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EXTENDED ABSTRACT

The Effect of Different Loading Patterns in Pushover Analysis on the Nonlinear Response of Concrete Bridges with Piers of Different Height

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1. Introduction

Bridges are an important part of a country's infrastructure. The response of earthquakes depends on several factors, including the correct evaluation of bridge demands (Jara, et al. 2017). In this paper, the overall force intensity has changed, but the load pattern remains the same until the end of the analysis, so the results of the Pushover analysis are highly sensitive to the applied load pattern. In the traditional Pushover analysis, uniform distribution, the response is only considered under the influence of the first mode assuming that it does not change, if the constant force distribution cannot be used in the distribution of internal forces due to the yielding of the structure and the changes related to the vibration characteristics, including the increase the participation of higher modes in the response of the structure gives a correct estimate. Therefore, in order to develop and include the effect of higher modes, three new load pattern examples are proposed in the analysis of concrete bridge with continuous straight deck and piers of different height.

2. Methodology

2.1. Parametric study

The parametric survey on the bridge with two lengths of 180 and 280 was representative of two short and long bridges, respectively, and it has been done with regular and irregular grouping based on the height of the bases (Fig. 1). In principle, piles are usually calculated and designed for service loads and controlled for seismic performance levels, and generally, equivalent linear springs are used to represent the deck restraint provided by packs (Chapter 4). To choose an equivalent spring, the dynamic behavior of the soil behind the packs, the structural components of the packs and the interaction between the soil and the packs are considered. Considerable non-linear behavior in some elements of the packs, which is expected after the yielding stage. In this research, the behavior of the packs is considered linear and with a damper that shows the excess elastic energy in it.

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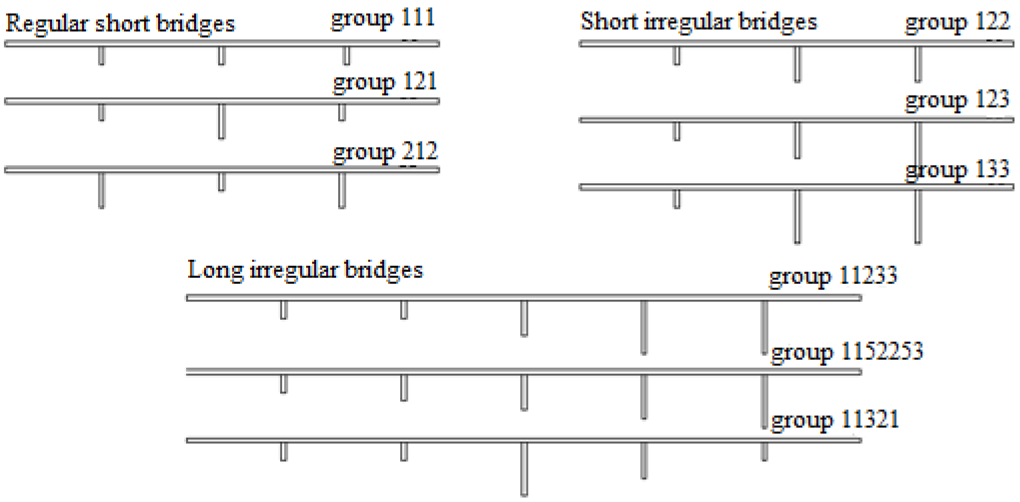


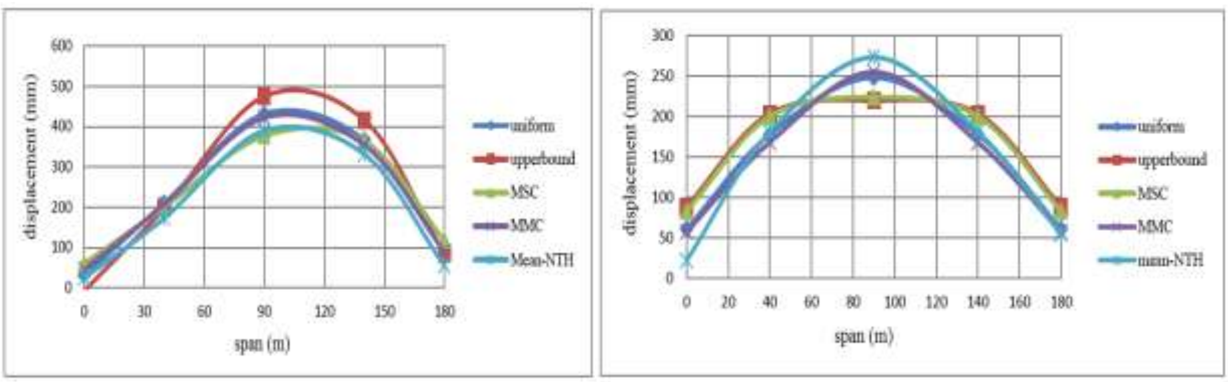
Fig. 1. Forms and grouping of studied bridges

2.2. Properties of materials

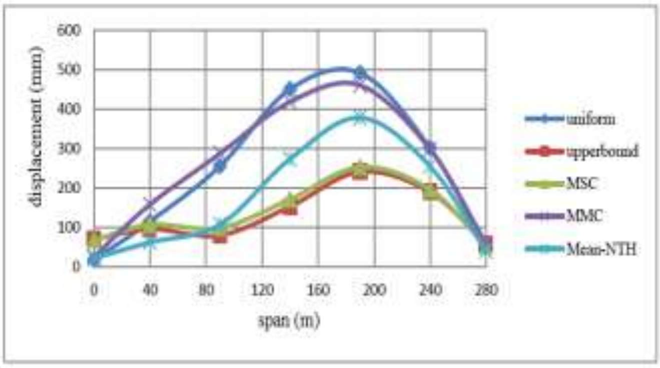
Rebar details of columns and other bridge components are also required. The properties of concrete containing Portland cement have been used according to the Mander model for the axial stress-strain behavior of confined and unconfined concrete (Maroney & Chai, 1994). Longitudinal and transverse rebar characteristics are determined according to Caltrans 2004 guide corresponding to ASTM A-706 steel characteristics. For the model of steel materials with symmetrical behavior in tension and compression, an elastic behavior up to the yielding stage, then a static behavior and as a result the continuation of the behavior until reaching the hardening strain is considered. The beginning of the hardening strain and the final reduction of the tensile strain, the breaking point, is determined by the size of the rebar in the cross section.

2.3. FE modeling

The software package used in this research, CSIBridge, v.15, was from the CSI software family and a finite element program (Restrepo, 2007). According to the research conducted by the University of Washington, this program has the ability to predict the behavior of large displacements and the displacement of destruction under dynamic and static loading, taking into account the non-linear geometric and non-elastic properties of materials. Since the nonlinear response of the structure is strongly dependent on the ground motion characteristics, a large number of records are required to cover the content of different frequencies (Fig. 2). Here, by selecting seven real earthquakes, all of them have been adapted to the design with a maximum ground acceleration of 0.7g (type c according to the EC8 code) using Seismo Match software (Seismosoft, 2011).



(a) (b)



(c)

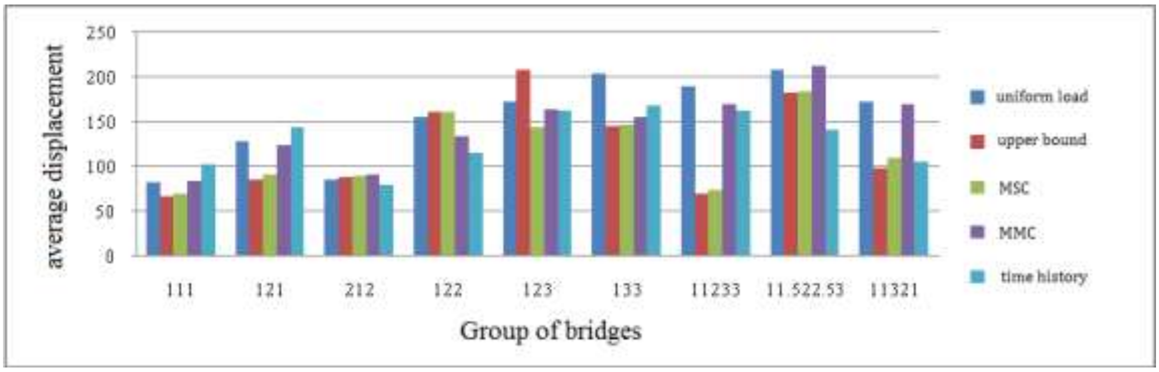
Fig. 2. Deformation pattern prediction: (a) Group 111 bridge, (b) Group 123 bridge, (c) Group 11233 bridge

3. Results

The response of different bridge groups from dynamic time history analysis (NTH), overload analysis with uniform load distribution, overload analysis with upper bound load pattern, overload analysis with modal spectral composition load pattern (MSC), the overload analysis is estimated with the modal combination load model (MMC).

The results are displayed in the form of curves that draw the displacement of the deck on top of each footing against the position of the footings. To compare the results of additional load with the dynamic analysis of the time history, the average value of the response in all seven earthquake records for each point above the foundations has been used.

Fig. 3 show the comparison of the bridge index and the standard deviation obtained from the average value for all four applied load patterns, and the average obtained from the time history analysis.



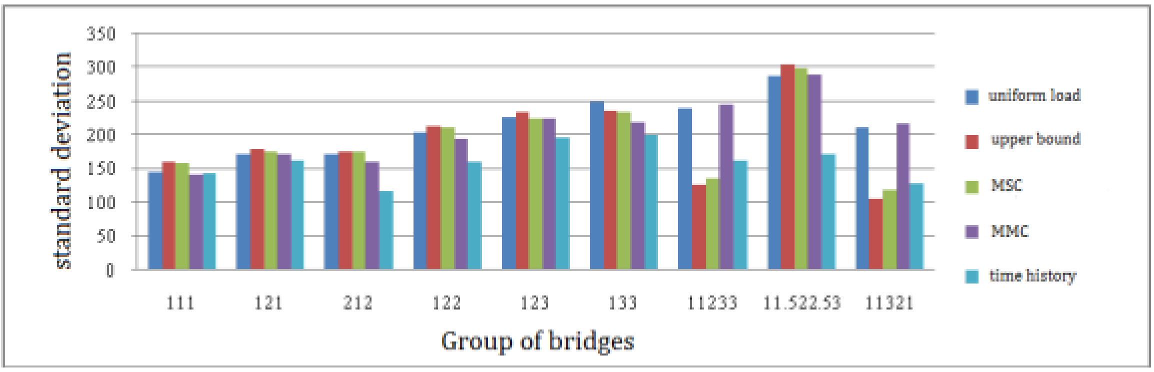


Fig. 3. Comparison of average displacement, standard deviation of four different model loads between groups of bridges

4. Conclusions

In short, regular and irregular bridges, the proposed method of modal combinations or MMC has provided acceptable results. This method has produced the closest estimation of the response parameters among other methods. In the group of long bridges, and with increasing irregularity and increasing degrees of freedom of the structure, the modal spectral combination method has had the best and closest answer in showing the seismic demand against other models, which due to the simplicity of these models, any practical use and It is possible to replace this method by engineers.

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