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Analysis and Design of a Steel Trussed Bridge of 93.20 M Span across Salt Creek in Kakinada

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Abstract—
This project is a real time project which is to be executed by the project authorities viz..Kakinada Municipal Corporation. The scope of study in this project involves Analysis and Design of 93.20 m span steel bridge structure using truss Type Bridge with built up sections. The sub structure involves a pile foundation with bored cast in situ piles connected with a rigid RCC pile cap nearer to the ground. The pile cap interns support a RCC bent type pier having a top trestle which supports the bridge bearing. The bridge bearing interns the supports are the steel truss. In the dissertation STAAD Pro software is used for the analysis and design of steel bridge structure. The foundation analysis and design is studied by using manual methods as for the Indian Standards (IS) and Indian Roads Congress (IRC) specifications and procedures.

1 INTRODUCTION

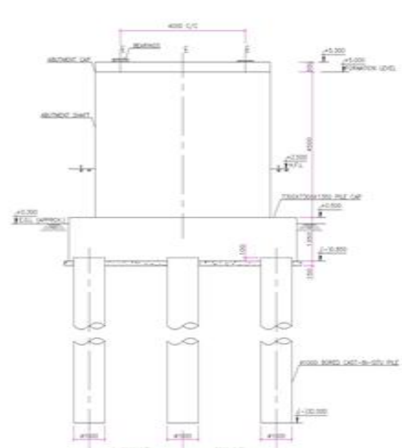
Bridges are the important structures in civil engineering infrastructure projects for communication between two inaccessible areas. Due to rapid industrialization and urbanization the infrastructure works in the country are going on faster phase. Hence, it is imperative to have the design knowledge of design of the bridge structure as a structural engineer.The present thesis involves the design of steel bridge structure to support M.S pipeline to convey water from Artalakatta village summer storage tank to Kakinada Municipal Corporation water works area. During alignment of pipeline, the pipeline is to cross salt creek near Jaganadhapuram area of Kakinada city. For which it requires a bridge structure to support this pipeline. Hence, Kakinada Municipal Corporation proposed to construct a new steel bridge of 93.20 m span to cross the MS pipeline across salt creek at Jaganadhapuram area of Kakinada.

This project is a real time project, which is to be executed by the project authorities' viz., Kakinada Municipal Corporation. The scope of study in this project involves Analysis and Design of 93.2 m span steel bridge. Bridge structure is of truss bridge type with built-up sections. The sub-structure is proposed with pile foundations with bored cast-in-situ piles integrated with a rigid R.C.C. pile cap. The pile cap intern support abutment shaft. Bridge bearings are provided on top of abutment level. The bridge bearings intern supports the super structure steel truss.
In the dissertation STAAD.Pro software is used for the analysis and design of steel bridge structure. The foundation analysis and design is done by using manual methods as per Indian Standards and Indian Roads Congress.

1.2 Staad.pro model

The overall geometry is prepared for the STAAD.PRO model is based on center line of geometry of the truss. The support at bearing level are treated as pinned, whereas the joint in the super structure are treated as fixed. The design of sub structure is done by using working stress method as per IRC: 21 & IS: 456-2000.The detailing provisions are also highlighted at the end of this project as per SP 34 Bureau of Indian Standards and general bridge practice as per IRC.

1.3 Figures



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2. Literature review

Alexander J. Stone, John W. van de Lindt, Suren Chen (2011) studied most feasible options for the design of cost effective
steel bridges in Colorado. The study proved method of constructing multi-span steel bridges is to build as continuous girders to distribute the load over all members.

F. W. Klaiber, K. F. Dunker, W. W. Sanders, Jr. (June, 1981) research work involves pre-stressed steel structures, pre stressed composite structures, bridge strengthening, and bridge deck analysis.

Khaled Sennah (March, 2002) studied the curvilinear nature of box girder bridges along with their complex deformation patterns and stress fields have led designers to adopt approximate and conservative methods for their analyses and design. Recent literature on straight and curved box girder bridges has dealt with analytical formulations to better understand the behavior of these complex structural systems. Few authors have undertaken experimental studies to investigate the accuracy of existing methods.

It is shown that the fractured structure carries dead and live loads as a "pseudo space truss". It is Shown that the after-fracture behavior of the structure is primarily dependent on the strength and stiffness of the redundant bracing system and its connections to the girder Flanges. It is shown that a properly designed and configured bracing system provides Effective and efficient redundancy to a two-girder highway bridge.

3 SECTIONS

Presents the loading calculations, analysis and design of the various structural components of bridge bearings, abutment cap, abutment shaft, pile cap, piles as per Indian Standards and IRC codes of practice. The welded joints are designed as per IS: 800-2007. The safe load carrying capacity of bored cast-in-situ piles are designed as per IS: 2911 (Part me /Sec.2).

4 MATERIALS OF CONSTRUCTION

Concrete "[10], Reinforcement Steel"[10], Structural Steel"[10], Loading"[11], Primary Loads"[11], Dead load of walk way"[21], Operating Load"[22], Impact Load"[22], Wind Load"[24], design of sub-structure - abutment"[28],"[30]

5 EQUATIONS

Calculation of Active Earth Pressure:
From Columb's theory of active earth pressure

$$K_a = \frac{\sin^2(\alpha + \varphi)}{\sin^2\alpha.\sin(\alpha - \delta) \times \left[1 + \sqrt{\frac{\sin(\varphi + \delta).\sin(\varphi - i)}{\sin(\varphi - \delta).\sin(\alpha + i)}}\right]^2}$$

Here angle of internal friction, $\varphi = 30^0$
Angle of friction between soil and concrete, $\delta = 2/3 \times \varphi = 2/3 \times 30 = 20^0$
Surcharge angle, $i = 0^0$, Angle of wall face with horizontal, $\alpha = 90^0$
Bulk density of earth fill, $\gamma_b = 1.8$ t/m^3
Sub merged density of earth, $\gamma_{sub} = 1.0$ t/m^3
Width of abutment = 6.0 m

$$K_a = \frac{\sin^2(2.09)}{\sin^2 1.57 \times \sin 1.22 \times 1 + \sqrt{\frac{\sin 0.87 \times \sin 0.52^2}{\sin 1.22 \times \sin 1.57}}}$$

$$= 0.75/2.523 = 0.2973$$

6 TABLES

6.1**Summary of Loads:**
Super Structure:

Case	P (F_y)	H_L F_x	H_T F_z	M_L (t-m)	M_T (t-m)
Load Comb 24 from STAAD.Pro for Supports 1 & 2	24 t	20	2 t	0	0
Span Dislodged	0	0	0	0	0

SUB-STRUCTURE LOADS UNDER DRY CONDITION:

S.No.	Dry	Vertical Load
1.	Abutment cap	5.4 t
2.	Abutment shaft	81 t
3.	Pile cap	179.85 t
	Total	**266.25 t**

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SUB-STRUCTURE LOADS UNDER H.F.L CONDITION:

S. No.	H.F.L	Vertical Load
1.	Abutment cap	5.4 t
2.	Abutment shaft	
	i. above H.F.L	45 t
	ii. below H.F.L	21.6 t
3.	Pile cap	107.91 t
	Total	**179.91 t**

Table 4.6

Earth Pressure At Bottom Of Pile Cap Level

S.No	Condition	Load	Moment
1	Dry	51.62 t	123.83 t-m
2	H.F.L	44.11 t	94.22 t-m

Table 4.7

BACKFILL WEIGHT AND MOMENTS DUE TO EARTH PRESSURE AND RETURN WALL AT PILE CAP BOTTOM LEVEL

		Load	Moment
Dry Condition			
a.	Backfill	180.35 t	383.24 t-m
b.	Return wall	0	0
	Total	180.35 t	383.24 t-m

Table 4.8

BACKFILL WEIGHT AND MOMENTS DUE TO EARTH PRESSURE AND RETURN WALL AT PILE CAP BOTTOM LEVEL

	HFL Condition	Vertical Load	Moment
a.	Backfill	144.72 t	307.53 t-m
b.	Return wall	0	0
	Total	144.72 t	307.53 t-m

Table 4.9

Load Summary for Piles Safe Load Carrying Capacity Estimation

Load Case		Total Load	Longitudinal Moment	Transverse Moment
I. Dry Condition				
i.	Superstructure load + abutment cap, shaft, pile cap & backfill	24 + 266.25 + 180.35 = 470.6 t (Vertical Comp.)	129 + 383.24 – 126.83 = 385.41 t-m (Counter clockwise)	12.9 t-m
ii.	Span Dislodged	0 + 266.25 + 180.35 = 446.6 t (Vertical Comp.)	0 + 383.24 – 126.83 = 256.41 t-m (Counter clockwise)	0
II. H.F.L Condition				
iii.	Superstructure load + abutment cap, shaft, pile cap & backfill	24 + 179.91 + 144.72 = 348.63 t (Vertical Comp.)	129 + 307.53 – 94.22 = 342.31 t-m (Counter clockwise)	12.9 t-m
iv.	Span Dislodged	0 + 179.91 + 144.72 = 324.63 t (Vertical Comp.)	0 + 307.53 – 94.22 = 213.31 t-m (Counter clockwise)	0

Number of piles = 9

Spacing of piles both in longitudinal and transverse direction = 3.0 m C/c

$I_{TT} = 3 \times 2 \times 3^2 = 54\ m^4$

$I_{LL} = 3 \times 2 \times 3^2 = 54\ m^4$

7 Conclusion

The followings conclusions may be drawn from the analysis and design carried-out.

1. As per the analysis and design of the super structure carried-out, it was found that for the design of steel bridge structure to support water pipeline/oil pipe lines, the present Indian Standards and IRC codes are not sufficient to evaluate the design loads for operating load of piping and fluids, thermal anchor load, vibration loads and impact loads for which we have to depend on Petro Chemical Industry Standards.
2. For the design of steel bridge structure to support water pipeline/oil pipe lines, the present Indian Standards viz., IS: 800-1987 and IS: 875 (Part 5) and IRC codes are silent in providing load combinations and its load factors for which we have to depend on International Petro Chemical Industry Standards.
3. The bridge code irc: 5 are silent in providing impact

factors for design of steel bridge structure to support water pipeline/oil pipe lines.

4. The present design practice in India for the design of steel bridge structures to support water pipeline/oil pipe lines is based on American Plate Industry Standards, American and British Petro Chemical Industry Standards. Bureau of Indian Standards and Indian Roads Congress should look into this matter for successful design of steel bridge structures to support water pipeline/oil pipe lines.

8 References

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