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Non Linear Static Analysis of RC Bridge

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Abstract

After the Bhuj earthquake in 2001 & the occurrence of the earthquake in Kashmir in 8 Oct 2005 derives the much attention on the seismic assessment of existing building. Many literatures are available based on the seismic evaluation procedures for the RC buildings using the non-linear analysis. But the seismic evaluation of the bridges is not taken out effectively while the bridges play an important role as a structure. No existing bridges evaluation & comprehensive guidelines are given to the structural engineer. For this problem the aim of the project to carrying the evaluation studies for the existing, RC bridge using non-linear static analysis. For the seismic assessment of the bridge a 3 span bridge is selected which is located on the hindon river at Ghaziabad (Uttar Pradesh).this area is highly vulnerable to the seismic activity because it is lie in the Zone – 4 .so , the high magnitude earthquake may be occurs in this region(may be greater than 7 magnitude).The Aravali series of rock formation having the quartzite rock formations in the Delhi NCR region. In this region mainly alluvium soil is found near the Yamuna and the area near to the Delhi. Hindon River is the branch of the Yamuna. The site of the Hindon River having the sandy alluvium soil which is perfectly suitable for the bridge foundation. Bridges extends horizontally with its two ends restrained & that makes the dynamic characteristics of bridges different from buildings. For doing the seismic evaluation of the bridge at the time of earthquake open sees software is used. The open sees model is used to describe the various performances of the bridge. By comparing the various results obtained through the non-linear analysis (static and dynamic). The concrete developed by Chang and Mander is used for assessment. This new material is used in assessment enhance the existing bridge capacity against the bridge element damage during the seismic activity. From the various evaluation results it is worked out that the bridge structure under the designed seismic vibrations is safe and the results obtained from this pushover analysis is verified through the results obtained from the dynamic analysis.

Keywords: *RC Bridge, Static Analysis, Earthquake.*

Introduction

In the modern age bridges are regarded as most important engineering structure. Bridges connected the two lands which is separated by the water body or a piece of land which separated by the any obstruction through the over ground. So its structural stability during the worst condition is also be considered as the Ghaziabad region where this hind on bridge is located is fall in seismic zone iv which is fairly good enough for the earthquake of moderate and the high magnitude. During the last decade in this region several earthquake of different magnitude (5-6, 6-7) and sometimes 7-8 are also occurs which proves dangerous to the structure which is not constructed according to the different aspects of designing.

In bridges, the design of superstructure is based on a set of loading conditions. There are several types of loads are occurs during the performance time of the structure. This frequently occurrence of the earthquakes of different magnitude makes the code design to improve the seismic building design code in 2002 i.e. (IS 1893, part 1). But there is no perfect guidelines are occurs to the practicing structural engineers to determines the structural demand of the constructed bridges during earthquake. There are several research papers are published on the pushover analysis of the buildings but less work are occurs on the reinforced concrete bridges. The purpose of the present work is to carry out a seismic evaluation of an already constructed river bridges using the nonlinear static analysis and compare it with the nonlinear dynamic analysis result. This work is performed with the help of open sees software. The Hindon river bridges is 3 span continuous bridge which is pre stressed box girder type and its tendons are tensioned. Its total length is 114.9m, and the height of its bents is 8.05m and 8.66m. The model of the bridge is required for the nonlinear study of this bridge. The most effected part of the RC bridges is the column during the seismic.

Theoretical Development

Finite Elements Model for Nonlinear Materials

To reduce the complexity of model strategy the models are classified into different model pattern according the complexity. That is:
(1)Global models
(2) Discrete finite member method
(3) Microscopic finite element method

These classifications of models helps in studying the different parts of the structure in detail.For the formulation of the analysis the following 2 methods are used:
(1)Displacement based formulation.
(2)Flexibility based formulation.

Both of the methods are used in frame analysis and both give the objective response at different levels (i.e. global and basic).

In both of the method force based method is good one as compared to displacement method because in force based method all members are subjective to equilibrium and no displacement is required for its formulation. Verifiably, concentrated plasticity models were the first details actualized in structural products for tremor designing reenactments purposes, formed to incorporate nonlinearities into bar segment components. Their first appearance goes back to the 1960s. In these models all the components of the structure goes about as linear elastic, while the convergence of the plasticity is into rotational springs, or plastic pivots. The way that all the structure is displayed as direct versatile, and just confined nonlinearities are presented, speaks to the biggest point of interest. It diminishes the computational exertion and the multifaceted nature of the model. Then again, focused pliancy models are in light of a few suspicions, expanding the danger of mistake, or deficiency, of the examination yield.

Hence, the need of awesome experience to beatthe accompanying primary issues: Circulation of the moved nonlinearities into the structure, indeed plastic pivots area can't be known without a doubt from the earlier;

Assessment of the length of such plastic pivots; numerous recipes are proposed in writing, every one of them require the suspicion that plastic pivots will frame at a particular area.

Determination of the suitable anxiety strain relationship ascribed to the nonlinear zones.In force based components the twisting minutes are biggest at the component closes, without load; in this manner it is suitable to utilize Gauss-Lobatto quadrature. Indeed, this system places integration focuses at the components closes. In Figure a graphical representation of the four-point Gauss–Lobatto quadrature guideline, where the integrand, is assessed at the i^{th} area and regarded as consistent over the length. The most elevated request polynomial incorporated precisely by the Gauss–Lobatto quadrature tenet is, which two requests are lower than Gauss–Legendre quadrature. For linear curvature elastic, prismatic beam– section component without part stacks, quadratic polynomials show up in the integrand because of the result of the direct bend dissemination in the vector e with the direct insertion capacities for the curving minute in the lattice b. In this way, no less than three Gauss–Lobatto incorporation focuses are obliged to speak to precisely a straight curve conveyance along the component. To speak to precisely the nonlinear material reaction of a power based beam–column component, four to six Gauss–Lobatto combination focuses are come.

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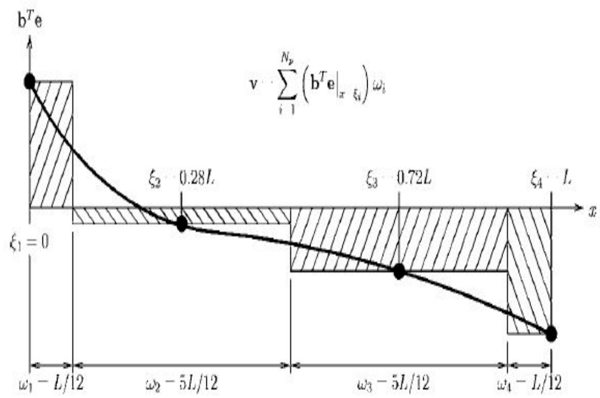

Figure 1: Application of gauss – Lobatto analysis quadrature

Conclusion and Future Scope

This work contains the pushover analysis of the RC bridge. This bridge is located on the Hindon River at Ghaziabad (U.P), India .This bridge plays an important role in connecting Delhi with the western Uttar Pradesh. This is a ordinary 3 span bridge which is cast in situ from the pre-stress concrete, it is a box girder type bridge, supported on the piers. The total length of the bridge is 114.9*m*, and the height of the right pier is 8 meter and the height of the left pier is 6.96 meter.

The first mandatory work was the determination of the seismic demand, of the bridge structure with respect to the maximum seismic vibration which have a chance of occurrence of about 5%.From the Caltrans seismic design criteria the 5% damped elastic design Spectrum is used. The readings from the accelerograms are taken from the NGA (Next Generation Attenuation) database which is well matched with the 5%damped elastic spectrum.

The present work is basically based on the use of force based beam column elements and their formulation the models of concentrated plasticity element and distributed plasticity element are briefly discussed above and the integration iterations are also discussed with respect to the nonlinearities of the materials.

The open sees software is used in this thesis work for creating the finite element models when using this software the main stretch is given on the input units because this software is designed according to the American Customary System which is different from the units used in India. The various elements of the open sees library are proved to be useful during the modeling of bridge piers.

The pushover analysis is used in the thesis for modeling of the bridge structure as a whole and also as a element i.e. piers and deck slab analysis. After the analysis under the seismic vibrations, various pushover curves are obtained which shows the relation between the base shear and central displacement curves which shows the different conditions of the model, after getting the pushover curves it is converted into the capacity spectrum as per ATC 40 for getting a performance point of the bridge. The result obtained from this conversion shows that the bridge structure would not be destroyed as under the designed seismic vibrations because the performance point is distant from the marked collapse point but some damages are induced in the bridge element due to the yielding of steel bars in tension which cracks the concrete.

In time history analysis the structure is subjected to the seismic vibrations which is obtained from the accelerograms with beam with hinges element modeling and the readings of maximum displacement and its relative base shear is evaluated and once the readings are obtained all the static and dynamic analysis results are plotted on the same graph. Thus the result obtained from the dynamic analysis validates the result from the pushover curve.

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