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COMPARITIVE STUDY OF PUSHOVER ANALYSIS OF THREE SPAN CONT. BOX GIRDER BRIDGE PIER WITH DIFFERENT PIER SECTIONS AS PER IRC: SP:114-2018: A Review Paper

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Abstract:

Incurrent design philosophy of bridges substructures are allowed to undergo plastic deformations during intense earthquakes. Bridges generally depends up on the capacity of substructure (i.e., pier, abutment) to sustain large displacement due to large earthquake without failure. Failure of Bridge Pier leads to the collapse of Bridge therefore bridge pier should be designed to dissipate seismic force by allowing plastic deformation. During the last two decades seismic provisions in bridge design code have changed drastically. In 2010 IRC:6 updated for limit state design approach which further superseded by IRC:6 2017 and new seismic guidelines were introduced in IRC:SP114-2018. This paper depicts comparative study of different section (hollow/solid) of substructure pier for three span continuous box girder bridge.

Keywords **—Bridge Pier, Seismic Design,IRC-SP:114.**

I. INTRODUCTION

In India 60% of area is considered prone to shaking of intensity VII and above (on MMI Scale). Himalayan belt is considered prone to earthquakes of magnitude 8.0 on Richter scale since, many such earthquakes have occurred in last 50 years. Bridges plays a vital role in today's infrastructure system therefore they should remain functional even after major earthquakes. The design and construction of earthquake-resistant bridges is essential to safeguard economic and social security. Failure of the bridges due to the earthquake not only resulted in loss of life and property but also delayed post-earthquake relief operations. It is less expensive to design very powerful earthquake bridges within an expandable distance. The design of the bridges is to be able to withstand small and moderate earthquakes without damage to any parts and minor or repairable damage in the event of a major earthquake. The damage must be visible and accessible for inspection and repair so that at least temporary measures can be taken to ensure that the bridge is used for small vehicles as soon as possible after a planned earthquake. Due to the simplicity of the structure, the bridges are in danger of being damaged or even collapsed during an earthquake. Past earthquakes have shown that bridges are one of the most dangerous parts of highways. In some major earthquakes, bridges have been damaged and collapsed due to structural and structural failures (structural and geotechnical), substructure, superstructure, and superstructure-substructure and substructure foundation connections. Investigations have shown that the bridge that was designed and rebuilt prior to the development of modern earthquake guidelines is at risk of serious damage due to many potential structural problems.

The structure of the bridge has little or no repetition at all, unlike buildings with an RC frame. Redundancy is defined as the ability of a building to retain damage without falling. In an unpredictable system, the failure of any critical component may result in the collapse of all or part of the structure. An unstable bridge is at risk of failure as it may have a reduced number of members or have no other way to load. An unwanted building system is a system of features and components that, in the unlikely event of a failure, can cause damage.

The stress method of operation using IRC guidelines (IRC: 6-2000, IRC: 21-2000) was used in India. IRC: 6-2000 has a very limited seismic design project. The boundary system uses the new IRC guidelines (IRC: 6-2017, IRC: 112-2020) with the latest guidelines for the construction of seismic bridges (IRC SP: 114-2018) covering the progress made in the field of seismic engineering. The classification of earthquakes in the form of a boundary is based on the "real" behavior of the structure and earthquakes rather than the method set out in IRC: 6-2000.

The primary objective of the current study was to determine the volume / need ratio of the RC bridge pier of various lengths designed according to the stress method and to limit the condition using a nonlinear static pushover analysis.

The specific objectives of the present study are as follows:

I.A.1 To design an three span continuous prestressed box girder bridge having an pier height of 10m with provisions of IRC:6-2017, IRC:112-2020.

I.A.2 To design 4 numbers of piers as per IRC:112-2020 (limit state method) having different cross sections.

I.A.3 To perform pushover analysis of all 4 bridge piers designed by Limit State Method for Design Basis Earthquake (DBE) and Maximum Credible Earthquake (MCE).

I.A.4 Assessment of non-linear performance of the RC bridge pier in terms of capacity curve, performance point, hinging patterns and performance level using Pushover analysis.

II. Literature Review

In accordance with IRC SP: 114-2018, bridges are designed for 100 years of service life, taking into account the Design Basis Earthquake (DBE). To measure seismic power, the Elastic Seismic Acceleration method, the Elastic Response Spectrum method and the Line Time History method are specified. The method used to design the bridges is based on the principles of volume design, i.e., plastic hooks occur only where the designer intends. Ductile details of concrete beams are sufficiently covered. (IRC, 2018)

Priestley et al., (1996) describe the model as a tool that assists the formation of geometric figures and behavioral characteristics of a model bridge structure within the process of analyzing an earthquake bridge. Lumped parameter models (LMPs), in which bridge features such as weight, stiffness and wetness are easily drawn or concentrated in different areas, are simple in their mathematical construction. Structural Part Models (SCMs) are based on sub-structural systems connected to match the normal geometry of a bridge model, and the phenomenological response expression is provided in the form of end-to-end member energy conversion in each component of the building. Factor models (FEMs) distinguish the actual geometric domain of a bridge building by a large number of small elements with functional features taken directly from the existing building material. Analysis tools provide a mathematical process to subtract answer results from models.

(Mander et al., 1988; Martinez□Rueda et al., 1997) In the global pushover curve, the base shear is built against feature degradation parameters. Generally, this deformation parameter is the lateral displacement of the roof. It is thought that the shape of the earth's pushover curve indicates the global or geographical path involved as the building approaches fluctuations in the course of a moving earthquake.

Kurian et al., (2006) considering a span sample, two railway lines over a bridge (ROB), located in an earthquake-prone area in India. The strength of the bridge is determined by the static analysis. Two different building models are considered in order to study the impact of structural modeling on developed curves. On a supported bridge with equal spaces and all the instruments placed in the same seismic motion range, a simple weight measurement is considered reasonable. The impact of structural modeling is significant at a high level of damage.

Priestley et al., (2007) they say there are a number of philosophical issues that need to be addressed before an earthquake assessment of an existing building. Examination of existing structures should include potential information, in order to make an informed decision about the need for consolidation. An important aspect of the removal method based on removal will be to determine the movement potential of a member defined by the ductility shift. There may be a significant difference in the relative displacement capacity compared to the small variation in material strength. It is often not possible to establish the total risk profile of an existing building, as a result of uncertainty in both structural and seismic aspects of both capacity and demand. The most promising future seismic assessment is clearly a credible approach based on the concept of opportunity.

Cardone et al., (2007) proposed a numerical procedure for the assessment of seismic fragility of road bridges. It combines elements from the Direct Displacement based design method and the Capacity Spectrum Method.

First, the seismic resistance of each structural subsystem (i.e. pier + bearing) is determined by performing a thrust analysis, monitoring the formation of bending plastic hinges or brittle shear fractures in the piers, achieving the maximum strength/deformation capacity of the support. /seismic devices, disturbance due to P-Δ effects. The contributions of each structural subsystem are then properly assembled to provide the Bridge's Thrust Curve. A set of performance levels is then determined for the bridge piers and reported on the Thrust Curve. For each equivalent viscous damping is calculated and a series of normalized highly damped elastic response spectrums (Demand Curves) are derived. The Repulsion Curve is then converted step-by-step into an equivalent SDOF Adaptive Capacity Curve based on the actual deformed shape of the bridge at each analysis step. The Adaptive Capacity Curve intersects with the Demand Curves to provide an estimate of the median thresholds of Peak Ground Acceleration associated with each performance level.

Aviram et al., (2008) presents a guideline offering a set of recommendations for the modeling and analysis of earthquake-exposed bridge structures. The emphasis here is on the application of nonlinear analysis procedures to estimate the seismic demand on critical bridge components. Bridge components that require special modeling considerations and nonlinear characterization are identified, and the specific criteria required to predict seismic demand with sufficient accuracy are established. Suggestions are presented for linear and nonlinear analysis of bridge structures using MIDASCIVIL software.

(Tandon, 2018) While considerable research and coding of seismic design has been done in relation to buildings worldwide, the same amount of effort and attention is not evident for bridges. The current situation in the codal provisions regarding the seismic design of bridges includes a major shift in the concepts of approach, plastic hinge and ductility, prevention of superstructure dislocation, energy distribution and energy sharing using passive and active measures.

(IRC SP:114, 2018) Bridges are designed for a service life of 100 years, taking into account Design Based Earthquake (DBE). For the estimation of seismic forces, Elastic Seismic Acceleration method, Elastic Response Spectrum method and Linear Time Domain method are specified. The approach taken for bridge design is based on the principles of capacity design, meaning plastic hinges only appear where the designer intended. The ductile detailing of the concrete feet is adequately covered.

(Gajera, 2019) For bridge infrastructure, seismic forces are one of the most disastrous in the world. The primary function of scaffolding is to support bridge spans and transfer loads from the superstructure to the foundation. Therefore, it must be strong enough to take both vertical and horizontal loads.

Vivek Gajera et al. (2019)studied the seismic behavior of bridge piers. The seismic analysis of the RC bridge pier is made in accordance with the provisions of the current IRC:6-2017 directive. The base cut-off of IRC:6-2000 is compared to IRC:SP:114-2018. Different span lengths of 25 m, 30 m and 36 m were used for the analysis. In order to evaluate the effect of pier height in earthquake analysis, various pier heights such as 10 m, 20 m and 30 m were assumed. According to the IRC guidelines, the analysis is made according to the Elastic Seismic Acceleration Method, taking into account the importance of the bridge and different regions. The effect of vertical ground motion is also taken into account in the analysis. From the analysis, it was observed that the base shear and vertical forces increased significantly compared to IRC:SP:114-2018 compared to IRC:6-2017.

CONCLUSIONS

In this study, the nonlinear performance of bridge piers in different sections will be analysed and designed according to the limit state method. Piers will be modelled in Midas Civil and seismic performance will be evaluated using nonlinear static pushover analysis. Results will be obtained in terms of base shear, top displacement, spectral acceleration, spectral displacement, effective time period, effective damping, thrust curves.

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