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Study on RCC Bridge Pier Using ANSYS

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Abstract*— ANSYS is finite element software. In the present work, finite element analysis of RCC pier models have been carried out. The study is based on the fact that stress and displacement variation depends on pier width. Present study is aimed to know the variation of displacement, stresses, Quantity of steel and Quantity of concrete. Linear static analysis is carried out using ANSYS 12 Software. Load on bridge is calculated from 18m span bridge deck. Analysis of bridge pier is carried out for different pier width with 0.3m decrements. Parameter considered is to study the effect of pier width on stress and displacement. The study shows that total displacement and stresses increases with respect to decrement of pier width. Also quantity of concrete and quantity of steel decreases with respect to the decrement of pier.

***Index Terms*—Bridge pier, Reinforcement, Displacements, Stresses, ANSYS.**

I. INTRODUCTION

Bridge piers are the intermediate supports of the superstructure. Piers are subjected to various forces in vertical and lateral direction, such as wind force, water current force and seismic force. The shape of a pier depends upon the type, size and dimensions of the superstructure. Piers can be solid, circular, trestle and hammer-head types. Solid piers are of masonry or mass concrete. Cellular, trestle and hammer-head types are constructed in reinforced concrete. The magnitude of the superstructure loads applied to each pier shall consider the configuration of the fixed and expansion bearings, the bearing types and the relative stiffness of all of the piers. The analysis to determine the horizontal loads applied at each pier must consider the entire system of piers and abutments and not just the individual pier.

II. DETAILS OF STRUCTURE

A. Modeling and Analysis

The Finite element Method (FEM) is a numerical technique for finding approximate solution to boundary values problems. It uses vibrational method to minimize an error function and produce stable solution. The basic concept in the physical interpretation of the FEM is the Subdivision of the mathematical model into disjoint components of simple geometry called finite elements or elements for short. The response of each element is expressed in terms of a finite number of degrees of freedom characterized as the value of an unknown function, as a set of nodal points. In the present work, finite element analysis of different RCC bridge pier models has been carried out. The element considered is SOLID 65 and Beam 188 element for reinforcement .mapped meshing has been done.

B. Modeling assumptions

The following are the assumptions made. The model of bridge pier dimensions considered are length 8.6m ,width 3.8m and thickness 1.5m. Different types of pier models are considered with pier width with 0.3m decrements. The value of Young's modulus, Density and Poisson's ratio are 27386e^3k N/m^2, 25kN/$m^3$and 0.2 respectively. Longitudinal reinforcement of # 25mm @150mm c/c and transverse reinforcement of # 25 mm @ 200mm c/c.

III. DATA FOR LOAD ESTIMATION ON PIER

The force estimation on pier is done as per I.R.C. codal provisions. Some forces will act in combination with other forces, Thus there are different probable load combination, likely to act on pier. Different load combinations are considered as mentioned by I.R.C. and for the sever combination pier section is analyzed. Following data is assumed for Load estimation on pier,

i) Superstructure – Tee-Beam bridge of span 18m
ii) Carriage way width – 12 m.

The loads on bridge pier were obtained by SAP-2000 software. The total load on bridge pier is 6240KN.

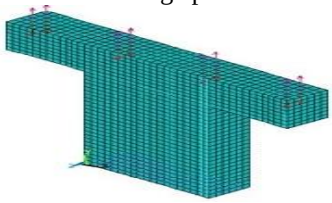

Fig 1.Pier model with load

IV. RESULTS AND DISCUSSIONS

The results obtained for RCC bridge pier models having various widths are presented. Ministry of surface transport, Government of India, has designed the RCC bridge superstructure for various spans, published drawings are referred as standard drawing for construction of bridge superstructure across the country, But where a the bridge substructure are to be designed with respect to field data. In the present study a bridge proposed at Karwar district is having 18m span and adopted SD232 for superstructure. In which the dimensions for pier are considered .Length 8.6m

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width 3.8m and thickness 1.5m.Looking to the width of pier it is seems to be at higher side. Therefore, an attempt has been made to study the effect of pier width, keeping the length and height of pier constant. The following are various type of pier sizes considered.

Table 1.Pier Dimension

Pier type	Width(m)
A	3.8
B	3.5
C	3.2
D	2.9
E	2.6
F	2.3
G	2
H	1.7
I	1.4

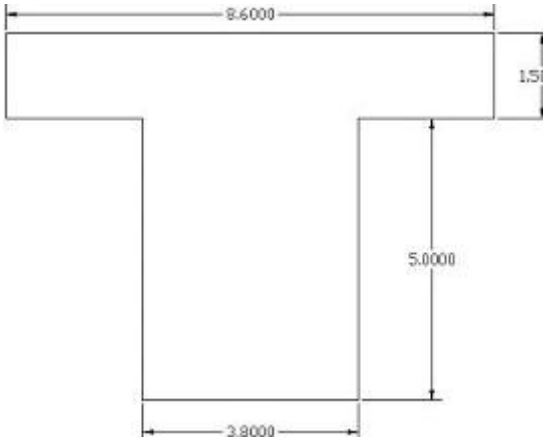

Fig 2. Dimension of pier 'A'

Analysis is performed for all the pier type given in table 1 using ANSYS. The ANSYS models are shown in fig the results obtained for maximum displacement, maximum stress, quantity of steel, quantity of concrete are given in the following table.

Table 2. Displacement and stress of pier having different width

Pier type	Displacement (m)	Stress(kN/m2)
A	0.0022	25565
B	0.0027	26459
C	0.0026	26612
D	0.0034	27885
E	0.0036	27000
F	0.0041	28134
G	0.0064	32048
H	0.0065	33052
I	0.00145	34048

Table 3. Quantity of concrete and quantity of steel having different pier width

Pier type	Quantity of steel (kg)	Quantity of concrete(m3)
A	2207.4	38.28
B	2207.4	36.48
C	2108.831	34.9
D	2010.17	32.88
E	1911.514	31.08
G	1812.8554	27.48
H	1714.1965	24.68
I	1615.53	23.88

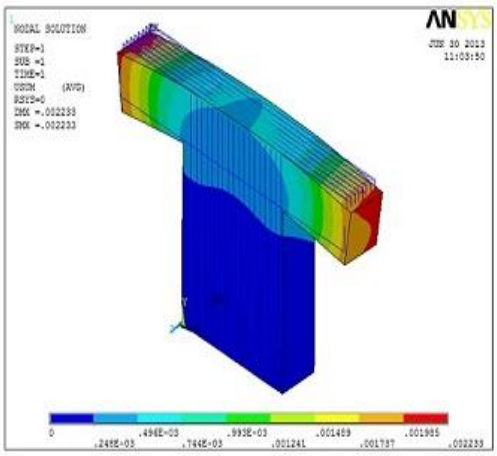

Fig 3.Pier model 'A'

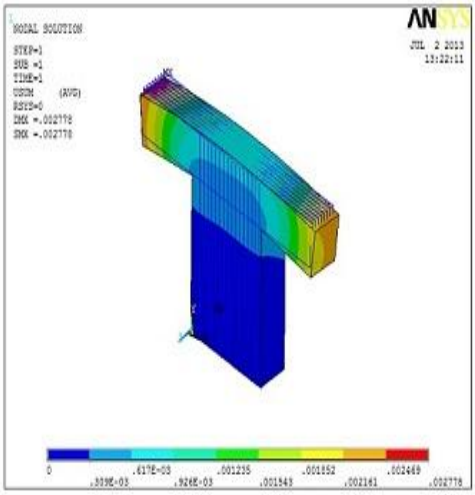

Fig 4. Pier model 'B'

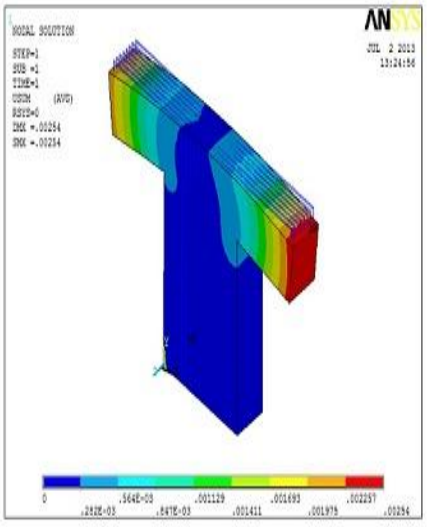

Fig 5. Pier model 'C'

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Table 4. Total displacement of pier

Pier type	Dimensions of pier(m)	Displacement(m)
A	3.8X1.2	0.0022
B	3.5X1.2	0.0027
C	3.2X1.2	0.0026
D	2.9X1.2	0.0034
E	2.6X1.2	0.0036
F	2.3X1.2	0.0041
G	2X1.2	0.0064
H	1.7X1.2	0.0063
I	1.4X1.2	0.0145

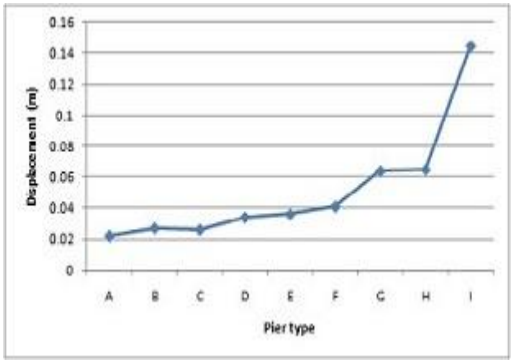

Fig 6.Variation of displacement for different pier models

Table 5. Von Mises stresses

Pier type	Von mises stresses (kN/m^2)
A	25565
B	26459
C	26612
D	27885
E	27000
F	28134
G	32048
H	33052

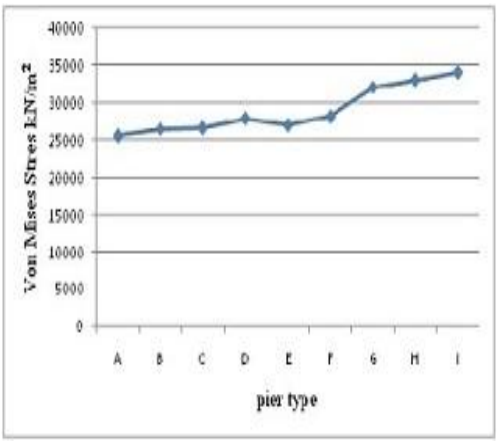

Fig 7.Variation of Von Mises stresses

V. DISSCUSSION

The curve in fig 6 indicates that the displacement fairly increases linearly by 10% up to type H and then there is a sudden increase in displacement by 55% for pier type I. this may be because of increase in cantilever portion. From fig 7 it is clear that stresses increases linearly except for pier type E ,in which the stress has decreased by 3% with respect to previous pier type D. The quantity of steel and concrete for various types of pier are calculated &given in table 6 & 7.

Table 6. Quantity of concrete

Pier type	Length (m)	Breadth (m)	Height (m)	Quantity of concrete (m3)	Total
A	8.4	1.2	1.5	15.12	37.92
	3.8	1.2	5	22.8	
B	8.4	1.2	1.5	15.12	36.12
	3.5	1.2	5	21	
C	8.4	1.2	1.5	15.12	34.32
	3.2	1.2	5	19.2	
D	8.4	1.2	1.5	15.12	32.52
	2.9	1.2	5	17.4	
E	8.4	1.2	1.5	15.12	30.72
	2.6	1.2	5	15.6	
F	8.4	1.2	1.5	15.12	28.92
	2.3	1.2	5	13.8	
G	8.4	1.2	1.5	15.12	27.12
	2	1.2	5	12	
H	8.4	1.2	1.5	15.12	25.32
	1.7	1.2	5	10.2	
I	8.4	1.2	1.5	15.12	23.52
	1.4	1.2	5	8.4	

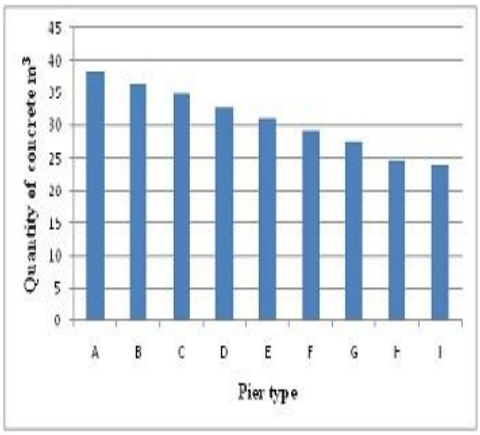

Fig 8. Variation of quantity of concrete

Table 7. Quantity of steel

Pier type	No of bars	Length (m)	Area (m^2)	Density(kg /m3)	Quantity of steel (kg)	Total Quantity Of steel (kg)
A	44	6.4	0.000491	7850	1085.24	2207.49
B	44	6.4	0.000491	7850	1085.24	2207.49
C	40	6.4	0.000491	7850	986.588	2108.83
D	36	6.4	0.000491	7850	887.92	2010.17
E	36	6.4	0.000491	7850	887.922	2010.17
F	32	6.4	0.000491	7850	789.27	1911.51
G	30	6.4	0.000491	7850	739.94	1862.18
H	28	6.4	0.000491	7850	690.61	1812.1
I	24	6.4	0.000491	7850	591.95	1714.1
J	20	6.4	0.00491	7850	493.294	1615.5

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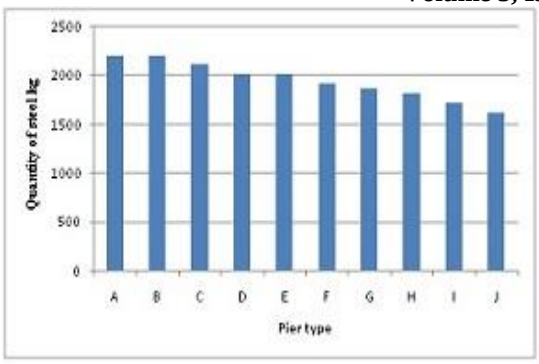

Fig 9.Variation of quantity of steel

From fig 8 the quantity of concrete decreased linearly from 37.92 m^3 to 23.52 m^3 with respect to the decrement of pier width. The displacements are found within permissible limits. The steel quantity in (fig 9) is not much varied for the pier type A,B,C,D &E also it is found that the steel quantity is almost same in pier type A &B and D& E.. In other types the steel quantity is linearly decreasing from 2207 to 1615kg.

VI. CONCLUSION

In this study, the displacements and stress of the concrete pier are analyzed by Finite Element method. Control model 'A' is analyzed using the specific set of control data, given by SD232 then compared to succeeding models as pier width changed. After compiling and analyzing the results from each analysis the following conclusions can be drawn.

- Displacement increases linearly by 10% up to pier type H and there is sudden increase in displacement by 55% for pier type I with respect to pier type H
- Stresses increases linearly except at pier type E.
- Quantity of concrete decreases linearly from 37.29m^3 to 23.52m^3 with respect to decrement of pier.
- Quantity of steel decreases linearly from 2207kg to 1615kg with respect to the decrement of pier

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