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Necessity of analysis of Stresses in RCC Bridge Piers

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Abstract— The Government of India has under taken 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). It is also the fact that large number of existing concrete bridges are in distressed condition. It is/may be due to the poor maintenance that leads to distressing of bridges & due to old construction methods/materials(UCR Piers & PCC Piers—gravity type structure) which raises doubts about the traffic worthy condition of these bridges in future. Therefore it is necessary to discuss the way of planning, designing and construction of new concrete bridges so as to prevent or minimize distress in future. The aim of this paper is to focus on the necessity of critical analysis of the Stresses on RCC Bridge Piers 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.

Keywords— Bridge Pier, Reinforcement, Stresses in Reinforcement & Concrete

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, breaking force due to live load and Seismic Forces. The shape of a Bridge Pier depends upon the location, topography and type, size & dimensions of the superstructure. Piers can be Solid Square, circular, Wall type (rectangular) and trestle. In earlier times Bridge Piers were solid piers of UCR masonry or mass concrete which were bulky gravity type structure. Only the check for stability of gravity structure was FOS against Overturning & Sliding and check for Base pressure. At any given loading condition, the maximum base pressure should not be more than the SBC of the founding strata. The negative base pressure ie uplift was overcome by increasing the area of foundation. Now a day with recent developments in the concrete technology & infrastructure sector, RCC bridge piers of smaller sections are being adopted. Also with the adoption of high quality reinforcement & concrete having higher value of permissible stresses, the pier section is considerably reduced.

II. NECESSITY

There are number of highway bridges, which are in distressed condition in India. Some of the major bridges are more than 100 years old. They are distressed due to various reasons like weathering effects, increase in volume of traffic, effect due to change in live load configuration than that considered during original design of existing bridge substructure, corrosion in rebars and pre-stressing steel, poor quality of construction, and design deficiencies.

In India, large numbers of highway bridges have been reported as distressed and need to be retrofitted. While minor damage affects the aesthetic appearance of the bridge and long term durability, severe damage reduce the structural capacity of the bridge.

Retrofitting is the only solution to restore any distressed bridge to service which can be done after careful diagnosis of existing bridges and restoration up to required level of load carrying capacity such as strengthening and rehabilitation of existing bridges. However, some of existing bridges have shown quick distress after retrofitting /strengthening in the post-strengthening life, which led to

restrict the traffic and subsequent problems regarding remaining service life. Therefore, it is necessary to predict the behavior of bridge substructure as well as super structure under various loading conditions as per the provisions of IRC:6-2014, to ensure the structure remains in traffic worthy condition for full designed service life of structure.

Now days many soft-wares are available for Checking of Stresses in Reinforcement & Concrete of RCC Wall type / rectangular bridge Piers under various combination of loading conditions. Each designer uses its own in house design software. For example BT, Pier etc.

For checking of Stresses in RCC circular Bridge piers the method detailed in Concrete bridges Handbook 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 square shape RCC bridge piers, the stress pattern thus generated would give us the clear picture of most critical area of the pier section. Accordingly the main longitudinal Reinforcement shall be placed in formation fulfilling the IRC codal provision. (IRC: 78). But 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 type 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 one corner and compressive forces at the other. It is also observed that the stresses generated / accumulated are in periphery of the pier body thereby leaving central portion of rectangular pier body under normal compression. The stress patterns can clearly be understood by using Polar scope (photoelastic material). The efforts can also be made to provide void in the pier body so as to have economic and aesthetic substructure.

III. SOFTWARES AVAILABLE

There are several softwares available to cross check the stresses generated due to vertical load and the biaxial moments acting on the Pier & Abutment body. These are as follows:

Sr. No	Name of Software	Brief
1	ABD-Automated Bridge Design	Computer service for bridge designers using ABD bridge design software. The software can handle several standard types of superstructures, substructures, and foundation types.
2	Altiscad Intellishape	Altiscad Intellishape is a general purpose biaxial bending calculation software tool, developed to design and check any geometry cross section. The software allows to design and check the bearing stresses.
3	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 read from the output file.

Sr. No	Name of Software	Brief
4	FB-MultiPier	The FB-MultiPier analysis program is a nonlinear finite element analysis program capable of analyzing multiple bridge pier structures interconnected by bridge spans.
5	GaLa Reinforcement	Advanced analysis and design of reinforced concrete elements (columns, beams, shear walls) subjected to axial forces and axial or biaxial (Mx and My) bending moments.
6	Load Combinations	Spreadsheet to assembles load combinations from individual load cases. The spreadsheet is very flexible to perform load combinations for different design methods, such as allowable stress design
7	LUSAS Bridge	Finite element analysis software for the design, analysis and load rating / assessment of bridge types. Software in available in 3 software levels with software options available to extend...
8	BRIGADE	Suite of finite element analysis tools for the field of structural and civil engineering. BRIGADE/Standard is program for three-dimensional analysis of bridge structures.
9	Leap Bridge Software Suite	Geomath - parametric bridge layout and design. (2) Conspan - precast/prestressed bridge beam analysis and design. (3) RC Pier - reinforced concrete substructure analysis and design. (4) Conbox

IV. CONCLUSION

Poor quality/lack of ability to predict the behavior of the pier under various loading conditions may result in many types of distresses such as cracks, corrosion in concrete and lack of cover to the reinforcement, spalling of concrete, etc. Therefore, special care needs to be taken for quality of design, construction and supervision.

Acute knowledge & exact prediction of the behavior may result in reducing the optimization of resources thereby making structure economically viable.

Lack of maintenance and routine inspection is the main cause for distress of existing bridges. Since the distresses at beginning level are unnoticed/undetected, many at times they became vulnerable to an extent of massive damages to the bridge components. Therefore, maintenance and inspection wings need to be strengthened.

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