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Seismic Performance Assessment of Existing Bridge

Sainath G Limbapure, Vishwajeet Kadlag

P.G. Student, Department of Civil Engineering, Dr. D Y Patil School of Engineering and Technology,
Charholi (BK), Pune, Maharashtra, India

Assistant Professor & PG Coordinator, Department of Civil Engineering, Dr. D Y Patil School of
Engineering and Technology, Charholi (BK), Pune, Maharashtra, India

ABSTRACT:In the present study, a simply supported 3-lane highway bridge having zone IV has been considered for analysis. The seismic performance of the considered bridge has been evaluated by performing non-linear dynamic analysis. The non-linear dynamic analysis has been performed by considering non-linearity in concrete and reinforcement materials, and geometric non-linearity (P-delta effect). The flexibility of foundation soil has been modelled by considering soil-structure interaction effect. The present study only focuses on the performance evaluation of the pier and its foundation. All other bridge components have been assumed to be safe throughout the analysis. The analysis results of the study show that the pier section has insufficient shear strength to resist earthquake forces.

KEYWORDS:seismic performance, interaction, dynamic analysis.

I. INTRODUCTION

The bridges are an essential infrastructure that connects different regions by crossing rivers, valleys, and some other obstacles. Such communication links are in the form of roads as well as rail network. All these bridges are critical lifelines for living people and should remain operational after an earthquake. However, many existing bridges had been designed as per previous seismic guidelines. After the publication of IS 1893 (1984), the seismic design of the bridge had been carried out as per the seismic coefficient method. According to this method, the seismic design force on bridge structure had been considered as a fraction of the total weight of the structure. The considered fraction of total weight was different for each seismic zone. Since 2002, the bridges in India were started to design with linear dynamic analysis methods such as response spectrum analysis. However, the design does not include a capacity design concept with ductile detailing.

Also, some bridges had been designed only for gravity loads. In the past earthquake, many bridges in India had subjected to severe damage. The Bihar-Nepal earthquake (1994) resulted in complete damage of piers and superstructure of bridges in that zone. Also, the Burma-India earthquake (1988), the Uttarkashi earthquake (1991), the Killari earthquake (1993), and Jabalpur Earthquake (1997) are the example of bridge failure during seismic action. The damage of bridges was in the form of unseating of the superstructure, failure of fixed type bearings, damage of non-ductile columns, and failure of abutments. Severe damage to such bridges resulted in economic loss, casualties, and loss of network.

II. RELATED WORK

For the present study, the existing road bridge of 3 lanes on the Amritsar-Pathankot highway has been considered for analysis. The considered bridge is located in seismic zone IV, and its foundation is resting in sandy soil. This bridge comes under the flyover category. A bridge has been built to carry traffic in only one direction, and it has three spans of length 15 m + 50 m +15 m, respectively. The four numbers of identical typical RC T-beams and four numbers of identical pre-stressed post-tensioned I-girders have been provided as a superstructure of 15 m and 50 m spans, respectively. All girders are supporting a slab of 0.24 m thickness at its top. The bridge deck width is 12 m with a carriageway of 11 m and 0.5 m wide crash barriers on both the edges. All spans are provided with POT-PTEF bearings

to transfer forces to the substructure and allow movement of the superstructure at a free end. Left bearings of all spans are fixed in a longitudinal direction, whereas free moment in the longitudinal direction is allowed at the right end.

III. METHODOLOGY

Mathematical modelling of the structure is an essential step in any analysis of the structure. Outcomes of analysis mainly depend on how we model structure in software, i.e., type of element used, support conditions, material properties, connectivity between elements. So, to get realistic structural behaviour and its analysis results, correct modelling is essential. For the present study, non-linear dynamic analysis of structure has been performed in the analysis software SAP 20 (2000)

IV. EXPERIMENTAL RESULTS

The 3D mathematical model of the bridge represents more realistic behaviour than the 2D model. Cracking of structural members takes place under service loading; therefore, it is essential to consider respective cracked cross-sectional properties. The full intensity of vehicular loads and full seismic force on the structure does not act simultaneously. Therefore, only 20% of the vehicular live load should be considered at the time of seismic action. For non-linear analysis, it is essential to consider expected non-linear material stress-strain characteristics. Also, confined stress-strain characteristics of concrete should be considered. In the case of conventional bridges, the failure mode is unknown: hence it is devised to model both force-controlled and deformation-controlled hinges. Auto hinges do not consider material stress-strain characteristics as per Indian standards. Hence, instead of using an auto hinge, it is better to use a user-defined hinge. According to IRC-112 (2011), shear resistance of concrete should be neglected for seismic action. Therefore, shear resistance of both pier and pile sections should be only because of available shear reinforcement.

V. CONCLUSION

All bridges are critical lifelines for living people and should remain operational after an earthquake. However, many existing bridges had been designed as per previous seismic guidelines. Also, some bridges had been designed only for gravity loads. However, in the past earthquake, many such bridges in India had subjected to severe damage. Damage to such bridges results in loss of network, economic loss, and casualties. Therefore, it is essential to assess the seismic performance of the existing bridges by performing non-linear time history analysis. In the present study, simply supported road bridge having seismic zone IV has been considered for the analysis. The performance of the considered bridge has been evaluated by performing non-linear time history analysis in software SAP 21 (2000). The non-linear analysis has been performed by considering the material and geometric nonlinearity. Also, the flexibility of the foundation has been modelled by considering soil-structure interaction effect as per API (2000). The present study only focuses on performance evaluation of the pier and its foundation.

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