To Evaluate Behaviour of Bridge for Varying Pier Height and Span Using Dynamic and Analytic Techniques

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Abstract— **Bridges are one of the most critical components of any transport infrastructure network, and their serviceability during earthquakes is vital to ensure the safety of society. To be able to overcome bridge failure, code committees started to focus on different methods to design bridges under the effect of seismic forces. They play an important role in the economic activity of a city or a region and their role can be crucial in a case of a seismic event since they allow the arrival of the first aid. Reinforced concrete (RC) bridges are worldwide used type view their durability, flexibility and economical cost. In fact, their behavior under seismic loading was the aim of various studies. In the present study the effect of different structural parameters i.e. the height and the type of piers of reinforced concrete bridges on seismic response is investigated. For that reason, different multi-span continuous girder bridges models with various geometrical parameters are considered.**

Keywords: ***Bridges, SAP2000, Time History, Response Spectrum, Unequal Pier.***

I. INTRODUCTION

Modern transportation system has great influence on nation's economy and Bridges are an important component of all type of modern transport system. The various types of bridges have simple geometry, still they attract structural designer attentions to have various types of geometry and their type of constructions. It has been observed that bridges perform very poorly due to lack of attention in the design details. Numbers of bridges were designed around the world during the period, when there were no provisions for the seismic loads in the bridge codes or when these provisions were inadequate according to the present standards. A large number of bridges are designed and constructed without considering seismic forces. Moreover, the linearly elastic procedures adopted for the analysis of bridges remain efficient as long as the structure behaves within elastic limit. If the structure response is beyond elastic limit, the elastic procedure is insufficient to perform assessment of the structures. This leads to an over estimating of structures thereby attracting more seismic forces. Presently there are no Comprehensive guidelines to assist the practicing structural engineer to evaluate existing bridges and their retrofitting.

A. Unequal Bridge Pier

The bridges supported on piers on unequal heights were called as irregular pier bridge. The seismic design response of such bridges supported by unequal piers is tedious and challenging task. Irregular bridge pier are classified as long pier and short pier. When ratio of effective length to least lateral dimension is less than 12 it is classified as short column and when ratio of effective length to least lateral dimension is more than 12 it is classified as long column. In this case, it has been observed that the shorter piers often result in brittle shear failure and this limits its ductility capacity, while the longer piers are most likely to fail in a ductile flexural mode.

II. STATE OF DEVELOPMENT

Camilo Perdomo, et. al. (2017) In this study, the original GPA implemented in buildings is adapted to bridge structures and four versions of the algorithm are tested. Two straight bridges, featuring different levels of vertical irregularity, are used as case study to validate the procedure, and the accuracy of the GPA algorithm is assessed by comparing the nonlinear static results with the ‘‘exact’’ prediction from NTHA. Several levels of seismic hazard, represented in the expected return period of the target spectra, are considered to test the accuracy of the method for low and high seismic demand.

Furthermore, the GPA results are also compared with a commonly employed NSP, the capacity spectrum method. The results obtained for the case study suggest that GPA algorithm for bridges is suitable as a NSP approach for the seismic assessment of bridge structures, demonstrating a good fit with NTHA results and superiority with respect to the predictions of the selected traditional NSP.

Themelina S. Paraskeva and Andreas J. Kappos, et.al. (2009) The key idea being that the deformed shape of the structure responding in elastically to the considered earthquake level is used in lieu of the elastic mode shape. The proposed MPA procedure is then verified by applying it to two actual bridges. The first structure is the Krystallopigi bridge, a 638 m-long multi-span bridge, with significant curvature in plan, unequal pier heights, and different types of pier-to-deck connections. The second structure is a 100 m-long three-span Overpass Bridge, typical in modern motorway construction in Europe, which, although ostensibly a regular structure, is found to exhibit a rather unsymmetrical response in the transverse direction, mainly due to tensional irregularity. The bridges are assessed using response spectrum, ‘standard’ pushover (SPA), and MPA, and finally using non-linear response history analysis (NL-RHA) for a number of spectrum-compatible motions. The MPA provided a good estimate of the maximum inelastic deck displacement for several earthquake intensities. The SPA on the other hand could not predict well the inelastic deck displacements of bridges wherever the contribution of the first mode to the response of the bridge was relatively low.

T. S. Paraskeva, A. J. Kappos and A. G. Sextos, et.al. (2006) The aim of this study is to adapt the modal pushover analysis procedure for the assessment of bridges, and investigate its applicability in the case of an existing, long and curved, bridge, designed according to current seismic codes; this bridge is assessed using three nonlinear static analysis methods, as well as THA. Comparative evaluation of the calculated response of the bridge illustrates the applicability and potential of the modal pushover method for bridges, and quantities its relative accuracy compared to that obtained through other inelastic methods. Nonlinear static (pushover) analysis has become a popular tool during the last decade for the seismic assessment of buildings. Nevertheless, its main advantage of lower computational cost compared to non linear dynamic time-history analysis (THA) is counter-balanced by its inherent restriction to structures wherein the fundamental mode dominates the response. Extension of the pushover approach to consider higher modes effects has attracted attention, but such work has hitherto focused mainly on buildings, while corresponding work on bridges has been very limited.

Yongliang Zhang, Xingchong Chen, et.al. (2020) In this study, an improved pushover analysis model for the pile group foundation with consideration of pile group effect is presented and validated by the quasi-static test. The improved model uses simplified springs to simulate the soil lateral resistance, side friction and tip resistance. PM (axial load-bending moment) plastic hinge model is introduced to simulate the impact of the axial force changing of pile group on their elastic-plastic characteristics. The pile group effect is considered in stress-stain relations of the lateral soil resistance with a reduction factor. The influence factors on nonlinear characteristics and plastic hinge distribution of the pile group foundation are discussed, including the pier height, longitudinal reinforcement ratio and stirrup ratio of the pile, and soil mechanical parameters. Furthermore, the displacement ductility factor, resistance increase factor and yielding stiffness ratio are provided to evaluate the seismic performance of soil-pile system. A case study for the pile group foundation of a railway simply supported Beam Bridge with a 32 m-span is conducted by numerical analysis. It is shown that the ultimate lateral force of pile group is not determined by the yielding force of the single one in these piles. Therefore, the pile group effect is essential for the seismic performance evaluation of the railway bridge with pile group foundation.

Reza Akbari, et.al. (2012) A set of fragility curves of a class of reinforced concrete bridges with different degrees of irregularity has been generated. Eighteen bridge configurations have been identified, from regular to so-called highly irregular models. The geometric irregularity in this class of bridges is assumed to vary with the height of the piers. Using non-linear analytical models and an appropriate suite of 60 ground motions, analytical fragility curves have been generated for the individual piers of each of these 18 bridge models. Discussions have been made about the imposition of the displacement ductility demand of the piers versus the earthquake intensity as well as the bridge regularity. Comparison of the fragility curves shows that the most vulnerable bridges are the irregular bridges and high damage probability is expected for the short piers of this class of bridges. It was found that the fragility curves may be used for categorisation of regular and irregular bridges.

Themelina S. Paraskeva and Andreas J. Kappos, et.al. (2009) The key idea being that the deformed shape of the structure responding in elastically to the considered earthquake level is used in lieu of the elastic mode shape. The proposed MPA procedure is then verified by applying it to two actual bridges. The first structure is the Krystallopigi bridge, a 638 m-long multi-span bridge, with significant curvature in plan, unequal pier heights, and different types of pier-to-deck connections. The second structure is a 100 m-long three-span Overpass Bridge, typical in modern motorway construction in Europe, which, although ostensibly a regular structure, is found to exhibit a rather unsymmetrical response in the transverse direction, mainly due to tensional irregularity. The bridges are assessed using response spectrum, ‘standard’ pushover (SPA), and MPA, and finally using non-linear response history analysis (NL-RHA) for a number of spectrum-compatible motions. The MPA provided a good estimate of the maximum inelastic deck displacement for several earthquake intensities. The SPA on the other hand could not predict well the inelastic deck displacements of bridges wherever the contribution of the first mode to the structural behaviour with the increase of the number of stores is investigated.

Y .P . Pawar et. al. (2016) Steel beams supporting concrete slabs have been used to form the basic superstructure of large numbers of deck bridges for many years. Since 1945 the number of composite bridges being built has significantly increased. The pressure of steel shortage in Germany after the Second World War forced engineers to adopt the most economical design method available to be able to scope with the large amount of reconstruction of bridges and buildings destroyed. According to various research papers, it has been found that composite bridge gives the maximum strength in comparison to other bridges and the design and analysis of various girders for steel and concrete by using various software for composite bridge design for girder. In this project, efforts will make to carry outto check the analysis of girder by using SAP2000 software. Hence, in this project determine three girders which can be effective to the composite bridges.

G. D. Lakade, Y. P. Pawar, et. al. (2015) The summary of this paper can be given as the future seismic designs to be based on different performance objectives and related earthquake hazards. The main advantage of performance based design is the predictable seismic performance with uniform risk. The reliability of this approach may ultimately depends on the development of explisit and quantifiable performance criteria that can be related to the calculated response parameters such as stress, strain, displacement, acceleration. The developments in performance-based design in seismic engineering will be directed towards a general design methodology that permits performance-based design at multiple performance and hazard levels, and with due consideration given to the complete soil foundation structure system, non-structural systems and components and the building contents.

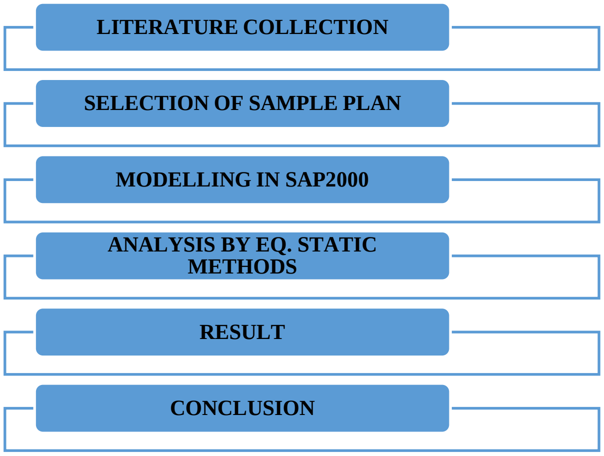
Y. P. Pawar et. al. (2016) The composite bridge gives the maximum strength in comparison to other bridges. The design and analysis of various girders for steel and concrete by using various software, that paper for composite bridge calculate the in bending moment for T girder and finding which is more effective. The efforts will make to carry out to check the analysis of bridge by using SAP 2000 software. To determine the static analysis of T girder by using manual method as well as software. The results obtained from the software in structural analysis are compare the results obtained from manual calculations.

Ganesh Lakade et. al. (2019) vibration is rarely a problem in most factories, since it is accepted by the workforce as part of the industrial environment. Vibrations of mechanical equipment such as rotating machinery should be strictly controlled according to the application and the criteria of existing technical standards and of those that are still being studied, and should be used as basis of the operating conditions of mechanical equipment, especially for predictive maintenance. At an early stage in the design process it is possible to locate both rhythmic activities and sensitive occupancy so as to minimize potential vibration problems and the costs required to avoid them. It is also a good idea at this stage to consider alternative structural solutions to prevent vibration problems. Such structural solutions may include design of the structure to control the accelerations in the building and special approaches, such as isolation of the activity floor from the rest of the building or the use of mitigating devices such as tuned mass dampers.

III. METHODOLOGY

A. Problem Statement

A parametric study of Bridges will be carried out by varying the height of piers and span length in different bridge models. Total 6 models of T Beam Bridge will model by considering the number of lanes, carriage way widths, span length, pier cap, abutments etc. Total length of bridge is 45 m. All Bridge models having 2 lanes (Total width 10m with 7.5m Carriageway). Slab thickness consider as 300 mm. Grade of Concrete – M40 and Grade of steel – Fe415



B. Bridge Configuration

Table 1 Bridge Configuration

Bridge Models	Type of Bridge	Height of Piers (m)	Span Length (m)
B-1	Long bridge pier	16,16	15,15,15
B-2	Long bridge pier	16,16	10,25,10
B-3	Short bridge pier	8,8	15,15,15
B-4	Short bridge pier	8,8	10,25,10
B-5	Irregular bridge pier	8,16	15,15,15
B-6	Irregular bridge pier	8,16	10,25,10

C. Material Properties

Table 2 Material Properties

Sr. No.	**Properties**	Value
1	Steel Grade	Fe415
2	Concrete Grade	M40
3	Modulus of elasticity	200000 MPa
4	Density of Steel	78 KN/m^3
5	Density of Concrete	25 KN/m^3
6	Density of Wearing Coat	22 KN/m^3

IV. SAP2000 BRIDGE MODELLING

A. Modelling

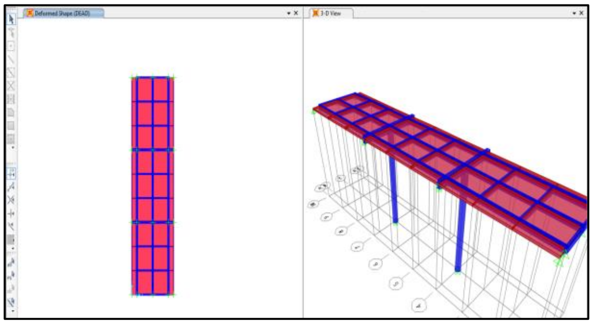


Fig.1 Model B1

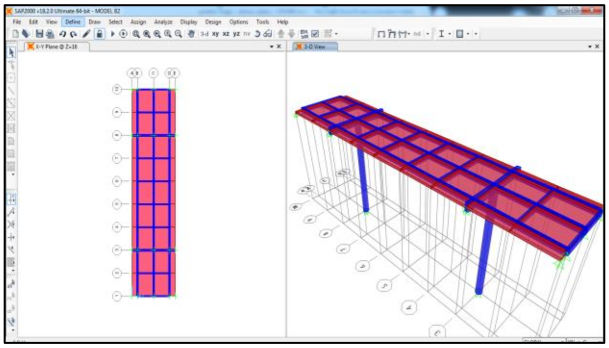


Fig.2 Model B2

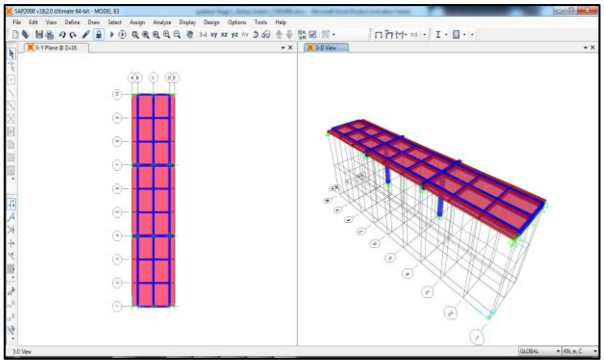


Fig.3 Model B3

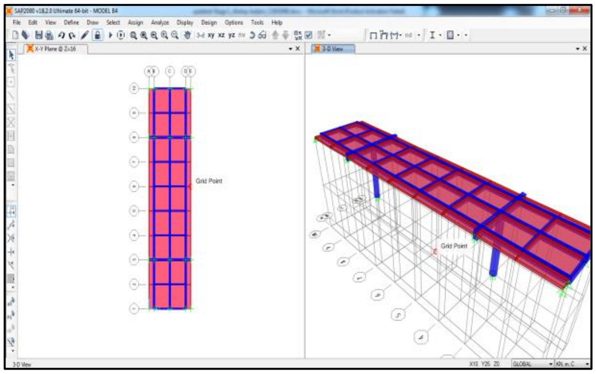


Fig.4 Model B4

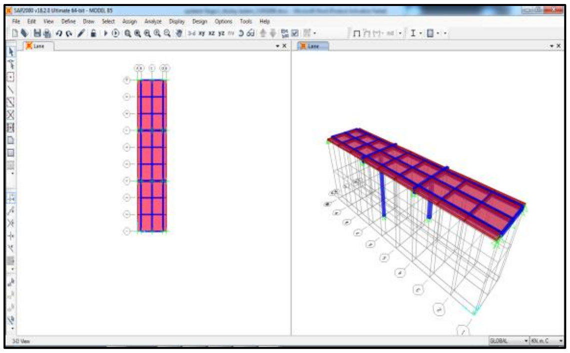


Fig.5 Model B5

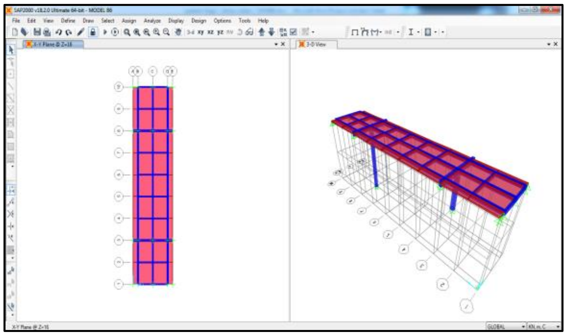
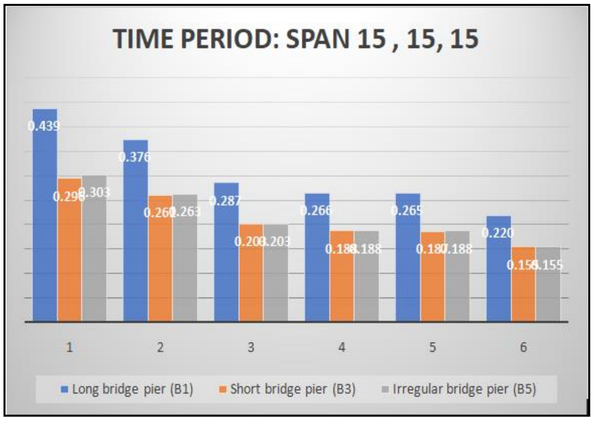


Fig.6 Model B6

B. Time Period

Table 3 Time Period Span 15, 15, 15

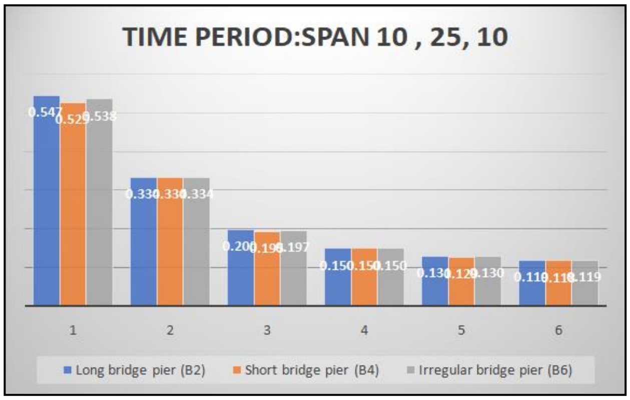
SPAN 15, 15, 15			
Mode	Long bridge pier (B1)	Short bridge pier (B3)	Irregular bridge pier (B5)
1	0.439	0.296	0.303
2	0.376	0.261	0.263
3	0.287	0.203	0.203
4	0.266	0.188	0.188
5	0.265	0.187	0.188
6	0.220	0.155	0.155



Graph. 1. Time Period: Span 15, 15, 15

Table 4 Time Period Span 10, 25, 10

SPAN 10, 25, 10			
Mode	Long bridge pier (B2)	Short bridge pier (B4)	Irregular bridge pier (B6)
1	0.547	0.529	0.760749
2	0.334	0.334	0.472699
3	0.200	0.195	0.27926
4	0.150	0.150	0.212796
5	0.131	0.129	0.183936
6	0.119	0.118	0.168095

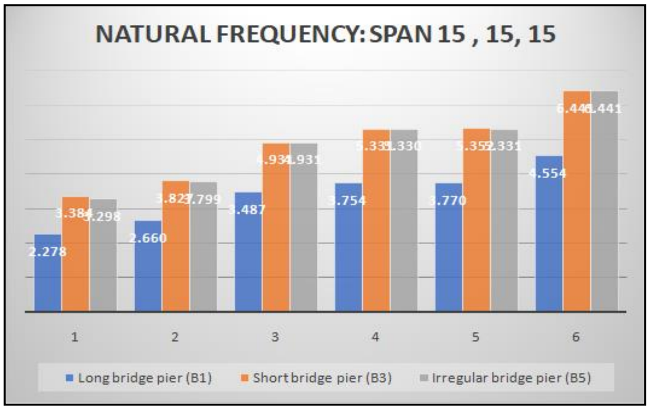


Graph. 2 Time Period Span 10, 25, 10

B. Natural Frequency

Table 5 Natural Frequency Span 15, 15, 15

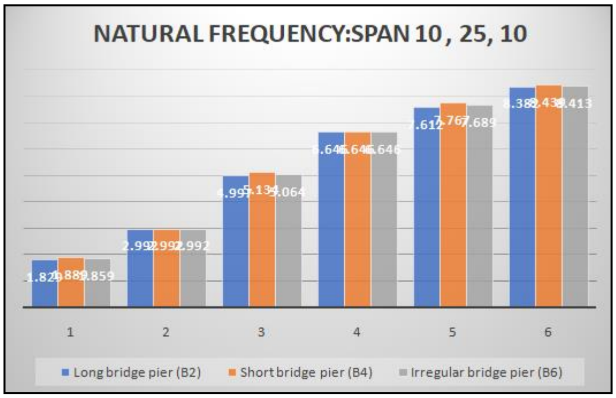
SPAN 15, 15, 15			
Mode	Long bridge pier (B1)	Short bridge pier (B3)	Irregular bridge pier (B5)
1	2.278	3.384	3.298
2	2.660	3.827	3.799
3	3.487	4.931	4.931
4	3.754	5.331	5.330
5	3.770	5.352	5.331
6	4.554	6.441	6.441



Graph 3 Natural Frequency Span 15, 15, 15

Table 6 Natural Frequency Span 10, 25, 10

SPAN 10, 25, 10			
Mode	Long bridge pier (B2)	Short bridge pier (B4)	Irregular bridge pier (B6)
1	1.829	1.889	1.859
2	2.992	2.992	2.992
3	4.997	5.134	5.064
4	6.646	6.646	6.646
5	7.612	7.767	7.689
6	8.382	8.439	8.413



Graph 4 Natural Frequency Span 10, 25, 10

VI. CONCLUSION

A parametric study of Bridges carried out by varying the height of piers and span length in different bridge models. Total 6 models of T Beam Bridge with having bearing and the design of bridge and bearings are carried out analytically. Total Six models of Bridge model are consider with span of equal and unequal spans and pier heights and analyze this modes in FEM software SAP2000 for various seismic analysis methods such as, response spectrum, time history analysis etc .to investigate and measure the performance of the bridge with different span and pier conditions the analysis conclude that the Short pier height models are economic than the unequal and long pier model as compare, but as compare with Unequal pier models having equivalent results with short pier model, so the bridge having unequal span and pier conditions are recommended for the seismic design purpose, the all final conclusions are carried out from the following results.

- In the seismic coefficient Method time period and natural frequency of the bridge are compare, as compare with time period results for equal and unequal spans, long span pier having more time period than Short &Irregular piers, the Short &Irregular piers time period difference are around 15-20%
- As compare with natural frequency results for equal and unequal spans, long span pier having less natural frequency than Short & Irregular piers, the Short & Irregular piers natural frequency difference are around 5-10%

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