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Technical Paper on Stress Analysis for Bridge Piers and Efforts /Necessity to Develop Standard Method for Analysis.

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Abstract: **-- Prime Minister Narendra Modi launched SETU BHARATAM on 4th March 2016 at a budget of Rs. 102 billion (US$1.6 billion) with an aim to make all National Highways free of Railway crossing by 2019. Under this project, as many as 208 ROB/RUB would be constructed at unmanned Railway Crossings. The National Highway Authority of India has undertaken a massive National Highway Road Development programme across the country to develop world class road network. A large number of new bridges are being constructed as per the Scope of Work (4lane/6lane configuration). The Bridge Designers adopts various methods / soft wares for the design of Bridges & analysis of stresses in concrete & reinforcement. But in absence of any standard method for the stress verification, which develops in Pier body under the influence of subjected loads and moments, the size of Pier substructure becomes the matter of dispute, leads to the adoption of larger size Pier at times, resulting in over expenditure. This paper deals with the methods adopted by Bridge designers for verification of Stresses in Pier body. The aim of this paper is to develop Standard method for Stress Analysis so as to have optimum utilization of the resources and maintaining the traffic worthy condition of the bridge structure up to the expected designed life.**

Key Words **- Bridge Pier, Loads, Moments, Reinforcement, Stresses.**

I. INTRODUCTION

Bridge piers are the intermediate supports of the superstructure. Piers are subjected to various forces in vertical, longitudinal & transverse direction, such as Wind Force, Water Current Force, and breaking force due to live load and Seismic Forces. The shape of a Bridge Pier depends upon the loads and moments it is subjected to, location, topography and type, size & dimensions of the superstructure. Piers can be Solid Square, circular, Wall type (rectangular) and trestle. Now a day with recent developments in the concrete technology & infrastructure sector, RCC bridge piers of smaller sections are being adopted.

Necessity:

With the adoption of high quality reinforcement & concrete having higher value of permissible stresses, the pier section is considerably reduced. But the most governing aspect for the finalization of Pier section is the Stresses in Concrete & Reinforcement of Pier body. The bridge designer adopts various soft wares for the design as well as for Stress analysis in bridge piers. Here efforts are being made to derive a standard method for stress verification based on the principals of Applied Mechanics & Strength Of Material, which would be easy to understand & use. For this purpose, the rectangular bridge pier cross section is considered as best example since the rectangular cross section is being widely used for long span bridges, Metro bridges as well as for Railway bridges. The main reason behind this would be the stability aspect, which the rectangular pier section provides over the other types such as circular or trestle.

For checking of Stresses in RCC circular Bridge piers the method detailed in..........by Mr V.K.Raina is being widely used. By critical analysis of stress pattern generated in the bridge piers under various loading condition, one may understand the area of the pier body which faces maximum compression as well as tension. The location of neutral axis for different load combination varies w.r.t. the Longitudinal & Transverse Moments acting on the pier body. In Wall type / rectangular pier section (where length of pier in transverse direction is more than thickness of pier in longitudinal direction), the main longitudinal reinforcement of pier body varies as compared to square

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type pier (area of reinforcement along length of pier body is more than that along the thickness), the stress pattern differs w.r.t. square shape pier. Also the distance of each main longitudinal reinforcement bar varies. At times, the neutral axis lies close to the one of corners of the rectangular pier body, thereby resulting in generation of tensile forces at opposite corner and compressive forces at the other. It is generally observed that the stresses generated / accumulated are in periphery of the pier body thereby leaving central portion of rectangular pier body under normal compression.

Softwares & Method:

Various software developers have developed software for design of bridges, few of which are listed below:

STRUCTURAL ENGINEERING FORUM OF INDIA

http://www.sefindia.org/?q=node/20 1/7

STRUCTURAL ENGINEERING FORUM OF INDIA

Some softwares with their contacts/ web addresses are listed below:

ABAQUS Non-Linear F.E.Analysis www.abaqus.com

ALGOR FEA Software www.algor.com

ANSYS FEASoftware www.ohiocae.com/

LUSAS FEA Bridge Design & Analysis www.lusas.com

NISA General Purpose FEA software www.emrc.com

SA P 3D Structural Analysis www.csiberkeley.com/products/sap2000.htm

LEAP Family of bridge design software www.leapsoft.com/

LUSAS Bridge Bridge engineering analysis, design and assessment software www.lusas.com/

ANSYS FEA Software

BIAX 1 Legacy software from 1992 to evaluate uniaxial and biaxial strength and deformation characteristics of reinforced concrete (R/C) sections. Source code in FORTRAN and related reports can be obtained in the output format generally in notepad.

Thus from above, it is seen that for designing / analysing the stresses in Pier body by using one of the softwares, high end configuration are required, which at times may prove costly. Also the designer, who has got good hands on experience in the bridge designing can only use these softwares leaving fresher / learners in the trap of confusion. This is because of the fact that, the iterations carried out by the software within itself are not readable or can not be checked intermittently as a benchmarks, resulting in carrying out whole process / to run the entire programme again with changed parameters.

So the efforts are made to develop a standard method for stress analysis in bridge piers with user friendly Xcel spreadsheet, so that the designer can check the results at every level thus minimising exhaustive efforts for the analysis.

For analysis, the already approved design & drawing of ROB PIER was used for validation of results. The design and drawings were approved by NIT Kurukshetra.

By using analytical method

Methodology followed for calculating Stresses in Concrete & Reinforcement.

A. DATA REQUIRED: (Unit)

- Vertical Load on Pier (V): MT.
- Longitudinal Moment or Moment in Traffic Direction (ML): MT-m
- Transverse Moment or Moment in Current Direction (MT): MT-m.
- Length of the Section (cm): cm.
- Width of the Section (cm): cm.
- Modular Ratio: 10

B. REINFORCEMENT CALCULATION:

- Cross Sectional Area of Bridge Pier (L x B):
- Minimum Area Of Reinforcement required as per IRC 78 or the Reinforcement required as per the design shall be mentioned.
- To work out the Area of Reinforcement on each side of Pier section.

C. PROPERTIES OF REINFORCEMENT SECTION:

- To work out the area of the Main Longitudinal & Equivalent Area of Reinforcement.
- To calculate Location of the existing centroid of the bridge pier (ie L/2 & B/2).
- Moment of Inertia of Reinforcement Section is worked out ie
- (based on the principal= bd3/12 + Ay2)
- Moment of Inertia in/along Traffic/Longitudinal Direction (ML):
- Moment of Inertia in/along Current/Transverse Direction (MT):

D. PROPERTIES OF EFFECTIVE CONCRETE SECTION:

- Area of Trapezoidal Pier Section (Sqmt) M2
- Moment of Inertia about CG in Transverse Direction cm4

- Moment of Inertia about CG in Longitudinal Direction cm4
- Moment of Inertia about Neutral Axis cm4

E. PROPERTIES OF TOTAL EFFECTIVE SECTION:

Area of Trapezoidal Pier Section (Sqmt) M2
Moment of Inertia about CG in Transverse Direction cm4
Moment of Inertia about CG in Longitudinal Direction cm4
Moment of Inertia about Neutral Axis cm4

F. RESULTANT STRESSES AT FOUR CORNERS:

P = V x [(1/A) – (Acc x K1) – [(Breadth – Act) x K2]]
Q = V x [(1/A) – [(Length – Acc) x K1] – [(Breadth – Act) x K2]]
R = V x [(1/A) – [(Length – Acc) x K1] – [Act x K2]]
S = V x [(1/A)+ (Acc x K1) – (Act x K2)]

Max. Stress in Concrete = Kg/cm2 less than (perm value as per grade)
Max. Stress in reinforcement = Kg/cm2 less than (perm value as per grade)

II. CONCLUSION

Thus it can be seen that, by carrying out stress calculation work in Xcel Spread sheet is more user friendly and adoptable. Also the user / designer can check his errors during working itself.

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