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GAMMON

IMS POLICY

Editorial

We are pleased to publish October-December, 2016 issue of Gammon Bulletin.

We take pleasure in presenting some of our recent significant achievements, successes, learning and events from across the country to our Gammon family, our esteemed customers and other beloved stake holders.

The lead article in the Bulletin is on Construction of Elevated Road at Patna for BSRDC. This is one of the flagship Projects of Bihar State Government. The Project has been executed on fast track basis and so far three Project Milestones have been achieved ahead of schedule. Record-breaking progress have been achieved on various activities like piling, casting of pre-cast girders, erection of girders etc. Achieving such consistent performance, month after month, was due to meticulous macro and micro planning, commensurate mobilization of matching resources duly line balanced, highest level of involvement from motivated team at site, positive attitude, team work, deep involvement of customer's and consultant's team etc. Site team has implemented several creative construction-friendly ideas and innovative construction methodologies while keeping an eye on cost-effectiveness and the same has been achieved without compromising on quality and safety considerations. The long list of innovations include innovative solution for movement of heavy launching gantry on compacted soil resting on soft ground and thereby avoiding normally adopted solution of providing piles, providing 2m long auger for pile boring in lieu of normally adopted 1 m long auger and thereby reducing boring time by 75 %, innovative pier formwork scheme for speedy erection and dismantling etc. The success story of this prestigious mega project, highlights the fact that if a project is mobilized in right earnest and initially execution is started on fast track basis without loss of time; a positive cycle is triggered which in turn results in improved progress unlike several projects where initial delays leads to triggering of vicious cycle.

The second Article titled "Bid Stage Economical Proposals for Bridges– A Critical Study" by Mr. A. K. Chatterjee highlights the importance of preparation of technical proposal and competitive bidding based on such economical technical proposal. This is the stage at which the fate of Bid is sealed though outcome will become public only when bids of all bidders are opened by the Owner/ Consultant. Few case studies of some classic success are worth noting.

In our quest to continually improve the Bulletin, we will be glad to receive feedback and suggestions from our valued readers to make Gammon bulletin more and more interesting and informative for the readers.

Your feedback and suggestions may please be sent to bulletin@gammonindia.com

We wish all our valued readers Merry X'mas and Happy and Prosperous New Year 2017.

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Cover Photo: High Rise Residential Building at Runwal Greens, Mumbai

ELEVATED ROAD PROJECT, PATNA

U.M. Kulkarni

Maruti Jambagi

1. PREAMBLE

India has a road network of over 4.7 Million km, the second largest in the world. Bihar being one of the largest states has a virtuous road network comprising of 29National Highways with thetotal length of 2,910 km and State Highways with total length of 3,766 km.

Bihar State Road Development Corporation (BSRDC) conceived this prestigious Project of Elevated Road Corridor (11.9 km length) connecting AIIMS and Digha. Hon'bleChief Minister,ShriNitish Kumar laid foundation stone to kick start commencement of construction work of India's one of the LongestElevated Corridor as his Dream Project. The projectinvolves construction of 2-lane semi-elevated and 4-lane elevated highway over Patna canal as approach road of rail-cum-road project across the Ganga at Digha. With the above inauguration, yet another glamorous project of BSRDC started taking shape.

After the Visit of Hon'ble Chief Minister of Bihar on 18th May, 2012; it was envisaged to consider the 4-lane approach road from Km 0.00 to Km 10.500 (starting point of Ganga Driveway) due to higher expected traffic flow from NH-84 ,NH-30 (Bye Pass of Patna and part of Patna - Buxur - NH-84), NH-98 (Patna-Aurangabad) , NH-19 (Chapra-Hajipur) and for the direct connectivity to AIIMS, Patna, and Ganga drive way.The approach road to Rail cum Road Bridge will get overfilled due to induced / diverted traffic with projected traffic of 30000 PCU in the year 2016 between Km 3.000 to 10.500 from 4-lane Patna-Buxur (NH-84), Patna-Bakhtiyarpur (NH-30), Patna-Aurangabad (NH-98), Danapur Railway Station, AIIMS, Patliputra Railway Station, Ganga Driveway and surroundings on both sides of the project.

The elevated road project will have major crossings at Bailey Road and Ashok Rajpath and will have connectivity with important places like Danapur railway station, proposed Patliputra railway station and AIIMS. Besides, it will also have connectivity with the Ganga Path and one Railway Bridge at Khagaul (Patna-Delhi) line. One minor bridge will also be linked to this project

Once completed, the road will provide much needed relief from the traffic congestion in the city, particularly on the narrow Ashok Rajpath as it would be connected with the Ganga Path at Digha end.

2. PROJECT DETAILS

2.1 Location Map and Satellite Images.

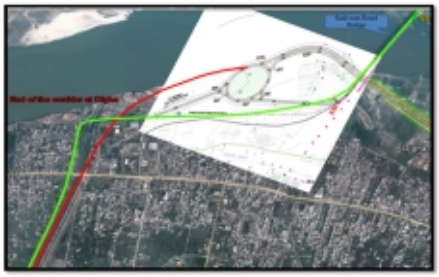
The Elevated Road Project is a part of prestigious Ring Road Project of city of Patna. The layout of Elevated Road as part of Ring Road Project and its satellite images are shown below:

Concept of Project to Develop Ring Road for Patna: Location Map

Concept of Project to Develop Ring Road for Patna: Satellite Image

CONNECTING NH-98 AT AIIMS to DIGHA BRIDGE

END OF THE PROJECT AT DIGHA



2.2 Scope of Work

The scope of work encompasses design, engineering, procurement and construction of a highway with 3 km (2-lane) semi-elevated structure and 8.5 km (4-lane) of elevated structure with divided carriageway with Junction improvements from AIIMS to Digha over Patna Canal, including construction of new pavement, construction of major and minor bridges, culverts, road intersections, interchanges, ROB, PUP,drains etc. and maintenance of the Project during the Defects Liability Period of five years.

The project proposal details are as below:

- Km0+000 – Km2+100: RHS 2 Lane road on Embankment
- Km2+100- Km2+300:- 4 Lane approach road
- Km2+300 to Km10+750- 2x2 lane Elevated Corridor

- Km10+750 to Km11+100 – 4 lane elevated on embankment / structure.
- Km 11+100 to Km 11+820 - 4 Lane with 2 Additional Lane Elevated on Embankment / Structure.

The project involves major activities like Pile foundations, Piers & Pier caps, Casting of Precast Pre-tensioned/ Post-tensioned I Girders, & Erection of the same using suitable capacity of Crane / Gantry, Cast in situ RCC Deck Slab Spans, Erection of structural span over Railway track (ROB), Fixing of Bearings, Installation of Expansion Joints, Cast in-situ Abutment, Abutment caps & Dirt wall, construction of Embankment, etc.

The site of the Four Lane Elevated and approach Road Corridor comprises the section of Highway commencing from AIIMS Patna Km 0+00 (Km 6+800 of NH-98) to Km11+900 at proposed junction of Ganga Path, Digha in the state of Bihar. The project highway from Km0+00 to Km 2+125 will be developed on RHS parallel to proposed NHAI road.

The proposed median will be developed from NHAI BT edge and new 2 lane road will be developed as per proposed alignment plan. The approach road to new 4 lane Elevated Road Corridor start after crossing the minor bridge and end at Km2+290 and 4 lane (2x2 lane) elevated road shall be developed from Km2+290 to Km10+755 following the canal bed up to Digha.

4lane elevated road on embankment /structure shall be developed from Km10+755 to Km11+100 and after that 4 lane with 2 additional lanes elevated on embankment/structure shall be developed from Km11+100 to Km11+820.

2.3 Salient Technical Features.

The Structure comprises of 25.0m two continuous span (deck continuity) with precast pretension I Girder sections resting on POT/PTFE bearing. The bridge is divided into two separate structures Left & Right carriageway separated by 3.50m – each structure carrying the traffic in one direction in two lanes with 1.55m wide footpath.

Each structure is supported by a pier and pile foundation. The Pier is solid rectangular in nature with a cantilever pier cap to support the superstructure. The Pier is in turn supported on pile foundation and a rigid pile cap. The piles are founded on firm strata to transfer the vertical and horizontal loads from the structure.

2.4 StructuralDesign- Overview

The Load cases under consideration are Dead Load, Superimposed Dead Load, Live Load, Footpath Live Load, braking force, Wind Load, & Seismic Loads. The certain conditions which occur simultaneously are taken together like, braking and live load. Bearing friction is considered along with each individual permanent load case and not as a separate load case. These loads are combined as per the recommendations of IRC 6 with appropriate load factors. While preparing the load combinations the worst effects of individual loads are taken to arrive at the design loads.

Bending moment in the pile is calculated by spring constant analogyarrived from horizontal & vertical subgrade reactions. The geotechnical capacity of the pile is as per the pile capacity calculation report. To calculate the forces in the piles which depend on the stiffness of the substructure, the fixity is considered at the top of pile cap. For the purpose of design the pile foundation is modeled in STAAD with spring constant & horizontal forces applied at the pile cap bottom. For the distribution of forces in the piles, the pile cap is considered as rigid. The pile cap is designed as a flexural member for the critical load case.

For Design of Pile Foundation of this Elevated Road Corridor Project following aspects are taken in to consideration:-

- Dimensions of Structure
- Forces on Structure from Superstructure
- Forces on Substructure
- Geotechnical Aspects of Pile
- Evaluation of forces & moments at base of the pile cap
- Load combinations Ultimate limit state
- Pile design by serviceability limit state
- Design of pile cap in ultimate limit state
- Stress check of pile cap in serviceability limit state

Forces on Structure from Superstructure

- Dead load and footpath live load
- Wind load : as per IRC -6
- Bearing forces : as per IRC-6 clause 211.5.2
- Water current forces : as per IRC-6
- Seismic forces : as per IRC-6 for zone factor, importance factor and foundation strata

2.5 Pavement design- Overview

Pavement design basically aims at determining the total thickness of the pavement structure as well as the thickness of the individual structural components.Flexible Pavement is designed using Cement treated base&Granular Sub-base by applying the mechanistic principles given in IRC: 37-2012.Design inputs required for the pavement design are established based on the site investigations. The Type of Pavement for the Main carriageway (except Elevated Portion) has been designed as Flexible Pavement with cemented base & sub-base.New Flexible pavement as well as widening and strengthening of the existing pavement have been designed for a minimum design period of fifteen years.The pavement has been designed for traffic of 150 msa (million standard axles). The pavement has been designed considering the CBR value of 9%.The design exercise has been carried out using Mechanistic-Empirical principles with non-conventional material i.e. by using the cemented base & sub-base. The assumptions and procedure adopted for the ME design approach are briefly discussed below.

Proposed pavement composition comprisesGSB, Cemented WMM base, Aggregate Interlayer above cemented base and bituminous layers.As the commercial vehicles are more than 2000 per lane during the operation period and the design traffic is more than 30 MSA, VG-40/PMB-40 or modified bitumen of equivalent stiffness is

considered for bituminous layers (BC and DBM).Cemented base layer consist of aggregates stabilized with cement containing 4 to 6 % Ordinary Portland or Pozzolanic cement which are required to give a minimum UCS Strength of 4.5 to 7MPa in 7 days determined by test on 150mm size cubes. Though the initial modulus of the cemented base is in the range of 10000 to 15000 MPa, the long term modulus of the cemented layer shall be taken as fifty per cent of initial modulus due to shrinkage cracks and effect of construction traffic. A Design value of 5000 MPa has been considered here for cement stabilized WMM. Curing of cemented bases after construction is very important for achieving the required strength. Curing should start immediately by periodical mist spray of water. The relevant design parameter for bound bases is the Elastic Modulus E, which can be determined from the unconfined compressive strength of the material. In case of cementitious granular base, the laboratory based E value is given by following equation:

E = 1000* UCS

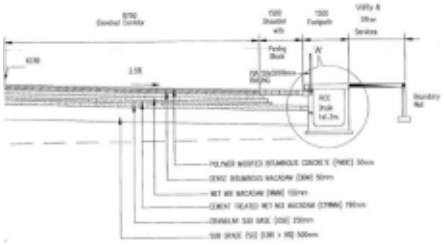
Where UCS = 28 days strength of the cementitious granular material.

Granular Sub-Base material confirming to MORTH Specification grading given in table 400-1 & physical requirements given in table 400-2 are recommended for use. The specifications suggest close & coarse graded granular material and specifies that the material passing 425 micron sieve when tested as per IS: 2720 (Part 5) should have liquid limit and plasticity index of not more than 25 and 6 respectively. Grading III & IV shall preferably be used in lower sub-base. Grading V & VI shall be used as a drainage layer.

The relevant design parameter for granular sub-base is Resilient Modulus (MR), which is given by the following equation:

MR GSB = 0.2 h0.45 x MR Subgrade

Where h = thickness of sub-base layer in mm.



A cemented layer normally develops transverse and longitudinal cracks due to shrinkage and thermal stresses during hydration and during the service life. A crack relief layer of wet mix macadam of thickness 100mm sandwiched between bituminous layer & cemented base layer is more effective in arresting the propagation of cracks from cemented WMM to the bituminous layer. The modulus of aggregate interlayer varies from 250 to 1000 MPa and a typical value of 450 MPa has been used in the analysis of pavement.

As per IRC: 37-2012, the elastic modulus of subgrade is estimated as given below

ESG in MPa = 10 * CBR for CBR ≤ 5%

= 17.6 * CBR0.64 for CBR > 5%

Poisson's ratio 0.50, 0.35 and 0.25 are considered for bituminous, unbound granular material and cement treated layers respectively.

A reliability of 90% has been considered for design traffic more than 30 MSA as per IRC: 37-2012.

2.6 Major Quantities of Prime Activities

Major Components:-

- **Road work** - Including culvert, Minor Bridge,Pedestrian underpass, Railway Over Bridge, Major Bridge/structure (Excluding service Road)
- **Structure** - Elevated Road corridor
- **Other Work** - Road side Drain, Slope Protection work, Road sign marking and safety device.

Project Facilities

- Road Side Furniture
- Pedestrian Facilities
- Traffic and Medical Aid Post
- Street Lightening
- Rescue Lane
- Noise Barrier

Major Quantities

Item of Work	Unit	Total Quantity
Pile	**No**	2965
Pile Cap	**No**	692
Pierand Pier Cap	**No**	692
Casting of I girder	**No**	4080
Erection of I girder	**No**	4080
Deck Slab	**Span**	688

3. FAST TRACK EXECUTION OF PROJECT

Immediately upon receipt of Letter of Award from BSRDC,field survey work, geotechnical Soil Investigation work, preparation of designs and drawings, detailed planning of the Project etc. was diligently taken up.

Also site mobilization was started in right earnest for undertaking expeditious and fast track implementation of the Projec. A camp with full-fledged establishment including field office, mechanical workshops, field laboratories, staff and labourquarters etc. was established. A state-of-art Casting yard for casting precast RCC girders was established with multiple casting beds and Gantry Crane for handling girders. Similarly fabrication yard with required facilities for fabrication work was also established. Huge investment was made for procuring fleet of Plant and Equipment and all Plant and Equipment were mobilized expeditiously for accelerated implementation of the Project. Stand by Plant and Equipment were also provided for critical category of Plant and Equipment so as to continue with the work uninterruptedly even if there are break-downs of some Plant and Equipment.

Because of the above actionson fast track basis, it was possible to commence physical activities at Project Site immediately on award of the work which helped in achieving Project Mile stones ahead of schedule as shown below:

Milestones as per Contract and achievements

PROJECT MILESTONE				
Project Milestone	% of Project Cost	Cumulative Value Rs. Cr.	Target days	Remarks
PM - 1	10%	78.8	Achieved on 31st May 2014	Achieved 48 days Before Schedule
PM - 2	30%	236.5	Achieved on 28th Feb 2015	Achieved 78 days Before Schedule
PM - 3	70%	605.61	Achieved on 07th Aug - 16	Achieved 10 days Before Schedule
PM - 4	100%	865.17	1395days from the Appointed date	16-Aug-2017

Site Conditions and external constraints.

Still some portion of our Project stretch is yet to be handed over due to encroachments made by Indira Aawas building, Irrigational Structure and other reasons.

Design Approval for the Railways over Bridge which is a part of this existing project isexpected shortly from Railways Design Department.

4.CONSTRUCTION METHOD STATEMENTS OF MAJOR ACTIVITIES.

For all major activities, detailed Method Statements were prepared in advance taking in to consideration site conditions and practical aspects apart from Technical Specifications and relevant Codes of Practice and the work at site was executed as per such Method Statements. Few Method Statements of major activities are reproduced below:

4.1 Soil Investigation

Introduction

This include Geotechnical investigation for subsurface investigation and submission of a detailed Geo-technical report.

Scope of Investigation

The entire field as well as laboratory investigation work will be supervised by experienced Geotechnical Engineer. The positions of bore holes will be marked as per the drawings and the Reduced Levels (RLs) at these locations determined with respect to the single Bench Mark (BM), indicated by the Engineer. All the field and laboratory data will be recorded in the standard format in the relevant Indian Standard Codes. The investigationshall be carried out without causing any detrimental effects to the nearby existing structures.

Exploration Plan

A complete soil, rock and ground water investigation should encompass the following activities:

- Review of available information, both regional and local, on the geological history, rock, soil and ground water conditions occurring at the proposed location and in the immediate vicinity of the site.
- Field reconnaissance for identification of surficial geological conditions and examination of performance of existing surface
- On site investigation of the surface and sub-surface materials by carrying boreholes.
- Sequence and extent of each soil and rock stratum in the region likely to be affected by the proposed structure.
- Nature of each stratum and engineering properties of soil and rock which may affect design and mode of construction of proposed structures and their foundations.
- Field testing and recovery of representative samples of the soils and rocks for laboratory tests.
- Identification of the position of ground water table.
- Obtaining general information on geology, seismicity of the area, surface drainage, etc.
- Identification and assessment of the location of suitable foundation material- either bed rock or satisfactory load bearing soils.

4.2 Pile Foundation

Piling was the major activity at site as nearly 2900 RCC Bored cast in situ Piles were involved in this Project. .

Survey/Setting Out:

The location of pile is set out with respect to the control points (coordinates). It is proposed to remove the top overburden manually for the piles coming in any particular pile cap group to identify the utility lines and services. If any such utility service lines are seen then the same will be intimated to the Engineer and will be removed with the assistance of concerned Authority. Once utilities are removed then pile-driving activity will start.

Temporary Casing / Permanent Liner:

Initial boring up to required depth is carried out for lowering the temporary guide casing / Permanent liner (as per approved drawings). It is proposed to use the 10mm thick MS plate for the temporary guide casing. The 10mm thick MS plate will be rolled in the plate-bending machine. The temporary / permanent liners of required diameter will be fabricated in the casting yard and will be transported to the piling location with the help of trailers. Integrated hydraulic piling rig will be used to drive the casing. The center line of guide casing will be checked with reference to guide points / reference points before continuing further boring. The verticality will be checked with the help of plumb and correction if required, will be made. For side stabilization of bore hole, use of bentonite will resorted to as per site conditions.

Pile boring:

On completing the lowering of temporary / permanent casing, pile boring will be continued with the help of Integrated Hydraulic Piling Rig. The boring in soil is continued till the founding level is reached. Pile termination level will be finalized as per approved drawings & as instructed by the Engineer. Muck / excavated materials will be transported with the help of tippers and disposed as directed by the Engineer.

Piles shall be installed as accurately as possible as per the approved drawings. Since Piles in this Project are having diameter more than 600 mm, Piles should not deviate from their designed positions more than 75 mm or D/10 whichever is more & tilt should not exceed 1 in 150.

Reinforcement cage – Preparation & Lowering:

Based on approved drawing, a bar bending schedule will be prepared and got approved from the Engineer / Client. The reinforcement is cut and bent to the required length / size and shape according to the approved BBS. Reinforcement cage

will be fabricated in casting yard and transported to site using trailers. The reinforcement cage will be lowered with the help of service crane. The reinforcement cage is to be lowered immediately after the pile boring is completed and the bore is flushed.

Cleaning of Pile bore:

- After completion of the pile bore up to the required depth the pile bore - especially the bottom of the pile bore, will be cleaned by three stage flushing of slurry using airlift technique.
- Cleaning will ensure that the pile bore is completely free from sludge / bored material, debris of rock / boulders etc.
- Pile bore will also be cleaned by fresh drilling mud through tremie pipe before and after placing the reinforcement and just before the start of concreting.

Concreting:

Immediately after lowering the reinforcement cage, tremie pipe of 200mm dia. and in segments of 1.2m to 2 m will be joined together and lowered into the pile and concrete funnel of approx. 1.5 cum capacity to the tremie pipe at the pile top level. Provide the gap/clearance of 300mm between the tremie pipe bottom and founding level. Once the concrete is built up to say 4 m and it is confirmed by sounding, the tremie pipe with funnel will be lifted up and the top tremie pipe will be removed, during this operation it should be ensured that the bottom of the tremie pipe is always embedded in the concrete for a depth of minimum 1000 mm. During the course of concreting, if tremiecomes out of concrete either accidentally or taken out to remove a choke in the tremie, the tremie pipe is re-introduced into the old concrete with small penetration. A vermiculate ball plug is introduced in the tremie, fresh concrete of slump between 150mm to 180mm is filled in the tremie which will go on pushing the plug forward and emerge out of the tremie. After this the tremie is pushed further in steps making fresh concrete displace the earlier concrete layer. When the tremie is buried about 0.6 m to 1.0 m in the concrete then the concreting is resumed / continued.

Concrete is built above the cut off level by about 600 mm and is confirmed by sounding chain. If borehole is left un-concreted for more than 6 hours after boring then it will be cleaned thoroughly before placing the concrete. In case, under the unavoidable circumstances, the concreting operation is to suspend for a period of 2 hours (maximum), the tremie shall not be taken out of concrete. Instead, it shall be raised and lowered slowly from time to time which would prevent the concrete around the tremie from setting. Concreting shall be resumed by introducing a little richer concrete with a higher slump for easy displacement of partly set concrete. After completion of Pile concreting, fresh concrete will be removed above the cut of level by using bucket. Only 150 mm concrete will be kept above the cut of level.

4.3 Cast-in-Situ Pile Cap

The area around the work location was barricaded as per traffic management plan and excavation for pile cap was started after pile concrete attains sufficient strength. Excavation is carried out up to the bed level with the help of excavator. Bed will then be prepared with leveling course (PCC) of required thickness (75 mm or 100 mm as per drawing). Subsequently reinforcementis fixed and shuttering is placed as per approved drawings. Concreting of pile cap is done in layers of 500mm ensuring proper compaction with needle vibrator.

4.4 Pile Load Test (Initial / Routine)

Initial Pile Load Tests -

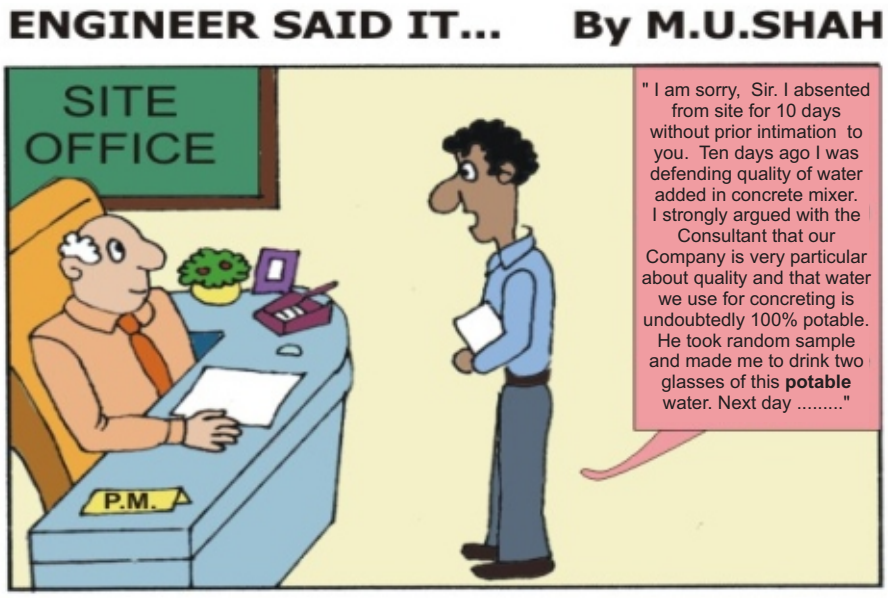
- For scope of piles less than 1000 numbers - A minimum of two tests.
- For scope of piles more than 1000 numbers - A minimum of two tests for first 1000 piles and additional one test for every additional 1000 piles and part thereof.

Routine Pile Load Tests - 0.5 percent of the total number of piles, subject to a minimum of one test.

Anchorage Pile Load Test

Preparatory Works:

a. Removal of laitance: After casting of pile, the additional built up portion shall be hacked up to the design cutoff level / or till sound concrete is reached whichever is lower.



b. Pile head: To distribute the applied load uniformly on the entire cross-section of the pile a suitable pile head as per detailed drawing should be cast at the pile cutoff level. The pile head shall be provided with reinforcement mesh as detailed in the drawing and shall be cast true in level. M.S. plate of 25mm thickness shall be placed for uniform distribution of load on the pile head.

c. Datum bar: The datum bar of size as detailed in the drawing shall be positioned over concrete blocks.

d.Placement of reaction frame: Reaction frames shall be placed in position as per detailed drawings.

e. Placement of jacks: A jack of desired capacity shall be placed with steel packing between the reaction pile and the top frame.

Application of Load:

300 t / 500 t capacity jack shall be connected to the power pack. The pile shall be tested for 2.5 times the working load capacity for Initial Pile Load Test & 1.5 times for Routine Pile Load Test. Thus for Design load of 300 t, the initial pile load and routine pile load work out to 750 t and 450 t respectively. The increment for loading shall be 20% of the safe design load. The increment of load for test shall be maintained till the rate of displacement of pile top is near to 0.1mm per 30 minutes. Displacement shall be read using four calibrated dial gauges of 0.01mm sensitivity.

Release of Load:

After taking observations, once the final load is attained, loading shall be released in the units of 20 % of the total safe load at a time. Observations may be discontinued as soon as the rate of displacement is zero.

Dynamic Pile Load Test

The test can be used to evaluate various pile parameters, important of these are mentioned below:

- Static capacity of the pile at the time of testing
- Static load test curve
- Total skin friction and end bearing of the pile
- Skin friction variation along the length of the pile
- Compressive and tensile stresses developed in the pile during testing
- Net and total displacement of the pile.
- Pile integrity and changes in cross-section, if any.

Pile monitoring and preparation

- High-Strain Dynamic Testing of piles is conducted by attaching strain transducers and accelerometers to the sides of the pile approximately 1 to 1.5 times pile dia. below the pile top. These pairs of gauges are fixed onto opposite sides of the pile so as to detect bending in the pile, if any during testing.
- These transducers are then connected through the main cable to a Pile Driving Analyzer, which is a state-of-art Pentium Computer System with ability to record strain and acceleration measurements and convert them from analog to digital form
- The signals are then triggered by the impact of a ram falling from a pre-determined height. The ram weight and fall height is determined in advance. As a thumb rule, the ram weight shall be 1% to 1.5% of the testing capacity of the pile. Thus for measuring a 500 ton load, the ram weight shall be approximately 5 t.
- Upon impact, the strain transducers measure strains whereas accelerations are measured by accelerometers connected on either sides of the pile. These signals are then converted to digital form by the Pile Driving Analyzer and then converted to force and velocity respectively by integration.
- The capacity mobilized under the blow is then obtained from the force and velocity values. The PDA has an in-built program which calculates and generates over 30 pile variables based on pile top force, displacement and velocity. Immediate field results in the form of the capacity of the pile, pile top settlement, integrity and stresses developed in the pile etc. are obtained.

Reporting

On completion of all field work, a final report covering all aspects of the pile monitoring and analysis work will be prepared and presented within a period of ten days.

4.5 Pier / Abutment Wall

Introduction

It is planned to construct the Pier/Abutment Wall for full height / suitable Lifts as per site feasibility at each location & Pier Cap/Abutment Cap with suitable staging and shuttering arrangement as per approved drawings and specifications. Concrete Pumps / Placer will be used to place the concrete. Construction joints, if any will be planned at locations as shown in the drawings only. Suitable treatment will be given to the construction joint before pouring fresh concrete. Curing will be carried out as per specifications. Access arrangement for inspection and safe working of labor during fabrication, erection of reinforcement, shuttering and placing of concrete will be done as per specifications.

Concrete may be brushed with a stiff brush soon after casting of Pier/Abutment Wall while the concrete is still fresh. If the concrete has partially hardened, it shall be cleaned by wire brushing immediately. Before further concrete of Pier Cap/Abutment Cap is cast, the surface should be thoroughly cleaned to remove debris and accumulated rubbish. Care will be taken to remove all loose materials around reinforcements.

The concrete of required grade will be produced as per the approved design mix at the centralized batching plant at the casting yard and transported by transit mixers to the pouring location. Before pouring concrete slump will be checked at pouring location. Before starting of concrete the pipeline will be pumped with cement grout. The concrete will be placed by concrete pump / Concrete Placer with

flexible hose or crane and bucket. Sufficient dia. tremmie pipe & hoppers will be used in the case of crane used for pouring of concrete. Initial 2 m height of concrete will be compacted by using shutter vibrator, if required. The concreting of pier will be done in one go. The drop height of the concrete should not be more than 1.5m. The concrete will be vibrated using 60mm diameter needle vibrators. Concrete cubes will be taken for testing of compressive strength as per IS: 456-2000 at pouring location. Concreting should be done continuously in one pour. Proper care will be taken to see that concrete temperature will not exceed 40^0C.

CONCRETING FOR PIER

4.6 Fabrication and Erection of Steel Super Structure

Weld Fit-Up Inspection:

- The surface to be welded shall be smooth and free from deep notches, irregularities, scale, rust, oil, grease and other foreign material.
- The fit-up components to be welded shall not show an appreciable off-set or misalignment when viewed from position apart.
- The root opening of components to be joined shall be adequate to provide acceptable penetration.
- In fillet welds the parts to be joined shall be brought as close to contact as practical, although in most instances a small opening between the parts is desirable.
- Weld area should be protected from drafts and wind to maintain inert gas shield.

Saw Welding

Welding of I-Girder:

Tack welded girder is placed on a welding fixture which is 45 degree inclined from the floor.

Once the tack welded girder is placed on the welding fixture, the stiffener rods of side-1 shall be removed and c-clamp & wedges shall be used to hold the upper surface of the flange plate of side-1 with plate in order to minimize distortion of the flange plate during and after welding.

- The joints to be welded are ground smoothly with grinder machine; edge shall be prepared as per requirement.
- Remove the slag of tack weld.
- If the moisture content in the atmosphere is more, then preheat the girder by using Oxy-acetylene flame or any suitable method.
- Set the track for SAW machine at the girder side. Mount the SAW machine on the track. Fix the filler wire in the bobbin and pass it through nozzle. Fill the flux in the hopper and set the flux.
- Remove the girder from the jig. Rotate the girder upside down in cross section.
- Again fix the girder on track of jig then carry out the welding of 3 and 4 similarto as in case of 1 and 2.

General Requirements for Welding:

- Ensure that the components to be welded arein accordance with the contract drawing, welding schedule and other relevant documents.
- The condition of welded surfaces to be inspected must be clean & dry.
- There shall be sufficient lighting to allow proper interpretation of visual inspection as well as NDT.

Checks during Welding Operation:

- Ensure the required minimum preheat temperature (if required) is applied and established during welding.
- Ensure correct electrode/filler metal used for welding.
- Examining tack welding by the welder before they are incorporated in the final weld.
- Ensure proper drying/holding of electrodes prior to use.
- Ensure correct inter-pass temperature is maintained.
- Ensure proper cleaning of the weld between beads.

Check on the Completed Weld:

- No visible defects like cracks, pinholes or incomplete fusions.
- The weld surface must be sufficiently free of coarse ripples, grooves, overlap, abrupt ridges and valleys, visible slag inclusion, porosity adjacent starts and stops.
- There shall be no overlaps. The faces of filled welds are not excessively convex or concave and the weld legs are of the proper length.
- NDT test to be carried out like DPT, RT, UT etc.

Sand blasting:

This procedure describes the minimum requirements and essential particulars of cleaning by sand blasting of IS: 9954 and Swedish Standard.

Equipment:

- Sand blasting hopper with blasting hose and Nozzle.
- Air compressor with its accessories like calibrated pressure gauge and safety valve.
- Sand and screening mesh.
- Wire brushes.
- Safety equipment like boiler suite / goggles / safety shoes/hand gloves etc.

Sand Blasting Process:

Fabricated Steel structural items etc. will be sand blasted A Sa 2-1/2 standard using River Sand as abrasive medium- size ranging from 600 micron to1700 micron. Air compressor engaged will be of 300CFM and above capacity and can produce a pressure more than 6 bar.

The surface shall be thoroughly cleaned and roughened by compressed air blasting using suitable abrasive sand. The sand shall be loaded into a suitable direct pressure type blasting hopper. From the mixing chamber, at the bottom of the hopper, the mixture is injected through the blasting nozzle at a very high velocity.

This jet is directed on to the surface to be cleaned traversing the nozzle each succeeding pass overlapping the preceding one by about 10% and exposing clean white metal.

Surface to nozzle distance shall be about 350 to 450 mm, with the nozzle inclination of about 30 degrees to the vertical. The diameter of nozzle orifice to be used shall be 4 to 8 mm. This process shall be carried out to cover the entire surface. The entire surface shall be free from rust, scale, previous paint, grease, oil and any other foreign material.

Precautions:

- Sand used should be dry and of fairly uniform grain size.
- If sand gets moistened in high humidity weather then it should be baked to remove the moisture before blasting operation.
- Blasting should not be done if humidity is more than 80%.
- Sand blasting shall be done in an enclosed area open from one side only.
- Sand blasting shall be done by an experienced blaster.
- Blaster should use safety device and clear vision spraying helmet.
- The person near the blasting operation shall wear safety goggles.
- Care shall be taken to protect the adjacent machinery, electrical equipment etc.
- No hammering or any other type of blows should be given to shot blasting machine while it is under pressure.
- Calibrated Pressure gauge shall be provided.
- Blasted surface must be coated within 2-4 hours with primer.

Metal spraying/ metalizing procedure:

Spraying shall be done with metal spraying gun. Spraying gun used shall be the gas or flame type wire spraying gun. Clean sand blasted area is to be metal coated/sprayed within 2 hours from the completion of blasting.

Equipment:

- Connecting hoses with spray gun.
- Air compressor with its accessories like calibrated pressure gauge and safety valve.
- Brushes.
- Elcometer.
- Paint mixing arrangement.
- Safety arrangement i.e. safety goggles and nose mask.

4.7 Erection of steel girder – structural spans

- Place the Pre-cast Footing at required location as shown in Annexure-I.
- Erect the temporary supporting arrangement like trestle and temporary Girders on both the sides of the span as shown in Annexure-I.
- Brace the vertical trestles and the temporary girders as shown in Annexure-I.
- Place wooden blocks on top of the ISMB Girders or place screw jack on both the sides of ISMB girder so as to rest the Deck girders.
- Assembled Diaphragm shall be erected with proper support at both the side of Pier cap using crane of suitable capacity and the alignment will be checked.
- Place the crane of suitable capacity in position as shown in Annexure-I for lifting the Deck girder "D1".
- Deck Girder "D1" (G1 & G2) shall be lifted and placed between the two supports as shown in Annexure-I.
- Place the crane of suitable capacity in position for lifting the Deck girder "D2".
- Deck girder "D2" shall then be lifted and placed between the supports as shown in Annexure-I.
- Deck girder "D3" shall then be lifted and placed between the supports and Pier as shown in Annexure-I.
- Tight all the bolts of Splice joint location as per approved drawings.
- Similarly, erect the Deck girder "D1", "D2", "D3" parts of G3 & G4 by crane of suitable capacity over the trestle.
- Tight all the bolts of Splice joint location.
- Fix / connect the Deck girders to Diaphragm with suitable Nut & Bolt as per approved drawings.
- After fixing all the Deck girders to the Diaphragm, release the screw jacks **placed** between the Deck girder & trestle arrangement or remove the wooden blocks placed between the Deck girder & ISMB girders.
- Trestle (supporting arrangement) is now free from the Deck girders.
- Lift G1, G2, G3& G4 Girders and place the Bearings underneath.
- Cast the Deck slab over complete assembly of Deck girders as per the approved Design & Drawing.

4.8 Cast-in-situ DeckSlab

- Corrugated sheet will be placed in-between of erected girders to support as a bottom shuttering for cast in situ deck slab or bottom shuttering will be fixed as per approved drawings.
- Reinforcement will be tied for deck slab.
- The concrete of required grade will be produced as per the approved design mix at the centralized batching plant at the casting yard and transported by transit mixers to the pouring location. Concrete will be placed by concrete pump / Placer with flexible hose. The drop height of the concrete should not be more than 1.5m. The concrete will be vibrated using 60mm diameter needle vibrators. Concrete cubes will be taken for testing of compressive strength as per IS: 456-2000 at pouring location.
- After the deck slab is cast, the top surface of the slab shall be finished rough for proper bonding with the wearing coat. Adequate care shall be taken for maintaining proper lines and levels of the surface as per drawings.
- Proper curing arrangement will be made for curing of Deck Slab. Necessary pipeline arrangement shall be provided for carrying water for curing the structures. Curing of concrete shall be done by water ponding method.

Laying of Profile sheet at COS-II

4.9 Cast-in-situ box girder

Casting Of Box Girder

Sequence of construction will be as follows.

- Place the pre-cast footings at the location as shown in drawing.
- Erect the trestle and lock in position over the footing.
- Erect the trestle heads over each trestle and fix.
- Provide bracings between the trestles.
- Place the main longitudinal girders over trestle heads and fix in position.
- Place the cross members over the main girders. The spacing will be as per the drawing.
- Place the soffit formwork over the cross member.
- Erect the supporting truss at the given spacing for outer side & cantilever formwork supporting.
- Erect longitudinal member and outer formwork over external truss and fix in position.
- Mark profile for sheathing ducts.
- Tie the reinforcement bars for soffit and web.
- Fix pre-stressed ducts and inserts.
- Fix internal shuttering for web.
- Concrete soffit and web.
- De-shutter the internal formwork of webs after concrete attains required strength.
- Erect the bottom shutters for deck slab and fix in position.
- Tie reinforcement for deck slab.
- Concrete the entire deck slab. Conventional curing will be done.
- Immediately after de-shuttering, concrete surface shall be checked jointly and curing of top surface of the structure will be done by pond making & side faces by using hessian cloth & by sprinkling continuous water.
- Stressing will be done after concrete attains required strength as per approved drawings.
- Dismantle the entire shuttering and staging arrangement after stressing.

Stressing Operation

- Suitable Pre-stressing System shall be adopted as per approval by Engineer for stressing of Box Girders.
- Stressing will be done after 7 days of concrete or after concrete achieves required strength as specified in Drawing. Number of cables to be stressed, will be as mentioned in Drawing.
- Extension at each end during stressing operation should be equal as far as possible, max. Difference should not exceed 5% of the prescribed extensions at each end. In case the required extensions are not obtained at the specified pressure, stressing should be continued till the required extensions are obtained subjected to jack pressures not exceeding the prescribed limits.
- Difference between calculated and observed tension and elongations during the pre-stressing operations shall be regulated as per MORTH sec. 1807 under post tensioning head as per point a, b, c, d.

Safety during stressing and casting

- Use hydraulic equipment supplied with a relief valve. Place safely valve in between jacks and connection high-pressure hose.
- Use hosepipes in good conditions and avoid using worn out hosepipes.
- Check the concrete around bearing plate and anchorage to see whether there are any voids / honeycombing.
- Do not allow anybody behind stressing devices, in line with tendon, or near hydraulic hoses.
- When the stressing works are in progress no other work should continue in the vicinity.
- Health of safety systems incorporated in the stressing equipment shall be ascertained once a week. Provide safety barriers during stressing operations.
- Display a clearly visible sign "DANGER...PRESTRESSING WORKS IN PROGRESS"
- Safety of workmen and public will be ensured throughout the construction at site. Traffic control devices such as cones, signs, flashing lights, barricades flagmen etc. will be provided as specified or directed.

Grouting Operation

Grouting shall be carried out within 2 weeks of stressing of cables.

- Ducts shall be flushed with clean water for cleaning as well as for wetting the surfaces of the duct walls. Water used for flushing should be of same quality as used for grouting.
- After cleaning all water shall be drained thoroughly by vent pipe or by blowing compressed air through duct.
- During and after 3 to 4 hours of grouting other non-stressed cables (if any) shall be checked manually for free movements.
- All outlet points including vent openings should be kept open before to commencement of grouting.
- Injection of Grout.
- After mixing grout should be kept in continuous movement and injection of grout must be continuous without any interruptions.
- Grouting shall be commenced initially with a low pressure of injection of up to 0.3MPa increasing it until the grout come out through the other end with same consistency as that of the grout @ injection end.
- Full injection pressure (approx. 0.5MPa) shall be maintained for a minimum of 1 minute before closing the injection pipe.
- Grouting records shall be maintained as per format conforming to MORTH, Appendix 1800/IV.

4.10 Road Works

Material selection and mix design

- The field laboratory will be established in stages, to meet the testing requirement schedule and the specifications indicated in contract till site laboratory is established, testing will be carried out at an approved laboratory.

➢ Borrow areas will be prospected for sampling materials for use in embankment. Based on the test results of such samples the approval of the Engineer's representatives for the material for use in embankment fill will be obtained. Similarly, based on the test results, the suitability of the material for use in sub-grade will be determined and approval obtained accordingly.

➢ The material proposed for use in Granular Sub-base / Drainage layer is crushed aggregate material or natural materials. The material will be also crushed aggregate, natural sand, gravel or combination, depending upon the grading requirement. Quarries will be identified for natural GSB. The crushed material directly from the crusher with required gradation will be used. The mix will be transported to the grader location in dumpers and graded to required line and levels using a motor grader and thereafter bringing the material to required OMC levels by water sprinkling, if required. The material will subsequently be compacted to the required density as per specifications.

➢ The crushed aggregate to be procured from the local market initially will be tested for suitability for use in the works and the test results will be submitted for the approval of the Engineer.

➢ The mix design for various grades of concrete will be carried out once the materials namely cement, sand (Natural or Crushed or blend of Natural &Crushed) and crushed aggregates are selected. The mix designs found complying with the requirements will be submitted for approval. Upon erection of the Concrete Batching Plant and the mobilization of the Concreting team, trials will be commenced for production of concrete mix complying with the approved mix design requirements.

➢ The mix design will be carried out with Engineers representative to ensure achievement of required strength.

GranularSub-base (GSB)

Scope

The work will consist of laying and compacting well graded material on prepared sub-grade in accordance with the details given in Typical Cross Section of Road.

Methodology

The sub-grade surface will be watered & compacted as per MORTH specification. The material to be used for the work will be crushed aggregate, natural sand, gravel or combination thereof depending upon the grading requirement. Gravel or any other material having dimension in any one direction exceeding 75mm shall be removed.

The selected source from quarry will be free from organic matters and other deleterious constituents. The material will confirm the IS specification and will be got approved by the Engineer prior to use. The spreading will be done with the grader. Each compacted layer will not be more than 225mm thick after compaction.

All tests to be done as per MORTH & IS requirement.

When the sub-base materials consist of a combination of materials, mixing will be done mechanically by mix-in-place method. Compaction will be done with a vibratory roller of minimum 80-100 KN static weight. Rolling will commence at the lower edge and proceed towards upper edge longitudinally for portions having unidirectional cross fall and super-elevation and will commence at the edges and progress towards the center of portions having cross fall on both sides.

Wet Mix Macadam (WMM)

Scope

The work will consist of laying and compacting crushed, graded aggregate and granular material, premixed with water to dense mass on a prepared sub base in accordance with details given in Typical Cross Section of Road.

Methodology

➢ The constituents of the aggregates will be produced by a multiple stage crushing / screening plant and will be carried out at-least in two stages.

➢ Grading requirement of aggregates is as per specification.

➢ The Physical properties of the aggregates that make the mix will be checked for their adequacy as per specifications.

➢ The percentage of the various ingredients that make up the mix will be as per specifications.

➢ The bin will be adjusted to feed the plant of defined quantities as per the requirement.

➢ The mix will be brought to the site by dumpers. The surface will be prepared by wetting.

➢ Wet mix macadam will be loaded in ready mixed condition; water will be added at the mixing point of batching plant as to ensure that additional water will not be necessary during the compaction of the layer.

➢ The surface of the sub-base to receive the WMM will be prepared to the specified lines & cross falls and made free of dust and other extraneous materials.

➢ The mix will be spread with the motor grader to the required width and thickness so that no supplementary spreading, shaping or finishing will be required to obtain tolerance, requirement after compaction.

➢ Rolling will be continued with vibratory compactor at speed not exceeding 5Km/hr.

DenseBituminousMacadam and Bituminous Concrete

Scope

The work involves of preparing an existing black topped surface of specified lines, grades and cross sections in advance of laying a bituminous surface.

Methodology

➢ The aggregates and the binder that make up the mix will be checked for their physical properties.

➢ The mix design will be prepared ahead of commencement of work and got approved by the Engineer.

➢ The course aggregate will consist of crushed rock, crushed gravel or any other hard material produced from integrated crushing plant. Fine aggregate will consist of crushed or naturally occurring material or a combination of two.

➢ The mix will be prepared in the hot-mix plant of adequate capacity & capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. The system shall have arrangement of accurate weighing at cold aggregate feed system, shifting of ingredients of different quantities conveying to the hopper, heating

storing and heating the bitumen, mixing of bitumen and aggregate to the requisite temperature of 150-163^{0}C.

➢ The tippers will carry the mix to the required locations. It will be transported in clean vehicles and will be covered while in transit. The rate of delivery of the material to the paver will be regulated to enable paver to operate continuously.

➢ The surface to receive will be primed with bituminous emulsion as laid down in contact and the primed surface will be left to be cured for 24 hr.

➢ The spraying will be done uniformly with nozzles with temperature as desired by the Engineer in charge.

➢ The laying will be done with approved paving machine. The thickness of DBM/BC will be as per specification and drawing.

➢ The rolling will be done with vibratory roller.

➢ In case of BC additionally pneumatic tyre roller will be used to give a uniform and smooth finished surface.

➢ After completion of Dense Bituminous Macadam layer and Bituminous Concrete layers, grid point levels will be jointly measured to ensure any level differences to be within acceptable limits. This will also be used for measurement of layer thickness for payment as applicable.

Tests (For Design) –

Following Field & Laboratory test needs to be initiated at site for Flexible pavement design

a) Lab Test -

• Physical Test on Borrowed Soil Sieve Analysis, LL, PL, Modified Proctor Test.

• 4- days soaked CBR Test on borrowed soil.

• Test on Aggregate Sieve Analysis, Flakiness & Elongation Index, Sp. Gravity & Water Absorption, Los Angeles Abrasion Value, Impact Value Test, Stripping & Coating test etc.

• Bituminous mixes will be as per IRC37-2012

b) Field Test -

• Field Density (by Core Cutter Method) & Field Moisture Content by Rapid Moisture meter.

• Dynamic Cone Penetration Test DCPT/ Field CBR Test.

5. RESOURCES DEPLOYED

The fast track execution of the Project was possible because of timely mobilization of ample resources. Major deployment of resources is as below:

Manpower Deployment

Description	Numbers
GM/DGM/Managers and Engineers	45
Officers	8
Surveyor/ Technicians	6
Sr. Accountant/Accountant/Store keeper	8
Foreman/Supervisors	63
Drivers/Operators/Helpers	170
Skilled & Unskilled workers	450
Total	750

Plant and Equipment Deployment

Sr.	Description	Quantity
1	Concrete batching Plant	2
2	Hydraulic piling Rig	2
3	Excavator	9
4	Crane	8
5	Tippers / Dumper	6
6	Vibro compactor	2
7	H M Loader	2
8	JCB backhoe	2
9	Transit Mixer	11
10	Hydra	7
11	Service van	1
12	Weigh Bridge	1
13	LMV	13
14	D.G. Set	17
15	Tower Light	1
16	Low bed Trailer	5
17	Welding DG	3
18	Welding Transformer	29
19	Bar bending machine	7
20	Bar cutting machine	6
21	Plate bending machine	1
22	Concrete Pump	1
23	Boom placer	2
24	Gantry–60 t	3
25	Compressor	1
26	Motor Grader	2

Enabling Structures deployed at site.

Sr. No.	Item	Unit	Quantity
1	Pile Cap	Sets	12
2	Pier	Sets	8
3	Pier Cap	Sets	11
4	I-Girder Casting	Bays	8
5	I-Girder Erection	Sets	2
6	Precast Panels Casting	Sets	100
7	Deck Slab	Sets	8
8	Crash Barrier Casting	Sets	35

Site Infrastructure and Layout

Site Office – Total Built-up Area (30 m x 20m)

Casting yard - 110 m x 60 m

Central Store - 44 m x 8 m

Central Workshop - 30 m x 10 m

Stock yard - 39 m x 53 m

Batching Plant - 56 m x 40 m

Material arrangement and Logistic.

Cement

Cement Store – 2 Nos.

Size- 40 M X 12 M & 25 M X 12 M

Total Capacity-3000 t

Source / Approved Vendor – Ultra Tech

Lead / Lead time – 500 K.M / 1week

Means of Transportation– Rail

Reinforcement Steel

Storage – Steel yard

Capacity -1500 t

Source / Approved Vendor - TATA, SAIL, JINDAL , EELCTROSTEEL

Lead / Lead Time - 60 K.M, (4 to 6 Hr.)

Means of Transportation–Trucks/Trailer

Sand/Aggregates/Minerals

Storage Capacity -30000 t

Lead / Lead time - 195 Km / 8-10 Hr.

Means of Transportation – Truck

6. Productivity

Actual Cycle Time and Productivity Chart.

S. No.	Activity	Unit	Time Cycle	Unit	Target Qty/Month
1	Pile	Nos.	3	Nos. /Day/Rig	150
2	Pile Cap	Nos.	4	Days/Set	40
3	Pier	Nos.	5	Days/Set	35
4	Pier Cap	Nos.	4	Days/Set	35
5	I-Girder Casting	Nos.	4	Days/Set	200
6	I-Girder Erection	Nos.	4	Nos. /Day/Gantry	220
7	Precast Panels Casting	Nos.	1.5	Days/Set	1350
8	Precast Panels Erection	Nos.	45	Nos. /Day/Gantry	1350
9	Deck Slab	Span	12	Days/Span	30
10	Parapet Casting	Nos.	1	Day/Set	720
11	Parapet Erection	Span	2.5	Days/Span	35

7. Quality Assurance and Quality Control

Summary of Concrete Mix / Pavement Design

PAVEMENT MIX DESIGN SUMMARY							
Table 400-1 : Grading :-1 for Granular Sub-Base Material (GSB-1)							
Source of Aggregate	**MDD**	**OMC**					
Chattarpur	2.4 gm/cc	5.26%					
Table 400-13 :Grading Requirement of Aggregates for Wet Mix Macadam (WMM)							
Source of Aggregate	**MDD**	**OMC**	**40 mm Aggregate Blending Proportion**	**20 mm Aggregate Blending Proportion**	**10 mm Aggregate Blending Proportion**	**Stone Dust Blending Proportion**	**Remarks**
Chattarpur	2.380 gm/cc	5.20%	35%	16%	19%	30%	
Table 500-10 : Composition of Dense Graded Bituminous Macadam -I (DBM-I)							
Source of Aggregate	**Density of compact Mix**	**Bitumen**	**40 mm Aggregate Blending Proportion**	**20 mm Aggregate Blending Proportion**	**10 mm Aggregate Blending Proportion**	**Stone Dust Blending Proportion**	**Filler Blending Proportion**
Chattarpur	2.515 g/cc	4.10%	18%	19%	22%	39%	2%
Table 500-10 : Composition of Dense Graded Bituminous Macadam -II (DBM-II)							
Source of Aggregate	**Density of compact Mix**	**Bitumen**	**40 mm Aggregate Blending Proportion**	**20 mm Aggregate Blending Proportion**	**10 mm Aggregate Blending Proportion**	**Stone Dust Blending Proportion**	**Filler Blending Proportion**
Chattarpur	2.484 g/cc	4.55%	0%	39%	20%	39%	2%
Table 500-17 : Composition of Bituminous Concrete-I (BC-I)							
Source of Aggregate	**Density of compact Mix**	**Bitumen**	**40 mm Aggregate Blending Proportion**	**20 mm Aggregate Blending Proportion**	**10 mm Aggregate Blending Proportion**	**Stone Dust Blending Proportion**	**Filler Blending Proportion**
Chattarpur	2.469 g/cc	5.23%	0%	33%	23%	42%	2%

WEEKLY TEST SCHEDULE AS PER FREQUENCY OF TESTING	
DAYS	TEST TO BE CONDUCTED
MONDAY	40MM &20MM GRADATION ,CUBE TESTING
TUESDAY	10MM & SAND GRADATION ,CUBE TESTING
WEDNESDAY	FLAKINESS ,AGGREGATE IMPACT VALUE & CUBE TESTING
THURSDAY	40MM &20MM GRADATION,COMBINED GRADATION, CUBE TESTING
FRIDAY	10MM & SAND GRADATION,ALL IN AGGREGATE,CUBE TESTING
SATURDAY	FLAKINESS ,AGGREGATE IMPACT VALUE & CUBE TESTING
SUNDAY	WEEK-1=40MM & 20MM GRADATION
	WEEK-2=10MM & SAND GRADATION
	WEEK-3=FLAKINESS INDEX
	WEEK-4=AIV

8. CHALLENGES ENCOUNTERED AND ITS REMEDIAL MEASURES.

8.1 Launching of I Girder on Rising Pier Cap.

Launching of I-Girder on 24m height Pier Cap was a puzzling task for Site Team. It was a complex situation where telescopic boom cranes could not complete the task as I-Girder of 35 t was to be lifted and erected at the height of 24 m. So, it was decided that the height of Goliath Gantry having load carrying capacity of 70 t (Main Hoist) to be increased up to 27 m Height.

But still the task seemed to be next to impossible due to progressive increase in height of pier. Finally, it was decided by the site team that the approach path along the direction of Gantry to be raised progressively by earth filling after which we have installed the rising Gantry track for launching of Girder on Pier cap .

8.2 Erecting of Steel Girder

Our COS-II portion (Elevated Structure) comprises 356.8 m of total length with eight steel spans of 44.6 m each. It was indeed a challenging task to erect the steel girder of 140 t over 53 m tall pier in very limited time period. We have placed the Pre-cast Footing at required location. Subsequently we have erected the temporary supporting arrangement like trestle and temporary Girders on both the sides.We also positioned wooden blocks on top of the ISMB Girders or placed screw jack on both the sides of ISMB girder so as to rest the Deck girders keeping in mind that assembled diaphragm shall be erected with proper support at both the side of Pier cap using crane of suitable capacity and the alignmen.t

8.3 Transportation of Pre-Casted I girder

Transportation of Pre-caste I Girders from casting yard to their launching point is a big challenging task for Execution team due unavailability of suitable road and high density of composite traffic on existing road. As our Project construction work is going on canal bank, no approach road was available. We collected data for Maximum Water flow level of canal and developed approach road at intermediate level throughout the Project alignment which then provided us clear passage for the Transportation of 25 m span I Girder.

8.4 Unpredicted high Tension underground Electric Cable

Along the seven kilometer of project alignment, we have encountered the 132 KVA Underground Electric cablesfor which no prior information was available to us due to which we have to change our pile/Pile cap Design. Places where Change of design was not possible, the utility shifting has been done.

8.5 Innovation/R&D.

- Erecting work for Steel span of Bailey Road Crossing (Cos-I Portion) is a stimulating task for the reason that our elevated portion is intersecting an existing flyover which is in operation and carrying heavy traffic.
- In COS-II where each steel span having the length of 44.6 m which is very rare in Elevated structure; concreting deck slab was a real challenge. In order to resolve this, profile sheet over girder was provided. Main objective behind provision of profile sheet is to replace shuttering arrangement, to reduce cycle time and to provide extra safety.
- Concrete work of Pier and Pier cap up to 25 m of height was carried out by making net type standing platform over the work zone and thereby staging was avoided which lessens our cycle time and supplementary possessions.
- A special arrangement of liner driving which pledge the verticality at the time of driving, resultant into lessening of Cycle time up to 2 hrs.
- Railways approach spans of Digha end had limited access for working in addition to the problem of lateral and vertical clearances with the running railways track with road.
- Innovative solution for movement of heavy launching gantry on compacted soil resting on soft ground and thereby avoiding normally adopted solution of providing piles.
- Providing 2m long auger for pile boring in lieu of normally adopted 1m long auger and thereby reducing boring time by 75%.

9.EXEMPLARY AND RECORD-BREAKING ACHIEVEMENTS

We have achieved our First Millstone-48 days ahead of schedule, Second Milestone-78 days ahead of schedule and Third Milestone-18 days ahead of schedule. In addition to this, several exemplary record-breaking achievements have been recorded on this Project few of which are:

- Erection works of 32 no steel plate girder for 8 no of spans (44.6 m lengths each) in 58 days only.
- Erection work for I-Girder having height up to 24 m through Gantry Crane.
- Concreting for 8 m Pier Height having dia of 2.4 m in a single pour.

As regards Quality Assurance and Quality Control, Site established Quality Award system that recognizes the commitment and dedication to the standards our organization has set for maintaining quality. This is an excellent way to show our site team that the corporate management team values our efforts. Such recognition was given when a team has consistently met a series of quality standards fixed by the site or when a team has exceeded the level fixed by the site , or when team has met the level for a certain length of time schedule. The criteria included reductions in errors while execution of task on site, and other such metrics that determine quality levels for the organization.

Awards were often given for successfully realizing ISO Certification for stores, Site execution team, workshops andfield Laboratory during periodical surveillance audit by certifying agency.

VIP Site-Visits

Hon'ble ChiefMinister of Bihar, ShriNitishKumar, Deputy Chief Minister ShriTejashviPrasadYadav and Secretaries of various departments visited our Project site on few occasions and appreciated the site progress.

Achievers Award

Hon'ble Chief Minister felicitated Mr. U.M.Kulkarni with "ACHIEVER AWARD" on behalf of BSRDC for for outstanding progress of the Project.

MEDIA COVERAGE

The Telegraph 29th December, 2015 flashed article titled **'Elevated path for cool drive'** by Amit Bhelari

KEY FEATURES

- **Project:** AIIMS-Digha semi-elevated/elevated road
- **Cost:** Rs 717.4 crore
- **Mode:** Engineering procurement construction
- **Length:** 12km
- **Piling (to fit pillars) completed:** 2691 of 2700
- **Pillars erected:** 680 of 700
- **Construction company:** Gammon India Limited
- **Work began:** November 2013
- **Deadline:** August 2017

"Commuters will have another reason to cheer with a part of the AIIMS-Digha elevated road will be becoming functional.

The construction of this stretch would provide a direct road connection between AIIMS in south Patna and Rupaspur point at Ashok Rajpath in west Patna."

10. CONCLUSIONS

Lessons learnt

➢ The success of a project is largely dependent on the knowledge, knowledge-application skills and strengths of the people involved. Therefore, a project needs to have competent, talented and dedicated set of individuals working towards a common goal with killing instinct.

➢ Also the success of a Project is dependent not only on Contractor's teams but also depends upon the Owner and Consultant's teams and integration and co-ordination among these teams. Better understanding and co-ordination goes a long way in fast track execution of the Project.

➢ Together with leadership skills, we need to be aware of the strengths and weaknesses of our team, so that the talents are harnessed and the shortfalls, if any, are downplayed for the benefit of the project.

➢ We need to know who the real decision makers are. Such individuals may not always be readily visible or may not be in limelight but they may be calling the shots. A good leader will spot such members from the team and develop a strong line of communication with such members which will reap benefits in the long run.

➢ If we have the knowledge, experience and judgmental skill to take a decision and implement the same right up to result stage, no matter what are the difficulties and hardships en-route, then we should go ahead and do so, without expecting top management to spoon feed us every now and then.

➢ Do not be afraid of taking calculated risks. After all, as the famous adage from Mr. William G.T. Shedd goes, "A ship is safe in the harbor, but that is not what ships are built for."

11. CREDITS AND ACKNOWLEDGEMENTS

Fast track execution of such mega Project would not have been possible without whole-hearted and positive support from BSRDC officers. We wish to place on record our sincere appreciation of entire team of BSRDC officers and in particular Mr. Vijay Shanker, Chief General Manager under whose dynamic stewardship the Project is executed. Credits are also due to entire Project Supervision Team comprising of Shri Sanjay Kumar (General Manager-Tech), Shri Arun Kumar (Deputy General Manger),Shri Sanjeev Kr (Manager-Tech), ShriRajnath Singh (Manager-Tech) and others.

Creditts are also due to team of BSRDC appointed consultants – M/s AECOM-RODIC (JV) who are having the valuable standing in consultancy services having executed number of prestigious project in the world.

We also wish to place on record our appreciation of guidance, mentoring and relentless 24X7 follow-up of Dr. N.V. Nayak apart from excellent support received from Design, Procurement, Plant, HR, Finance and other teams from Corporate office.

The entire Team at site put substantial extra efforts in fast track execution of this Project and made this Project a success. The Key Members of the site team includes:-

Mr. Shashi Ranjan (D.G.M. -Projects)

Mr. P.S Rao (D.G.M-Plant)

Mr. R.N Tiwari (Senior Manager/ Incharge –Execution)

Mr. Sudeep Verma (Senior Manager –Administration)

Mr. SashiKushwaha (Manager/Incharge-COS II -Execution)

Mr. D.K Roy (Incharge –Casting yard)

Mr. Suman Jha (Incharge QA/QC)

Mr. Mithilesh Ray (Incharge-Stores)

Mr. Rajeev Kr (Accounts Incharge)

Credits are also due to our partnering Subcontractors including Arti Infra, Amhara Construction, Meccaferi, Siddharth Tanks and Vessels, Sarenes Heavy Lift India Pvt. Ltd and others and various PRWs.

MISSION IMPOSSIBLE?!!!!

- M. U. Shah

One Project Manager working at construction site stumbled upon a bottle and a magic Genie came out.

The Genie told to Project Manager, Gentleman, "I am impressed by your dedication, hard work and loyalty to your organisation. You ask any one wish. I will fulfill your wish."

Project Manager thought for a while and said, "I have built many Roads and Highways in my State, in my country and abroad also. Having achieved everything in my career and having reached a pinnacle, I now want to build Road from Earth to Moon for yet another zenith in my career."

"Impossible, my child, impossible" said the Genie; "Ask something else, something which is possible."

"OK. In that case, get my claims passed from the Authority." said the Project Manager.

"What will be the width of the Road you wish to build from Earth to Moon. ? Will it be a four-laned Road or six-laned !!!? " was the instant response from the Genie.

Bid Stage Economical Proposals for Bridges– A Critical Study

A. K. Chatterjee

A. K. Chatterjee

1. Preamble

For any bridge construction contract, the phase of preparation of technical proposal and competitive bidding based on such economical technical proposal is of vital importance. This is the stage at which the fate of Bid is sealed though outcome will become public only when bids of all bidders are opened by the Owner/Consultant. A bid stage proposal which is not economical or which is not based on efficient and creative conceptualization will be automatically out priced at the hands of efficient competitor. Naturally, to stay in business, no company wants to be a loser. Hence it puts in the best efforts at the bid stage for preparing an efficient and economical technical proposal for winning a contract, some of them, very prized ones, for the growth and reputation of the company.

2. Two types of Bids

1) In the case of the first type of bid, the Owner/Employer appoints a Consultant who prepares technical proposal, carries out the designs and estimates quantities of various items and prepares Bill of Quantities. The bid is then invited based on such BOQ prepared by the Consultant. In such cases superiority of construction techniques, good planning, a proper appreciation of the site, use of state-of-art Plant and equipment will enable a particular construction company to have and edge over his competitors, which will most likely enable him to secure the work. This type of bidding is usually known as Item Rate bidding with pricing based on the aforesaid BOQ.

2) There is however another type of bid of the 'Design and Build' type, where the construction agency bids a lump sum price (wherever stipulated in the tender by the Employer to do so) based on quantities arising out of its own design, which could be either prepared by its in-house design team or could be based on the design of a consultant engaged by it.

While in case of Item Rate bidding all bidders are on the same platform as far as BOQ is concerned, the bidding is more complex in nature for a construction company who bids for Design and Build types of contracts. Here the construction company not only must have superiority in matters that factor the construction itself to its advantage, but his technical proposal and design also has to be very competitive as also easily constructible vis-à-vis possible technical proposal and design of competitors, is superior. Here the skill of a design engineer, his experience, his creativity and alertness will have a significant influence on the bid if the bid has to be a winning one.

It is important to analyse and study the considerations that dictate the selection of economically viable proposals for various types of bridges that may not necessarily need to use complex techniques of construction, except for a few special type of bridges.

3. Types of bridges

Bridges can be normally categorized as

i) Overland/ Land based bridges. e.g. Flyovers, RoB's. RuB's, elevated roadways and similar such overland crossings.

ii) Bridges across waterways: River bridges, bridges over creeks or sea or canals, hill streams, deep valleys etc.

3.1 Land based bridges

Land based bridges can be again sub categorized as below:

Flyovers, RoB's etc. of maximum height of 8 to 10 m where spanning over railway tracks, obligatory spans etc. are involved. The foundation medium could be reasonably hard soil or could be an over burden of very poor soil underlain by rocky strata.

Elevated roadways are usually concrete bridges of considerable length with relatively tall piers. These could also have hard soil or poor soil as founding medium as for flyovers, RoB etc. as mentioned above.

3.2 River Bridges

Usually the design and the construction engineer will encounter many complex problems when dealing with river crossings. The various types of crossing for bridging waterways are as below:

1) Bridges of appreciable lengths across rivers flowing through alluvial plains e.g. Ganga, Brahmaputra, Sone, Godavari, Narmada. These bridges, because of the soil composing the bed and high water current velocities, display very deep scours due to obstruction to flow created by piers and their foundations. Usually such rivers have large water depths in their channels sometimes even during dry season.

2) Bridges of large lengths but having rocky strata, hard or soft as the case may be, below a manageable depth of overburden soil, formed of silt sand and clay. In such cases usually the scour is considered up to the surfaces of the rock, depending on the rock quality.

3) The type of waterway crossings that need special attention particularly are for those waterways which are associated with large scours, large perennial depths of water and no bedrock to support the foundations. The foundations system that would occupy the waterway in such cases are very expensive and the usual layout to choose for economy is with long spans, minimizing the number of such expensive foundations as much as practically possible.

4) For waterways which are mostly dry in the dry season and rock is available at shallow depths of the bed, foundations will not be very expensive (usually simple open foundations will do) and here simply supported or continuous spans ranging from 25 to 40 m may prove to be economical for the superstructure as well as for the bridge itself.

5) Also there are other types of crossings where overall bridging length is not much, but the site characteristics are peculiar and challenging and the solutions are very limited. This is particularly true of hill bridges. e.g. Lubha Bridge in Meghalaya and Jadukata Bridge, also in Meghalaya, which necessitated providing a large central span covering the waterway and counter weight arms on either side of the main span over hilly banks for providing stability. Both the above bridges were constructed by Gammon by cantilever construction method.

While in case of Lubha bridge, the bed between the banks were very deep and velocity of flow was extremely high, in the case of Jadukata Bridge (Fig. No1) the waterway was a type of deep ponding, associated with a velocity of flow not very small. This was really a challenging job, as, for stability, counterweight arms had to be provided, being partly located inside tunnels on either side because of limitations in length on the banks. It currently has the largest single span in prestressed concrete box girder construction with a span of about 140 m.

6) Then there are crossings where the river bed is composed of boulders but with large velocity of flow (12 to 13m /sec) causing moderate scours, but still requiring costly well foundations and therefore warranting the use of long spans to bridge for economy. An example is Passighat Bridge over river Siang at Passighat, Arunchal Pradesh, the river being a tributary of river Brahmaputra and descending from China. The author was deeply involved in the design of this bridge, and the bridge saw the light of the day after almost 16 years from commencement of construction as there was intense differences in

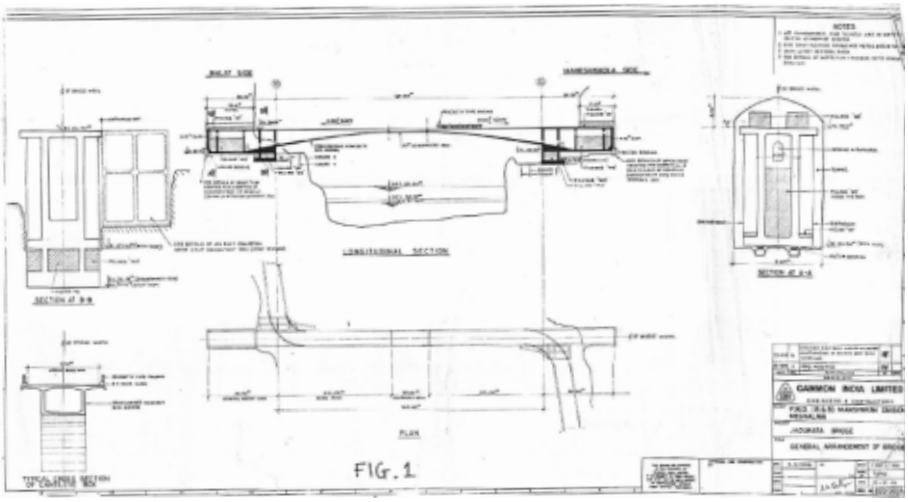


FIG. 1

the opinion about the scour level provided by the client at the tender stage, an over conservative one, which took many years to resolve and client finally accepted the foundation level proposed by GIL, following numerous deliberations, dialogues etc. between the client and GIL.

This is a fine example where long spans (about 117m) were found suitable for economic considerations.

While dwelling on construction of long span systems a few important things must be kept in mind. The questions that are usually posed to the engineers are:

i) Do we have the necessary design expertise to design a long span?

ii) Do we have necessary resources i.e. plant and machinery to construct a long span?

iii) Do we have skilled and trained construction engineers to meet the challenge?

iv) Do we have the necessary interfacing coordination between the design engineer and construction personnel to discuss and resolve the problems that might encounter during construction?

Most of the times, in mid 20th century in India, the answers would have been difficult to provide, in context of the prevailing times, then.

Thus, in the earlier periods (early sixties) of Gammon's history of bridge construction, there were limitations in going for long spans. The designers had to be satisfied with provision of 35 to 40 m simply supported spans formed with precast concrete girders and launched into position by aluminum launching trusses which were not easy to handle and considerable care had to be taken during launching. Thus economy had to be sacrificed in many cases. Some improvement in achieving longer spans came later by using cantilever pier heads also known as 'Hammer Heads' with prestressed concrete simply supported spans supported on the Hammer Heads with articulated supports e.g. first Thane Creek Bridge, Maharashtra, Kosi bridge at Kursela, Bihar (Fig no.2), Dorighat Bridge in U P etc.

The breakthrough in long span construction in prestressed concrete came in early sixties when Gammon developed the cantilever construction system in house and indeed it was a very good development which won Gammon contracts for many long span of bridges later. With this development Gammon successfully completed Barak Bridge at Silchar (Fig no 3), Assam, using the cantilever construction method for the first time in India. This bridge has a central span of 120 m with side spans of about 56 m, covering the waterway of the river. Twin wells under each pier (double plate piers) formed the foundation system. The longitudinal seismic forces were resisted by two stiff trestle piers in prestressed concrete (space frame) one at either end of the side spans and supported on shallow wells.

The successful construction of Barak Bridge, an economically competitive structure, paved the way for many more cantilever bridges in the country later when many contracts were won due to these competitive designs e.g. Ganga Bridge at Patna (which is the longest river bridge), Buxar Bridge , Bihar, Narmada Bridge in Gujarat, Pamban Bridge, Tamil Nadu.

4. Study of Site

The designers before making a proposal for a bridge layout, must make a good study of the site to consider a few alternatives which would at a first glance furnish possible economical solutions. Thereafter with preliminary calculations (simple ones) the designer will be able to pick up a satisfactory and economically viable alternative for selecting the final proposal.

5. Applications of long spans bridges

In terms of economy long span bridges find their application in

1) Very wide waterways where foundations have to be deep due to considerable bed scours, large water depths at HFL and considerable current velocities.

2) On tidal creeks of large lengths e.g. Thane Creek, Vasai Creek near Mumbai, Pamban bridge, Tamilnadu etc.

3) Crossing over deep gorges encountered in hill rivers e.g. Mandi River, Himachal Pradesh & Teesta bridge in Sikkim, West Bengal. They are usually the only solutions for economy.

4) Crossings near deeply ponded waterways e.g. Jadukata Bridge

5) Elevated roadways in deep valleys with very tall piers

6) With peculiar site characteristics that render construction of multiple piers at relatively close intervals uneconomical and time consuming.

6. The Initial Approach for targeting the most economical proposal

As a thumb rule a bridge proposal will generally approach an economical one when the superstructure cost and the cost of foundation and substructure will tend to be equal in cost i.e. each will be 50 % of the total cost. This perhaps is an ideal situation, which can never be realised in practice, because of many other influencing factors governing the design. Hence where foundation medium is generally good with founding possible at shallow depths and no scour is encountered, repetitive short spans e.g. 20 m to 25 m will display economy. At the opposite end, the designers will encounter large, turbulent and high velocity water ways with associated deep bed scours etc warranting adoption of long span superstructure units for economy. Apart from the range of basic span configurations suitable under various site conditions and site peculiarities, the important factors that mostly govern the economy in pricing of bridge proposals are :

1) The material content e.g. cement , coarse and fine aggregate, steel rebars, structural steel, high tensile steel etc..

2) The Labor component.

3) The plant & machinery that would be suitable for the implementation of the proposal at site, practically and swiftly.

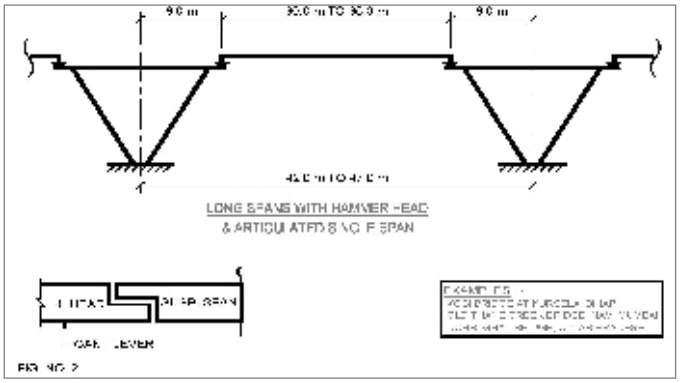
It may be noted that under the prevailing market situations in India the material component in a bridge structure is perhaps the costliest component. In India, the labor costs are still cheaper when compared to developed countries.

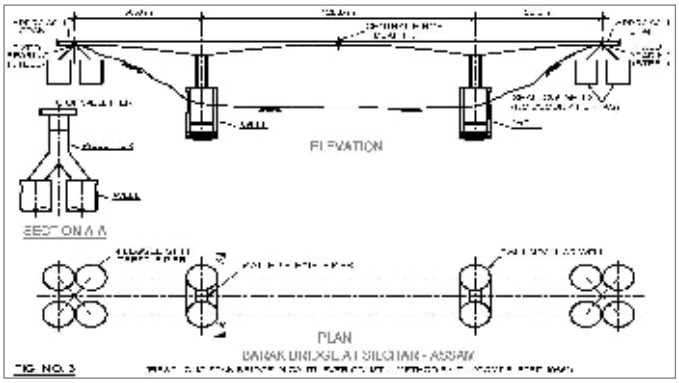
With the advent of the arrival in the scene of many manufacturers for cranes, excavation equipment, batching plants, concrete pumps etc. and other related bridge construction plant and machinery, an increase in speed of construction has resulted and the overall cost is showing trends of improved economics in bridge construction than earlier, referred however to equivalent prices, accounting for inflation etc. But the material costs are the heaviest.

In the U.S.A and other advanced countries in the world, the material component is much cheaper, labor expensive and plant costs reasonable. Hence proposals which are economically viable in U.S.A may not be necessarily be so in our country because of reasons explained above.

Now the question is how do we assess the material component in a decking. The simple formula for bending $wl^2/8$, $wl^2/12$ (continuous) & $wl^2/2$ (cantilever) will give us an idea. These formulae will indicate the mass content. The longer the span the heavier the mass and that will therefore guide the designer to set up a proposal in which he can optimize the proportions of mass in the superstructure and substructure and foundations with some preliminary calculations for assessing the material content.

Base on this preliminary guidance, the designer can then think of a few alternative proposals closely fitting the site characteristics for fine tuning and with the process of elimination select the most optimized structure involving the least material content, leading to economy.





Surajbari Creek (fig no 4) near Kutch is a fine example where Gammon won a large contract for a simple bridge, just by introducing a slight innovation whereby it was possible to reduce the net span length by providing integral short cantilevers to the precast girders.

6.1 Superstructure:

Transverse arrangements

1) RCC/Prestressed concrete I or T sections are very suitable for land based structures with short spans and will give economy when foundations soil is good and scouring is absent.

2) Box girder (single or multiple as the requirement may be) in situations as in item 1 above will be highly uneconomical unless the spans are in sharp curvature.

3) Box Girders are very suitable for long spans because of their high flexural & torsional rigidity, for right bridges, as also for skewed and curved bridges.

4) Cable stayed decking is most suitable for spans beyond 180 to 600 m and that too for waterways with deep scour.

5) The cable stayed decking is not economical for land based bridges with small heights of piers albeit they are many times constructed in city areas also mostly for aesthetic considerations rather than economic considerations.

6.2 Foundations:

1) The most economical are those with open foundations if the site conditions and soil quality will permit.

2) Well foundations supporting long spans give a balanced cost of the proposal itself when very deep foundations are necessitated due to very deep scours, high seismicity, tall piers etc. Although piles have been and are being used as deep foundations in many cases, presently, in cases with deep scour, well foundations are economical under certain compelling situations.

3) Pile foundations display economy when sandy/clayey soils are met as the medium for founding for land based bridges with nominal or no scour but may not be economical in cases of deep bed scour, large water depths and intense seismicity.

6.3 Piers:

Usually for good aesthetics, solid circular piers are economical and pleasing to the eye, these however display economy when supporting short to medium spans and up to a pier height between 8 m to 12 m. Beyond this height, piers categorized as tall piers with heights reaching above 30 m, circular annular piers or rectangular box shaped piers in concrete are very effective both structurally and economically.

1) Where rocky strata is easily available at relatively shallow depths in the bed, open foundation are usually fine for medium simply supported spans if the excavation is generally in the dry requiring relatively small dewatering.

2) The size of open foundations will increase when the founding medium displays soft rock with allowable bearing capacities of the order of 40 to 50 t/m2. Hence under high seismic forces the depth of footing will become considerable and not only bending but punching shears will dictate which will increase footing depths considerably. In these cases rectangular footing with RCC wall piers can be used, effectively proportioned in such a way that from both bending and punching shear considerations the footing could be designed economically without providing large depths for span ranging between 30 to 35 metres.

However under certain situations, for aesthetic considerations and where considerably high velocity of flow exists, circular piers are many a time adopted, particularly when high depths of water are encountered in the waterway. If resultingly, the piers are high and high seismic forces are associated, large footings circular in shape would be required, leading to considerably large footing depths. Thus for tall piers, cellular annular circular piers in concrete flared to a larger diameter at the base will help in reduction of footing depth, by controlling both flexure and punching shear in the footing, for economy.

The author was faced with a vexing problem during the design execution of an elegant bridge constructed in the nineties by Gammon namely Kaladan Bridge, Mizoram constructed for Border Roads Organisation.

For superstructure this bridge had a central span of 122m with 71m side spans on either side in the continuous system with one fixed bearing in C.S at one pier location and C.S roller bearing at the other supports. The piers were about 33m in height with a seismic acceleration of G/10 as was specified those days. There was no response reduction factor for use. The river also had a high velocity of flow about 12m/sec and considerable water depth at HFL.

Hence an annular circular pier with gradually increasing diameter towards base was initially thought of. However, as the foundation strata was soft rock with an allowable bearing capacity of the order of 40 t/m2, a large footing diameter was required which in turn led to a solid RCC footing, extremely heavy rendering it very uneconomical . As the author recalls, the diameter of footing was around 30 m and solid RCC footing of depth of over 6 m was required. The large diameter of the footing was required to cater to the codal provision of not to exceed a certain percentage of the overall footing area coming under tension (i.e. no contact) under the action of critical forces & moments. After a careful study an alternative was thought of, instead of providing a solid footing, a ring foundation was examined which had a diameter of about 26m and a depth of 2.5m (Fig no.5). Although the design of the foundation and the pier shell became very complex in absence & digital computers & software in those days but the problem was solved with success based on manually prepared calculations for this complex design. The economy achieved in both concrete and steel was considerable and substantial saving in costs was achieved. Fig no 5 shows the general shape of the pier and the ring foundation.

7. Conclusions :

The concept of an economical proposal is normally difficult for a young designer to ingest, as this requires experience. However with careful study of the site condition and with experience the designer can develop the skills of identifying an economical proposal, gradually. The author had the good fortune to have had the opportunity to be deeply involved with the design of many of the bridges mentioned herein and thus could gather valuable experience for identifying economical proposals.

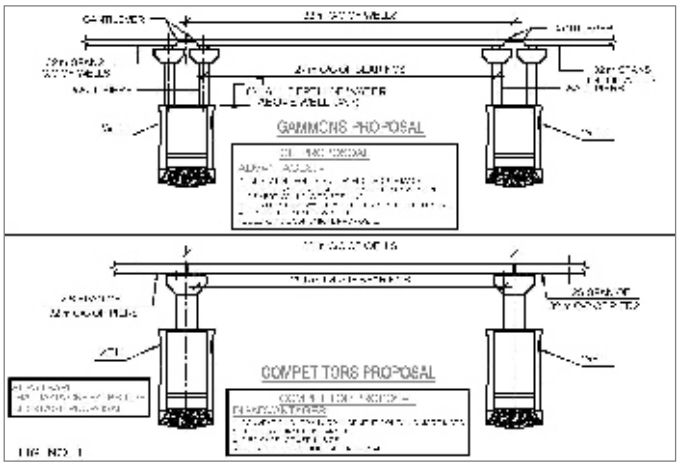
The key is to examine a few alternatives (may be two or three), prepare simple preliminary calculations; assess the quantities of each proposal for arriving at the most economically viable proposal. Although easier said than done, the designer, with application, can gradually develop a maturity which will enable him to easily recognize an economical proposal amongst several others, with confidence.

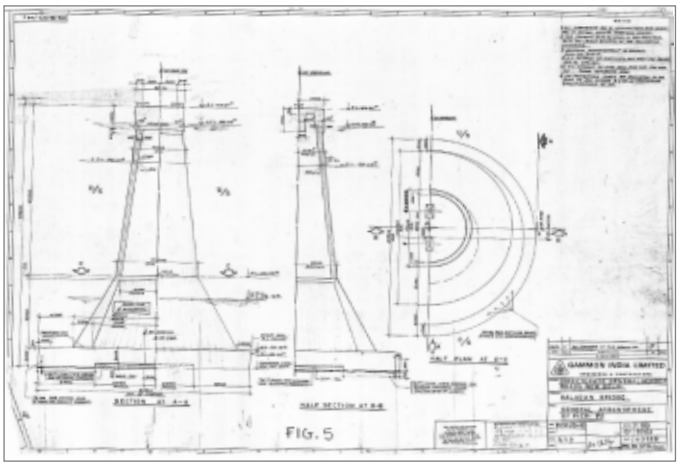
8. Acknowledgements:

1) Gammon India Ltd

2) i) To my senior colleagues for their valuable guidance, at those times when the bridges were designed.

ii) To my junior colleagues at those times who with their dedication and hard work kindly assisted me in contributing to the successful completion of these projects by Gammon.





NEWS FLASH

1. HON'BLE PRIME MINISTER DEDICATES THREE FLAGSHIP HYDRO POWER PROJECTS TO NATION

Hon'ble Prime Minister, Shri Narendra Modiji dedicated three flagship Hydro Power Projects on 18th October, 2016 to the nation at a function in Mandi, Himachal Pradesh. The Projects include 800MW Koldam Project of NTPC, 520 MW Parvati Project of NHPC and 412 MW Rampur Hydro Station of SJVNL. Shri Acharya Devvrat, Governor of Himachal Pradesh, Shri Vir Bhadra Singh, Chief Minister, Himachal Pradesh, Shri Jagat Prakash Nadda, Union Minister of Health and Family Welfare; Shri Piyush Goyal, Union Minister of State (IC) for Power, Coal , New & Renewable Energy and Mines and eminent dignitaries were present on the occasion.

Appreciating the contribution of Public sector companies in country's growth, Prime Minister, Shri Narendra Modiji said that these hydro projects will bring prosperity to the State of Himachal and other parts of the nation.

With commencement of generation from four 200 MW units, NTPC's Koldam Project has achieved capacity of 800 MW and provides peaking capacity to the Northern grid. It shall annually generate 3054 GWh electricity at 90% dependable year basis.

NHPC's Parbati-III Power Station is a run of the river scheme having a 43 m high rock fill dam, underground Power House and 10.58 km long water conductor system. A net head of 326 m is utilized to run four vertical Francis turbines with an installed capacity of 520 MW (4x130 MW). The power plant is designed to generate 1963.29 Million Units annually.

SJVN's Rampur Project (412MW) in Kullu district will be operated in tandem with Nathpa Jhakri Hydro Power Station.

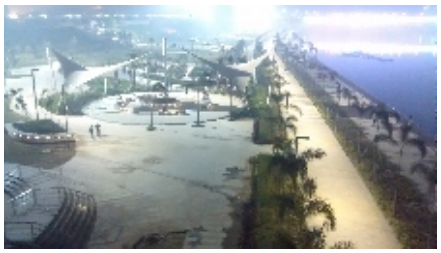
Gammon is the only civil construction company who has the unique distinction of working on all the three projects stated above. Gammon is proud to be associated with these flagship Projects namely Koldam, Parvati and Rampur and thereby contributing our bit in development of Himachal Pradesh and other parts of the nation.

2. DEDICATION OF GOMTI RIVER FRONT TO PUBLIC

Hon'ble Chief Minister Shri Akhilesh Yadav, on 16th November, 2016 said that the U.P. Government had set an example for balanced development and timely completion of projects for other states.

CM was speaking at a function to dedicate the Gomti Riverfront Development Project to public in the state capital.

"The Gomti Riverfront is one of the largest eco-friendly projects and has no parallel anywhere else in the country. It will not only be a tourist attraction but also generate business and employment opportunities," CM said.



CM congratulated the Officials and Engineers of the Irrigation Department and Gammon team for completion of the project ahead of schedule.

Under this prestigious River front Development Project, RCC Diaphragm Walls have been constructed on both the banks of Gomti river, channelizing the water-way. The land between the water-way and the embankment has been developed for public use by constructing a cycle track, a jogging track, walking track, kids play area and facility of toilet, potable water and parking at every 500 m.

Commuting in the water-way has also been arranged through a water bus, which would start plying from December. Under the project, a lake has also been developed which would have a musical fountain, place for yoga, wedding ground, 2000-person capacity amphitheater and stadium for playing football and cricket.

Gammon has executed the above Project on fast track basis ahead of schedule registering a record breaking progress in construction of Diaphragm Wallsun paralled in the country.

Hindustan Times Dated 17th November, 2016 flashed the above news prominently.

3. SITE VISIT BY HON'BLE MINISTER OF STATE MoRTH

Shri. Pon. Radhakrishnan Hon'ble Minister of State MoRTH, Mr. Anand Kumar, the first Managing Director of the National Highways and Infrastructure Development Corporation Ltd. (NHIDCL) and other NHIDCL officers visited New Brahmaputra Bridge & Road Work Project on 27th October, 2016.

Hon'ble Minister and the team inspected entire site and also crossed the river in the project site boat and appreciated the progress achieved so far.

4. VIP VIST : SABARMAT BRIDGE

Mr. Aadesh Sharma, MD, DFCCIL along with other DFCCIL Executives visited the Sabarmati Bridge site on 11th November, 2016 and reviewed site progress.

Also present during site visit were

JV Lead members (JFE Engineering – Japan) and Executives of Nippon Koi Consultants who are PMC for this project.

5. VIP VISIT : BRAHAMPUTRA BRIDGE AT TEZPUR

Sri. Shamsher Singh, Deputy Commissioner of Nagaon District Assam visited New Brahamputra Bridge at Tezpur on 4th October, 2016

6. SIGNATURE BRIDGE

Hindustan Times dated 13th October, 2016 carried the news of Signature Bridge across Yamuna River.

The Signature Bridge at Wazirabad is on the verge of completion. The construction of the bridge is in its final phase and may be completed by April

When the project was first conceptualized in 2004, it was decided that the space close to the bridge would also be developed as a picnic destination. As per a proposal, the Delhi Tourism and Transportation Development Corporation (DTTDC) was to initiate revamp on areas surrounding the bridge.

The previous Government had planned recreational facilities such as water sports, boating, open-air theatre, food plazas with promenades and winding walkways at Yamuna bank to attract a larger number of tourists. The area is also to be rejuvenated as a habitat for avian and aquatic life.

The Signature Bridge will connect Outer Ring Road (National Highway 1) on the western side and Marginal Bund Road at KhajuriKhas intersection on the eastern side. It will serve as a vital link for commuters travelling between north Delhi and northeastern part of the city and Ghaziabad.

7. SAFETY AWARD

VallurThemalPowe Plant site has received Safety Award from NTECL on 28th October, 2016 for having achieved 2 million safe man hours. The Award was received by the GIL representatives(PM and site safety In-charge) from the Project Head/AGM (P), NTECL

8. SAFETY MONTH CELEBRATION

Like every year, this year also Gammon decided to celebrates the month of November as "Safety Month". The entire gamut of Gammon including all Projects, Regional Offices, Workshops and HO are actively involved and encouraged to participate in the celebration of the Safety Month with various safety programmes for awareness, motivation, propagation and enhancing Safety Culture as a whole. The theme of the Safety Month for year 2016 was "Focused Supervision and effective participation for Safety".

The celebration of Safety Month is to ensure full participation by all concerned with zeal and enthusiasm for continual development of Safety Culture in the company.

Various activities aimed to enhance Safety awareness and build sound Safety Culture were planned during the month.

Opening ceremony at Corporate office

Udhampur Ramban Road Project

RVNL Kolkata Metro Project

Bajoli Holi Hydro Project

Nathani Heights Building Project

Patna Elevated Road Project

Gomti River Front Project

9. DEVELOPMENT OF GATES FOR INUNDATION BINS

Taloja Workshop conceived, designed and developed Water Tight Gates for inundation bins of Vyasi Hydro Project. These gates are developed in-house by Gammon team for the first time in the country.

10. COMMISSIONING OF 2nd PUMPING UNIT AT KALWAKURTHY

Having successfully commissioned 1st Pumping unit in September, 2016, now 2nd Pumping unit of 30 MW capacity has been successfully commissioned at Kalwakurthy on 16th November, 2016. With this achievement, now 1300 Cusecs water is being discharged which is providing irrigation for 1.50 Lakh acres apart from filling about 200 Village Tanks in this

The puja of 2nd Pump commissioning was done by Mr. Penta Reddy, Advisor Lift Irrigation Schemes, Govt. of Telangana.

harvesting season . It is planned to commission the 3rd, 4th and 5th units progressively in coming months.

Kalwakurthy Mahatma Gandhi Kalwakurthy Lift Irrigation Scheme is designed to provide irrigation and drinking water facility to the chronically draught affected, upland areas in Mahabubnagar District by lifting water from the river Krishna from the foreshore of the Nilam Sanjeeva Reddy Sagar (Srisailam Reservoir) project with First lift at Regumangadda of Kollapur Mandal of Mahabubnagar District.

The Scheme envisaged to irrigate 3.40 Lakh acres at a cost of Rs. 2990 cores utilizing 25 TMC of water by series of 3 lifts located as follows:

Lift-1 (Stage-1) at Regumangadda with static lift of 95 m.

Lift-2(Stage-2) at Jonnalaboguda with static lift of 86 m.

Lift-3 (Stage-3) at Gudipalli Gattu with static lift of 117 m.

The above 3 lifts are interconnected with series of balancing reservoirs, gravity canals and tunnels along with other relevant components.

COMPANY NEWS

THANKS TO ESTEEMED CUSTOMERS

Turnkey Design and Construction of Well Foundation at River Brahmaputra for Guwahati Ropeway Project, Assam

C.V. Rs. 12. 24 Crores

WELCOME TO GAMMON FAMILY

Pradeep Kumar Kulshrestha
Nilesh Pundalikrao Vaidya
Soubhagya Panda
Arun Vasudev Panchal
Gaurav Dilip Jadhav
Jitendra Sanjay Jambhale
Navneet Dhiman
Md Jasim .
Nayan Kumar
Harshit Kumar Dwivedi
Mahesh Kumar
Prem Prakash
Bikkina Sivannarayana
Ravish Kumar Bhardwaj
Khem Raj Malhotra
Nadeem A Sanadi
Parikshit Singh
Yurendra Yadav
Harihara Pani
Awadhesh Sharma
Prasenjit Kumar Kundu
Vishal Nivas Kachare
Shruti Brat Shukla
Yarrabothula Malleswararao
Angshu Lahiri
Brajesh Kumar Patel

..... contd.

AWARDS

S. A. Reddi

Mr. S. A. Reddi, Ex-Dy. Managing Director, Gammon India Limited has been conferred with the Life Time Achievement Award by the Indian Roads Congress (IRC) during 77th Annual Session held at Hyderabad on 17th December, 2016.

The Award is in recognition of his outstanding achievements and personal commitment to Highway Engineering profession.

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The Award was presented by the Honourable Minister of Road Transport and Highways, Mr. Nitin Gadkari and was received by his son Mr. Ashok Reddi on behalf of Mr. S. A. Reddi.

This is an indeed great honour conferred on Mr. Reddi and speaks a volume about the contributions made by Mr. Reddi in various IRC committees and other activities of this august body in the country.

Mr. Reddi has been a role model and source of inspiration for all Engineers not only in private sector but in PSUs and Government organisations also.

We extend hearty congratulations to Mr. Reddi on this honour bestowed on him by IRC. .

It is indeed a proud moment for all of us in Gammon.

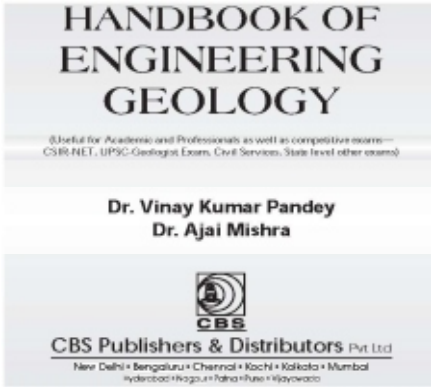
V. N. Heggade

Conferred Maharashtra PWD Medal instituted for the Best Paper on Construction for his Paper " Evolution of Precast Segmental Technology for Bridges in India"

Hon'ble Minister Shri Nitin Gadkari presented the Medal during 77th IRC Annual Session at Hyderabad on 17th December, 2016.

PUBLICATION OF BOOK

Book titled 'HANDBOOK OF ENGINEERING GEOLOGY' authored by Dr Vinay Kumar Pandey, Manager-Geology, Udhampur-Ramban Highway Project has been accepted for publication by CBS publication, New Delhi.



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Ravirala Srinivasulu
Jayanta Samanta
Taj Ahmad
Ravindra Kumar
Rana Ranjeet Singh
Bhim Patar
Mangal Singh
Prasanta kumar Barik
Amit kumar Sharma
Chandra Narayan Das
Bhavusingh Bhukya
Ajay Kumar V
Ajay Kumar Singh
Nihal Tripathi
Manish Srivastava
Gudiwada Gopikrishna
Sujeet Kumar
Sunil Kumar Mishra
Jeet Kumar
Avinash Karshanbhai Santoki
Lanka Venkata Sivarama Krishna
Shivayya A Hinemath
Kartheek Chava
Kartik Tiwari
Sourav Chatterjee
Siva Sankar
Nishant Kumar
Sachin Rewachand Indulkar
Dibyendu Maiti
Dhrubajyoti Thakuria
Harsh Kumar Singh
Amit Kumar Patra
Vikash Mehta
A Rakesh
Manoj Biswakarma
Amirul Hoque
Jitendra Giri
Anshumaan .
Sandeep Kumar Singh

PHD EVALUATION

Dr. N V Nayak

3rd November, 2016

Evaluated Research work of PhD Candidate at VJTI.

LECTURES DELIVERED

P.Y.Manjure

4th October,2016

Mr. P.Y. Manjure, Director, Freyssinet Prestressed Concrete Company Limited delivered a Key Note Address in Technical Session No.4, during the conference organized by Ministry of Surface Transport and IDDC Ltd on 'Bridge Management System' at New Delhi on 04th and 05th October, 2016.

In appreciation he was felicitated by an IBMS Momento by the Chairman.

The Ministry of Surface Transport has launched an ambitious project on Bridge Management System in 2014. The project envisages identification of all bridges on National Highways. It includes collection of various particulars of the bridge, technical parameters and structural details of the bridge. Besides, the project will bring out the conditions of the bridge and would identify the bridges which need strengthening measures to maintain their service life.

The Ministry has appointed IDDC Ltd and 18 other consultants to inspect all these bridges and collect the necessary information.

Also biennial conference was held under the aegis of Ministry of Surface Transport and IDDC Ltd to discuss various aspects of the Bridge Management System in the light of information collected during the last two years. The Ministry and Organizers invited Mr. P.Y. Manjure to address the conference and speak on 'Challenges in Rehabilitation of Bridge Structures'.

GIL PARTICIPATION IN SEMINAR

Dr. N.V. Nayak

15th October, 2016

Workshop on "Outstanding Steel Structures" at VJTI

19th November,2016

Attended a Technical Lecture on Concrete arranged by ICI at Bandra Kurla Complex, Mumbai

V. N. Heggade & P. S. Raizada

15th -18th December, 2016

Attended Annual Session of IRC at Hyderabad

STUDY TOUR

Mr. M.V. Jatkar and Mr. V. N. Heggade visited China on invitation to study cable supported technologies in China on 13th to 14th and 17th to 18th October,2016

BEREAVEMENT

With deep regret, we inform the sad and sudden demise of Sh. Rahul Srivastava, Senior Manager – WSS, located at Kolkata Office. Mr. Rahul Srivastava passed away on 21st October, 2016 at the age of 63 years.

He worked with Gammon for nearly two decades. Mr. Srivastava was known for his positive attitude & helping nature. Mr. Srivastava is survived by his wife, daughter and son.

We offer our deepest condolences to his family and pray almighty God that his soul rests in peace.

A CAPITAL EXCELLENCE

- THE Signature Bridge ACROSS YAMUNA RIVER AT DELHI

India's First Cable Stay Bridge with an Inclined Steel Pylon

India's first *"Signature Bridge"* being constructed by Gammon across Yamuna river at Wazirabad, promises to be a great tourist attraction of Delhi, the Capital of India. This cable-stayed bridge will link NH-1 at Wazirabad on Western bank and at Khajuri Khas on eastern bank of the river Yamuna, connecting North Delhi with East Delhi.

With a length of about 575 m (main bridge) +100 m extension and a height of 154 m, with glass facade at top part, the proposed *Signature Bridge* would have a bow-shaped steel pylon in the middle. Two high towers will provide double cable support in the inner periphery of the carriageway. The deck will be composite (steel and concrete) while the pylon will be in steel.

Equipped with four lanes, this engineering masterpiece will have a 1.2 m wide central verge, space for anchoring cables, maintenance walkway and crash barrier on either side of the central verge. Once operational the *Signature Bridge* will dramatically improve access between North and East Delhi reducing present congestion and traffic jams and will become the identity of Capital City – the way Taj Mahal is to Agra

CLIENT: DELHI TOURISM & TRANSPORT DEVELOPMENT CORPORATION

CONTRACTOR: GAMMON INDIA LTD- C. CIDADE - TENSACCIAI JV

DESIGN CONSULTANTS: SCHLAICH BERGERMANN & Partners, Germany

PROOF CONSULTANTS: M/s SYSTRA SA, France

GAMMON INDIA LIMITED

GAMMON HOUSE, V. S. MARG, PRABHADEVI, MUMBAI 400025 INDIA

www.gammonindia.com, www.gammoninfra.com

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