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A Unique Design of R.C.C. Bridge on Godavari River at Sironcha Dist. Gadchiroli - India

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ABSTRACT

Reinforced concrete bridges may have various systems: Beam (with simply supported or continuous beams), Frame, Arch, or combined of it.. Beam reinforced concrete bridges are the most common type, Spans with plate structure are generally used to cover gaps of 6–18 m. Ribbed spans with main beams supporting the plate of .The bridge floor are used to cover gaps of more than 12m. For gaps of more than 40 m, beam spans frequently have box shaped cross sections. Arch systems are most appropriate for bridges on stable soil. The spans of beam-type reinforced concrete bridges are up to 200 m; those of archer in forced concrete bridges, up to 300 m. The main advantages of reinforced concrete bridges are durability and relatively low maintenance cost. Precast reinforced-concrete bridges, using finished plant-Manufactured components, are the type primarily built in the USSR. Methods of suspension assembly of spans and delivery of precast components to local areas by ships are extremely efficient in the construction of large reinforced-concrete bridges.

Keywords: RCC Bridge

Introduction

I have Visited The R.C.C. bridge across Godavari river at Sironcha Dist. Gadchiroli on Saturday dated 19 -11-2016. The bridge is constructed across Godavari river near the confluence of Godavari river and Pranhita river. I have studied about the various components of bridge. this R.C.C. Bridge comes under PWD Gadchiroli of Government of Maharashtra , this R.C.C. bridge is very beneficial as this joins two states Telangana and Maharashtra for exchange the social, economical and cultural aspects.

Design standards for this project conform with "Manual of Standard & Specifications for two laning of State Highways (IRC: SP:73-2007)", "Specification for Road and Bridge Work" by Government of India, and various relevant IRC Standards and BIS Standards. Also "Geometric Design Standards for Highways" published by Ministry of Construction, Public Works.

The paper is organized as follows. The section II introduces the design standards., The section III introduces design methodology. The section IV describe the design parameters and section V as conclusion respectively.

Design Standards

The R.C.C. Bridge was constructed as a part of transportation project by government of Maharashtra in the year 2011. It's construction completed in the year 2016. This R.C.C. Bridge is constructed by MANTENA INFRA Company.
The design of this bridge as follows

A. Material

a) Cement

For construction of structures 43 grade ordinary Portland cement conforming to IS: 8112 and 53 grade ordinary Portland cement conforming to IS: 12269 will be used.

b) Admixtures

To improve workability of concrete, admixtures conforming to IS: 9103 will be used.

c) Aggregates

Aggregates will consists of clean, hard, strong, dense, non-porous and durable crushed stone for coarse aggregates and natural particles for sand. The aggregates will conform to IS: 383 and will be tested to conform to IS: 2386 parts I to VIII. Size of coarse aggregate will be selected as per mix design requirement.

d) Water

Water used for mixing and curing will be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. The pH value of water will not be less than 6.

e) Concrete

The grade of concrete will be as per design requirement and mentioned in execution drawings for each component of the structure. Cement and water content will be as per mix design requirement.

f) Reinforcement

Deformed or TMT reinforcement bar conforming to IS: 1786 will be used for components of the structures. The reinforcement grade will be Fe500.

g) Pre-stressing Steel

Pre-stressing tendons normally take the form of separate wires, wires spun together helically to form strands or bars. For pre-tensioned steel, wires, strands and occasionally bars are used, simply to permit the concrete to bond directly to them; when post-tensioning is used, it is common practice to the separate tendons together, so as to reduce the number of anchorages and ducts required to accommodate them. When grouped in this way, the tendons in each duct are usually termed a cable.

Uncoated stress relieved low relaxation steel conforming to IS: 14268 will only be used for prestressing steel so as to reduce losses due to relaxation. Data in respect of modulus of elasticity, relaxation loss at 1000 hours, minimum ultimate tensile strength, stress-strain curve etc. will necessarily be obtained from manufacturers. Pre-stressing steel will be subjected to acceptance tests prior to actual use on the works (guidance may be taken from BS: 4447). The modulus of elasticity value, as per acceptance tests, will conform to the design value which will be within a range not more than 5 percent between the maximum and minimum.

Many cables with different arrangements of wires and strands and different methods of anchorage are available as pre-stressing steel. So type and size of cable and methods of anchorage will be decided on the basis of design requirement.

h) Sheathing

The duct or sheath for cables to be used of Corrugated HDPE having coefficient of friction as 0.17 and wobble coefficient per meter length of steel 0.0020. The thickness of sheathing will be as specified in Section 13 of IRC:112. The sheathing will conform to the requirements of Section 13 of IRC:112 and test certificate will be furnished by the manufacturer. The joints of all sheathing will be water tight and conform to the provision contained in Clause 13.6 of IRC: 112.

i) Void Former

Void former are required to possess the necessary rigidity and integrity of dimensions in addition to being water tight, since special machines are available for manufacturing of corrugated steel void formers, so only corrugated steel void former will be used. The materials and other requirements for void former will conform to the provision of IRC: SP: 64.

Design Methodology

I. Pile Foundation

In general, the design of pile and pile cap will conform to provisions of IRC:78. The various specific assumptions to be made for the design of pile and pile cap will be as follows:

(a) The vertical load carrying capacity of the pile will be determined based on static formula given in Appendix-5 of IRC:78-2014. The following limiting values will be considered for computation of safe load:

- Results of sub-soil investigation will be used for adopting the value of angle of internal friction "Ø" and cohesion "C" of the soil.
- Angle of wall friction 'Ø' to be taken as equal to Angle of internal friction 'Ø'.
- The coefficient of earth pressure, 'K' will be taken as 1.5 while calculating the safe load carrying capacity.
- The entire overburden will be assumed fully submerged for the purpose of Calculation of safe load.
- Maximum overburden pressure at the bottom of pile for the purpose of calculation of shaft friction and end bearing will be limited to 20 times the diameter of the pile.
- Factor of safety will be taken as 2.5

(b) The vertical load carrying capacity as calculated by static formula will be verified by conducting initial load tests on piles conforming to IS:2911 (Part 4).

(c) The lateral load carrying capacity of the pile will be determined by using empirical Formula given in IS:2911 (Part-1/Sec-2) by limiting the lateral deflection of 5mm at its tip considering it as fixed headed pile under normal conditions. The capacity so evaluated will be used purely for the purpose of arriving at the upper bound of lateral load capacity. This deflection limitation will not be applicable in load combination with seismic conditions for which the resulting stresses and the structural capacity of the section would be the governing criteria.

(d) Soil stiffness for lateral loads will be taken from IS: 2911 (Part-1/Sec-2), Appendix – C. Unconfined compressive strength will be calculated from the results of Geotechnical Investigation Reports. Cohesion as calculated using unconsolidated un-drained test with required modification of angle of internal friction will be used for working out unconfined Compressive strength.

II. Pile Cap

- Theminimum thickness of pile cap will be kept as 1.5 times the pile diameter.
- Top of the pile will project 50mm into the pile cap.
- The top of pile cap will be kept at least 300mm below the ground level in case of urban interchange structures or road over bridges. For bridges on rivers / streams / canals, the bottom of pile cap will be kept at LWL.

Pile cap will be designed either by truss analogy or by bending theory, depending upon the spacing and number of piles in a pile group. Truss analogy may be used for pile caps with a maximum of 5 piles in a pile group. Beyond 5 piles, bending theory will be used.

- Pile cap will be provided with an offset of at least 150mm beyond the outer face of the outer piles.

III. Piers & Pier Caps

- The piers are to be designed for combined axial load and biaxial bending as per the provisions of IRC: 112.
- Pier cap is checked as either as a flexural member or as a bracket, depending upon the span / depth ratio.

- In case it is a flexural member, the bending moments are checked at the face of pier support. Shear force will be checked at a distance deft away from the face of support.
- In case the pier cap acts as a bracket, the design will conform to provisions of IS: 456 in absence of any specific provision in IRC code for bracket design.
- Analysis, design and detailing will in general conform to the stipulations of relevant IRC codes and good engineering practice.

IV. Superstructure

Design of PSC T Beam and Slab (Precast Girder and in-situ slab)

- The design of such type of structure is very much dependent on the construction sequence. The structure is in iso-static condition up to the stage of casting of deck slab and diaphragm and after developing proper bond with girder, the structure behave as composite section.
- The design therefore will be done with only the girder section being effective up to the stage of casting of deck slab and diaphragm and composite section will be considered for all subsequent loads (i,e for SIDL and live loads).
- The deck structure will be analyzed using grillage analogy method for SIDL and Live Loads. Self weight of girder and Dead Load of slab will be applicable on girder section alone and hence the design forces for DL and SW will be calculated separately and results superimposed. The superstructure will be idealized into a cross set of discrete members which are able to resist the loads applied in a plane perpendicular to the plane of assemblage, through bending shear and torsional rigidities of the members.
- The minimum dimension of various elements will be provided conforming to the latest IRC codes and standards. The minimum deck slab thickness will be kept as not less than 200mm. The minimum web thickness for the longitudinal girders will be not less than 200mm plus the sheath diameter of prestressing cable. Thickness of cross girders will not be less than the thickness of longitudinal girder. There will be at least three cross girders in any beam and slab type structure (i.e. one at the centre and two at the ends.).
- For obtaining maximum shear stress, the section at a distance equal to effective depth from the face of the support will be checked and the shear reinforcement calculated at the section will be continued up to the support.
- The design of deck slab supported transversely on the precast girder will be carried out assuming un-yielding support at the girder points.
- Effect of differential shrinkage and creep between precast girder and in-situ slab will be considered.

Design of RCC T Beam and Slab (Precast Girder and in-situ slab)

- The design of such type of structure economical for smaller spans only.
- The design therefore will be done with only the girder section being effective up to the stage of casting of deck slab and diaphragm and composite section will be Considered for all subsequent loads (i,e for SIDL and live loads).
- The deck structure will be analyzed using grillage analogy method for SIDL and Live Loads. Self weight of girder and Dead Load of slab will be applicable on girder section alone and hence the design forces for DL and SW will be calculated separately and results superimposed. The superstructure will be idealized into a cross set of discrete members which are able to resist the loads applied in a plane perpendicular to the plane of assemblage, through bending shear and torsional rigidities of the members.
- The minimum dimension of various elements will be provided conforming to the latest IRC codes and standards. The minimum deck slab thickness will be kept as not less than 200 mm.
- For obtaining maximum shear stress, the section at a distance equal to effective depth from the face of the support will be checked and the shear reinforcement calculated at the section will be continued up to the support.
- The design of deck slab supported transversely on the precast girder will be carried out assuming un-yielding support at the girder points.
- Effect of differential shrinkage and creep between precast girder and in-situ slab will be considered.

5.5.3 Seismic Design & Detailing

I. Seismic Analysis & Design

The project corridor falls under seismic zone – v, which is a high seismic zone. In general, Seismic analysis of the bridge structure is proposed to be carried out in 2 steps.

Step-1: To carry out single mode analysis to obtain the fundamental vibration period of the bridge in two orthogonal directions (i.e. longitudinal & transverse direction).

Step-2: To estimate seismic forces using the spectrum response, defined in IRC:6.

The calculation for fundamental period can be done either by using the simplified expression given in Appendix – D of IRC:6-2014 or else by modeling the structure in STAAD/Pro and carrying out dynamic analysis.

a) Bearings

Bridge bearing must be designed to transmit all the loads and appropriate horizontal forces. From the material point of view, these bearings can be made from metal, rubber, metal and elastomer and even concrete. However following two types of bearings are recommended to be used on this project.

b) Elastomeric Bearings

Elastomeric bearing can accommodate translation movements in any direction and rotational Movements in any axis by elastic deformation. They should not be used in tension or when rotation is high and vertical load small. The basis of design is that the elastomeric is an elastic arterial, the deflection of which under a compressive load is influenced by its shape (shape factor). Reinforcing plates should be bonded to the elastomer to prevent any relative movement at the steel/elastomer interface. The dimension and the number of internal layers of elastomer chosen will satisfy the following clauses of IRC: 83(Part-II) Loading

In case of structure sensitive to differential settlement such as continuous structures the value of differential settlement will be taken as 10mm.Temperature Gradient Effective bridge temperature will be taken as 34°C estimated from the isothermal of shade air temperature given in fig 8 and fig 9 of IRC: 6. Difference in temperature between the top surface and other levels through the depth of the structure, where ever applicable will be taken in accordance with clause:218.3 of IRC:6.

Design Parameters

The design detail is shown in Table 1

TABLE 1

Design Details

Description	As Per DPR	As Per Revise Estimate
F R L	110.245	11O.245
H F L DESIGND 105.65 OBSERVED 102.655 92.22		
R F L		
TOTAL COST OF PROJECT	167.142 Crore	241.716 Crore
Bridge Portion		
Cost Of Bridge	114.615 Crore	189.232 Crore
Length Of Bridge	1620 M	1620 M
TOTAL LENGTH OF APPROACH ROAD	26612 M	26612 M
LENGTH OF SPAN C/C	45 M	45 M
NO. OF SPAN	36 Nos.	36 Nos.

NO. OF PIERS	35 Nos.	35 Nos.
NO. OF ABUTMENT	2 Nos.	2 Nos.
DIA OF R.C.C. CAST IN SITU PILE	1.5 M	1.5 M
NO. PILE EACH GROUP	07 Nos.	12 Nos.
TOTAL PILE IN FULL BRIDGE	252 Nos.	432 Nos.
NO. OF PILE CAP	36 Nos.	36 Nos.
NO. OF OPEN FOUDATION	1 Nos.	1 Nos.
NO. OF PSC-I GIRDER EACH SPAN	6 Nos.	6 No.
TOTAL NO. OF PSC-I GIRDER FULL BRIDGE	216 Nos.	216 Nos.
HEIGHT OF PSC-I GIRDER	2.4 M	2.4 M
APPROACH ROAD MAHARASHTRA SIDE		
LENGTH OF APPROACH ROAD	3460 M	3460 M
COST OF APPROACH ROAD	16.395 Crore	16.395 Crore
NOS. OF MINOR BRIDGE @ ch 1/920, ch. 1/980	2 Nos.	2 Nos.
COST OF MINOR BRIDGE	85.295 Lakhs	85.295 Lakhs
COST OF BOX CULVERT @ CH 3/200	83.580 lakhs	83.580 lakhs
COST OF HUME PIPE CULVERT (5 NOS)	31.417 lakhs	31.417 lakhs
APPROCH ROAD ANDHRAPRADESH SIDE		
LENGTH OF APPROCH ROAD (NEW APPROCH)	23.159 Kms	23.159 Kms
COST OF APPROCH ROAD	32.237 Crore	32.237 Crore
PARCAL MAHADEVPUR ROAD KM 64/353 TO 68/760 (WIDNING & STREGTHNING)	4407 M	4407 M
MAHADEVPUR KALESHWARAM ROAD KM 00/00 16/00 (WIDNING & STREGTHNING)	16000 M	16000 M
KALESHWARAM-KENNEPALLY ROAD Via METAPALLY ROAD KM 00/00 TO 2/00 (WIDNING & STREGTHNING)	2000 M	2000 M
GODAVARI BRIDGE KALESHWARAM ROAD KM 5/080 TO 5/820 (NEW APPROACH)	740 M	740 M
COST OF MINOR BRIDGE	1.842 Crore	1.842 Crore
COST OF HUME PIPE CULVERT (1 NOS)	4.76 lakhs	4.76 Lakhs
top width of carriage WAY	10.00 m	10.00 m
TOP WIDTH OF GSB	13.960 M	13.960 M
THICKNESS OF GSB	250 MM	250 MM
TOP WIDTH OF WMM	10.800 M	10.800 M
THICKNESS OF WMM	250 MM	250 MM
TOP WIDTH OF DBM	10.00 M	10.00 M

THICKNESS OF DBM	75 MM	75 MM
TOP WIDTH OF BC	10.00 M	10.00 M
THICKNESS OF BC	40 MM	40 MM

Confluence of Godawari river and Pranhita river is in fig 1

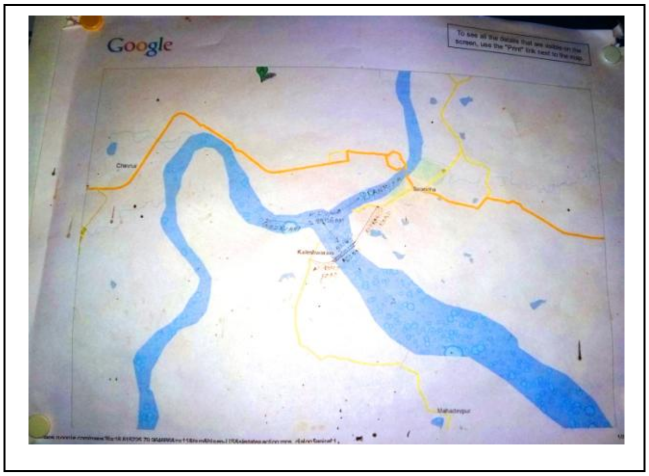

Fig.1 Confluence of Godawari river and Pranhita river

Bridge Construction Technique:-

I. Superstructure

Superstructure is that part of the structure which supports traffic and includes deck, slab and girders. All the parts of the bridge which is mounted on a supporting system can be classified as a Super structure.

II. Substructure

Substructure that part of the structure, i.e Piers and abutments, which supports the superstructure and which transfers the structural load to the foundations.

III. Foundation

Foundation is the component which transfers loads from the substructure to the bearing strata. Depending on the geotechnical properties of the bearing strata, shallow or deep foundations are adopted. Usually, piles and well foundations are adopted for bridge foundations.

Component of Bridge:-

Beam / Girder

Beam or girder is that part of superstructure which is under bending along the span. it is the load bearing member which supports the deck. Span is the distance between points of support (eg piers, abutment). Deck is bridge floor directly carrying traffic loads. Deck transfers loads to the Girders depending on the decking material. Total nos. of PSC-I girder full bridge is 216 nos. Each span have 6 nos. of girder and height of girder is 2.4 m , Details are shown in fig 2

Fig. 2 Details of Beam/Girder

Bearing:-

Bearing transfers loads from the girders to the pier caps. Bearing is a component which supports part of the bridge and which transmits forces from that part to another part of the structure whilst permitting angular and/or linear movement between parts Details are shown in fig 3

Fig. 3 Details of Bearings

Pier Cap / Headstock is the component which transfers loads from the superstructure to the piers. Pier cap provide sufficient seating for the Bridge girders and disperse the loads from the bearings to the Piers. Total no. of pier cap is 35 nos.

Details of pier cap are shown in fig 4

Fig. 4 Details of Pier cap

Pier is that part of the substructure which supports the superstructure at the end of the span and which transfers loads from superstructure to the foundations. Depending up on aesthetics, site, space and economic constraints various shapes of piers are adopted to suit to the requirement. Mostly Reinforced Concrete or Prestressed concrete are adopted for the construction of piers. Piers are compression members. This R.C.C. Bridge has 36 nos. of piers in each span and full bridge has 36 nos. of span. Every span have 45 M c/c distance. Details are shown in fig 5

Fig. 5 Details of Pier

Pile foundation is the most commonly used foundation system for bridges. Pile is a slender compression member driven into or formed in the ground to resist loads. A reinforced concrete mass cast around the head of a group of piles to ensure they act together and distribute the load among them it is known as pile cap. This R.C.C. Bridge has 36 nos. of pile cap. Below image shows the testing of pile. Details are shown in fig 6

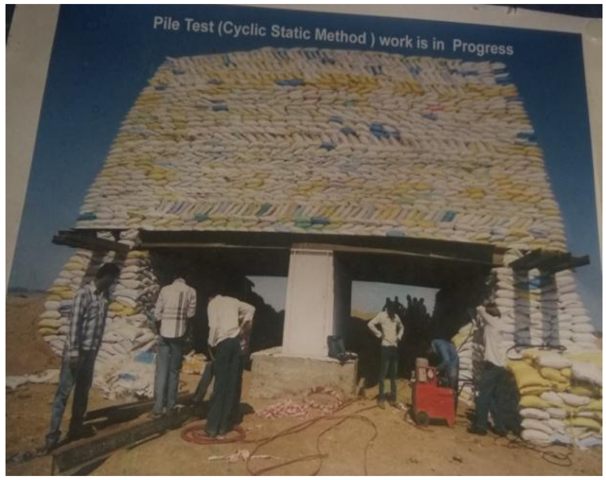

Fig 6 Details of pile testing

Conclusion

We can conclude that due to construction of this R.C.C. Bridge it helps in development of surrounding area by means of transportation. In rainy season the area suffering from flood problem. Now this problem is solved by construction of R.C.C. Bridge on Godavari River.

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