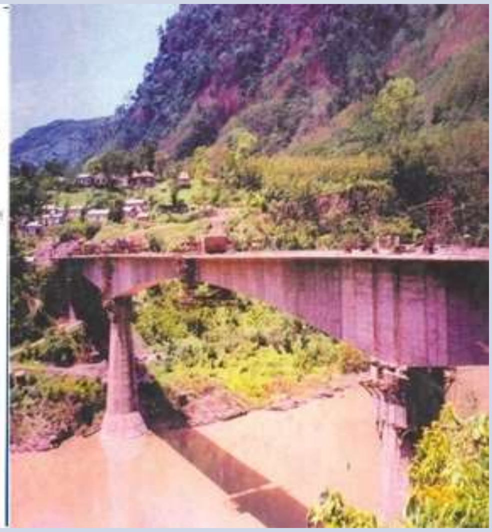
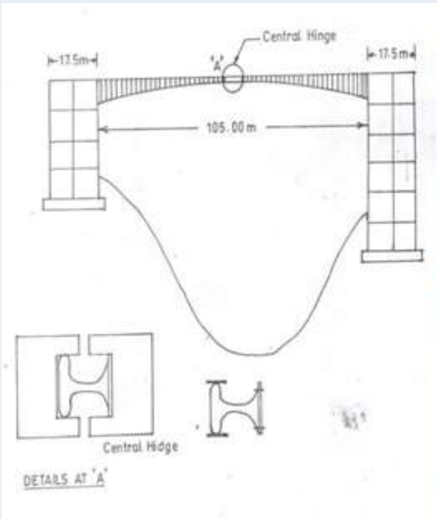
Fig 6 & 7: Casting of Elements on either side

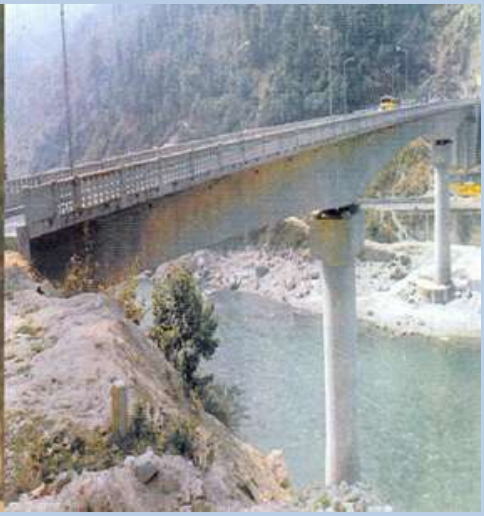
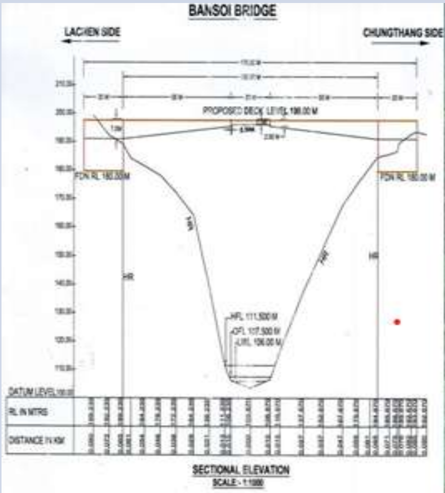
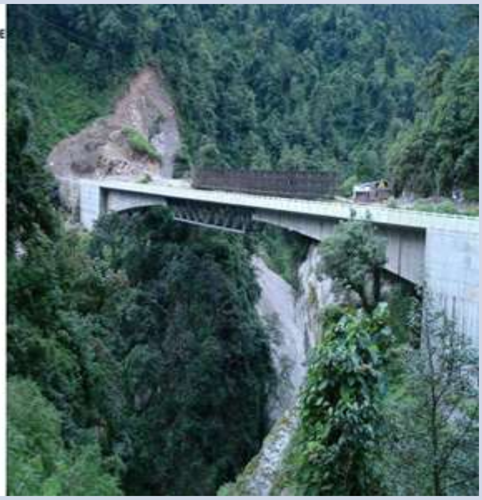
Fig 8 Completed view of Lohit Bridge

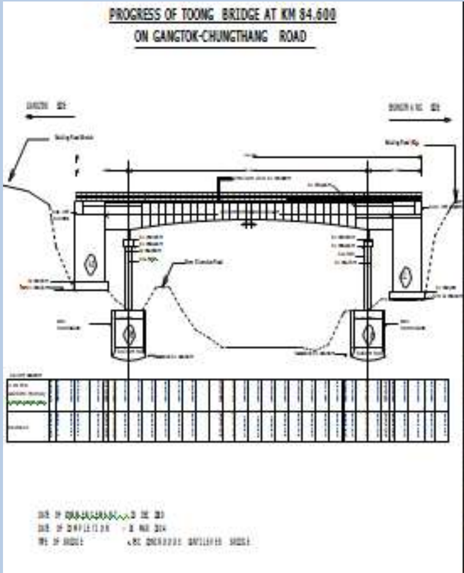
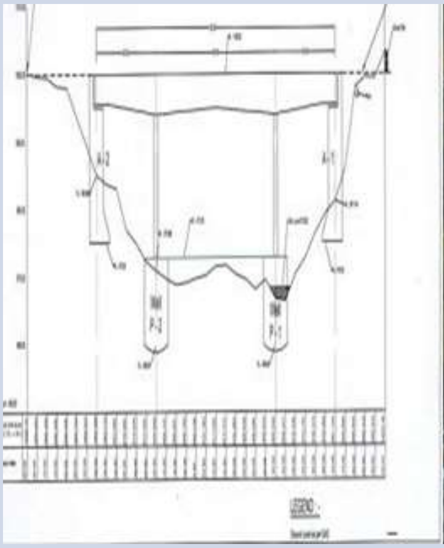
SEGMENTAL CONSTRUCTION ON OTHER BRIDGES

BRO has constructed number of bridges using segmental construction in the past. All were cast-in-situ, as launching yard arrangement is very difficult in the vicinity of the bridge site in hilly areas. Details of these bridges are as under:

S/No	Bridge Description	GAD and Completed View of bridges constructed through Segmental technique
1	Pasighat Bridge (463.5M) : Located on Siang river. Bridge got delayed badly due to difficulties in construction of well foundation	 

S/No	Bridge Description	GAD and Completed View of bridges constructed through Segmental technique
2	Chenab Bridge (180.0M) : Located on Chenab river in J&K. Initial scheme of the bridge was changed as difficulties were faced in construction of well foundation in this river.	 
3	Kaladhan Bridge (285.0 m) : Located in Mizoram over Kaladhan river. Delay in construction was due to foundation works.	 
4	Singdhar Bridge (140.0 m) : This bridge is located in Uttaranchal and has central hinge in super structure.	 

S/No	Bridge Description	GAD and Completed View of bridges constructed through Segmental technique
5	Teesta Bridge (185.0M) : Located over Teesta river. Initial proposal was to make arch bridge, which was later on changed to balanced cantilever, due to poor strata available for arch.	 
6	Bansoi Bridge (170.0M) : Located in Sikkim.	 
7	Rangrang Bridge (140.0M) : Located in Sikkim.	

S/No	Bridge Description	GAD and Completed View of bridges constructed through Segmental technique
8	Toong Bridge (130.0M) : Located in Sikkim.	 
9	Bakacha Chu Bridge (120.0M) : Located in Sikkim on Bakacha Chu river. Piers were constructed in well foundation	 
10	Beripattan Bridge (120.0M) : Located on MaunavarTawi river in J&K	

SPECIAL CONSIDERATIONS TO BE KEPT IN MIND DURING CONSTRUCTION

Construction of bridge by cantilever/segmental construction is a very delicate exercise and requires a proper insight on design and construction processes. A very thorough and careful approach is needed to maintain proper balance while casting of girder on both sides of piers, as any imbalance therein could lead to severe consequences. Following are some of the issues which need due considerations in such construction:

(a) Casting of first element on the pier head needs a detailed planning and special measures to facilitate casting of segment and thereafter this segment on bearing (wherever provided). This segment needs to be properly anchored with the pier cap during construction stage so that any imbalance in the moment is taken care of.

(b) Movement of gantry over this cast segment is another exercise which needs to be performed with equal care to ensure proper balances and alignment control.

(c) Pre-stressing of each element require proper care to ensure proper continuity with previous element and transfer of stresses accordingly.

(d) Last element which is called continuity element needs to be completed after examining stress transfer mechanism of whole arm and super-structure.

(e) Complete alignment and profile needs regular check at each stage. It is maintained in a manner that the last continuity element could match with each other properly and facilitate transfer of stresses in the designed manner. Any mismatch at this stage could lead to severe consequences and effect serviceability and durability of the structure.

(f) In case of cast-in-situ construction, quality control over the concrete mix is of vital importance.

Events held during last Quarter

A On-site Training on Planning and Construction of Tunnels.

On-site training is being conducted at Sela Tunnel for capacity build-up. As on date, 09 Officers and 13 JEs in four batches have been trained at site.

Following lectures are taken on various aspects of the tunnel project during training :

(a) Introduction to Tunneling

(b) Approaches to Tunnel Design. Four methods of design as below were covered in detail :

- Analytical Method
- Empirical Method
- Numerical Method
- Observational Method (NATM)

(c) Tunnel Support System

(d) Case study of Rohtang Tunnel

- Seri Nala Fault zone
- Rock burst at KM 7
- Severe Weather Conditions

(e) Drilling & Blasting Technique

Officers/Pers attending Lecture related to On-site Training on Planning and Construction of Tunnels at HQ 42 BRTF

B A **Compendium of Drawings of Superstructures** of thirteen Steel and seven Prestressed Concrete bridge has been compiled based on various bridges undertaken by BRO. All designs and drawings have been proof checked by experts in the field. BRO engineers can use these drawings to start the bridge work on ground which will save time. The same shall be released during BRO Day on 07 May 2022.

C Peculiarities of Runway Design and Construction at Bagdogra and Barrackpore.

The 4th lecture as part of Monthly Lecture Series on this topic was delivered by Brig S P Singh, CE (P) Swastik and Col Praveen Padmanabhan, Cdr 755 BRTF on 21 Jan 2022. The following major aspects were covered:

Brief History on Bagdogra Airport. Bagdogra is a Joint User Airfield (JUA) which serves people of four Indian states (West Bengal, Sikkim, Assam, Bihar) and three friendly neighbours (Nepal, Bhutan & Bangladesh). This Airfield was constructed during the Chinese aggression in 1962. On completion of the work, the runway and other operating surfaces will be able to handle all IAF aircrafts and civil airlines. In 2019-20, Bagdogra Airport handled 3.2 million passengers, 5000 MT of cargo and was the 18th busiest airport in India

The last resurfacing was done in 2000.

Brief History on Barrackpore Airport. During WW II, the airfield was used as a reconnaissance airfield by the USAF Tenth Air Force, which flew unarmed P-38 Lightening aircraft from the station equipped with several mapping cameras to gather intelligence on Japanese forces in occupied Burma. Barrackpore was also home to Spitfire Squadrons in the early 1950s. The last Heavy aircraft to land was C-130J Super Hercules in Jan 2012.

(a) Important technical details and challenges faced in runway reconstruction and resurfacing works at airforce station Bagdogra and Barrackpore were discussed by CE (P) Swastik.

(b) Execution of Works. List of broad execution plan with quantities of materials consumed are given in the following tables :

S/ No.	Work	A/U	Qty
1	Soil Stabilisation (250 mm)	10 Sqm	24,442
2	GSB (150 mm)	10 Sqm	57,860
3	WMM (75 mm)	10 Sqm	83,939
4	DLC (150 mm)	Cum	39,119
5	PQC (400 mm)	Cum	1,04,316
6	Resurfacing Flexible (140 mm)	10 Sqm	23,838

S/ No.	Items	Qty (MT)
1	Aggregates of various sizes	4,91,593
2	GSB Material	2,08,245
3	Cement	59,990
4	Steel various dimension	540
5	Bitumen VG 10	1,428
6	PMB 40	2,135
7	Admixture	313

Fourth issue of newsletter will focus on “Analysis of Bridge Damages and Rehabilitation”. Projects are requested to send suitable content related to the above topic in their respective AsOR, up to a maximum of 5 pages along with good quality photographs.

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