Journal of Engineering and Applied Sciences 12 (9): 2254-2258, 2017
ISSN: 1816-949X
© Medwell Journals, 2017

Concrete Bridge Pier Performance under Earthquake Loading

[1, 2]Rozaina Ismail and [2]Mohd Ritzman Abdul Karim
[1]Institute for Infrastructure Engineering and Sustainable Management (IIESM),
[2]Faculty of Civil Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

Abtract: This study discussed the performance of concrete bridge pier due to earthquake loading by using LUSAS. This research included analysis of the seismic behaviour of concrete bridge deck. An analysis was conducted by using real earthquake records. The variation of normal stresses under seismic loading on the bridge deck in vertical direction is high compare with stresses in horizontal direction seems to be low. Overall the bridge deck can safely withstand by a variation forces and it is achieved based on the determined stress and displacement from the seismic load. This study has demonstrated a nonlinear analysis capable of capturing an extreme loading under seismic excitation which can be very effective in assessment of the damage and stability condition of the bridge deck. In the case of Kepong Bridge, Kuala Lumpur such analysis proved that the bridge suffers damage but remain stable. The result of this analysis shows that the bridge pier suffers some damages but it still remains stable. The result was captured using LUSAS 14.3 Software which means that the software able to analyze a seismic response. The research also provides evidence on a nonlinear analysis that able to capture an extreme loading under seismic excitation which is very reliable in assessing the damage and the stability condition of the bridge pier. Based on thedamages during the analysis under time history, it can be said that Kepong Bridge, Kuala Lumpur is still save under earthquake load which is the maximum ground acceleration of the earthquake is 0.012 g.

Key words: Performance, earthquake loading, stress, displacement, deformation shape, bridge deck

INTRODUCTION

Since 2010, the structure built of the bridge began to be viewed primarily on design and architecture. The safety of the bridge is highly regarded because of the many problems and failures occurred in recent years. Design engineers are challenged more to provide economic solutions that could be implemented within minimum time schedules, making an efficient use of the available resources.

From the review of literature, it can be conclude that the problems related to dynamic amplification factors were recognized in the 19th century (Lin, 1994; Wang *et al*., 1998). Further, many researchers work on this more realistically in the 20th century where a major effort has been direct towards the nonlinear dynamic analysis of the bridge (Adnan *et al*., 2008; Johnson *et al*., 2009; Xu *et al*., 2009; Liu *et al*., 2012; Ismail *et al*., 2016; Zeng and Dimitrakopoulos, 2015; Tubaldi *et al*., 2015; Khoury *et al*., 2016). Now a days, there are some cases of earthquake event that was reported in Malaysia but the earthquake event was in a small scale. Earthquake already happen in Malaysia especially in Sabah. Normally the design for the structures in Malaysia does not cover the earthquake condition. When earthquake happens, the structure will collapse. So, the analysis for the structure especially bridge should be made to make sure the performance of the bridge during the earthquake.

Research background: Even though Malaysian is located faraway from seismic zones of Sumatra, recently the effect of earthquake had made some impact in Malaysia. Several problem and cracking have been reported in Malaysia during earthquake in Acheh, Indonesia during 2004. This may affect the bridge as a connector from one place to another. Therefore, it is essential that the bridge should undergo seismic vulnerability under non linear analysis. For this research, Kepong Bridge, Kuala Lumpur is used as a model for 3D concept using LUSAS Software and the bridge also had undergo a specific analysis to determine the behaviour, displacement and also normal stress and shear stress while undergo earthquake analysis. Result from the analysis shows the influence of variation of bridge pier. This research project attempt to determine whether the bridge pier can resist by a variation forces, considerable respect from manyrelatedresearchers. For the generation of the target language based on the knowledge compilation and achieved good results.

Corresponding Author: Rozaina Ismail, Institute for Infrastructure Engineering and Sustainable Management (IIESM), Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

MATERIALS AND METHODS

Bridge description: In this research, information from public work department (structural and bridge unit) known as JKR and also WCE Consulting Engineers was taken in terms of full details of structure drawings, data investigation and cost project. The bridge is located at Kepong, Kuala Lumpur. The project title is cadangan membina jejambat konkrit di persimpangan Jalan Kepong/mainstreet, Jalan Kepong, Kuala Lumpur. Figure 1 shows the typical cross section at Pier 7 design by perunding sutera and peremba. Table 1 shows the material properties and the structural member details used in the analysis.

Non-linear dynamic analysis: Figure 2 shows the peak ground acceleration during earthquake events at Acheh, Indonesia on 24th December, 2004, the time history at surface were 0.012 g recorded at Ipoh station. Figure 3 shows the flow chart of non linear analysis for LUSAS 14.3 process starting by create the model until running the analysis. LUSAS is a UK-based developer and supplier of Finite Element Analysis (FEA) application software products that bear the same name. LUSAS is an associative feature-based modeler. The model geometry is entered in terms of features which are sub-divided (discretised) into finite elements in order to perform the analysis. Increasing the discretisation of the features will usually result in an increase in accuracy of the solution but with a corresponding increase in solution time and disk space required. The features in LUSAS form a hierarchy that is volumes are comprised of surfaces which in turn are made up of lines or combined lines which are defined by points. The finite element analysis using the LUSAS Software, involved three major steps: pre processing phase which involved process creating a geometric dimension that will representation of the structure being analysis by assigning it properties, then output the result of informationas a formatted data file for be analysis by LUSAS; finite element solver which dealing with a sets of linear or nonlinear algebra equations that have different value nodes are solved simultaneously to get nodal results such as displacement values or temperature values and; result-processing where the results of analysis can be processed to show the contour of displacements, stresses, strains, reactions and

Table 1: Structural member details

Structural members/Description	Values
Prestressed concrete beam	Grade 50/20
Pier, parapet, slab, other reinforced concrete	Grade 40/20
Concrete cover for abutment and walls	50 mm
Concrete cover for footing	70 mm
Concrete cover for 600 diameter bored pile	100 mm
Concrete cover for deck slab	35 mm
Mild steel	250 N/mm
High yield	460 N/mm

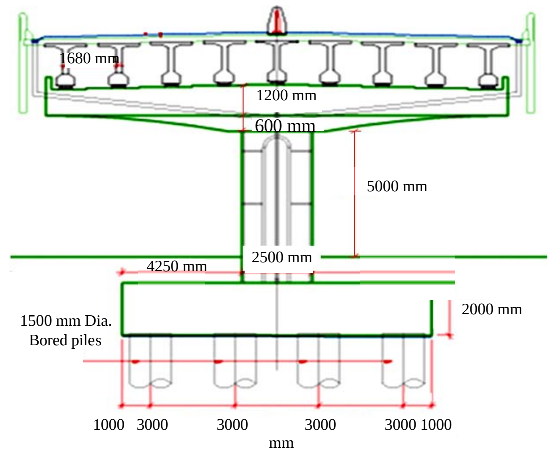

Fig. 1: Typical cross section at Pier 7

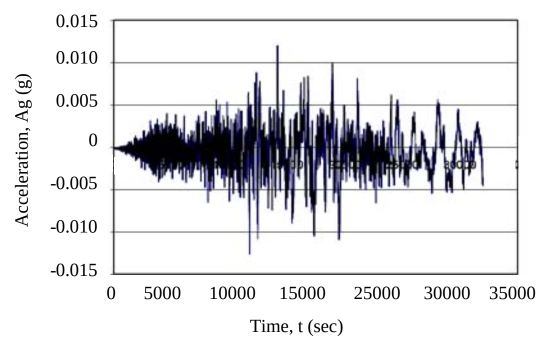

Fig. 2: Peak ground acceleration at Acheh earthquake 2004 (IPOH: PGA = 0.012 g)

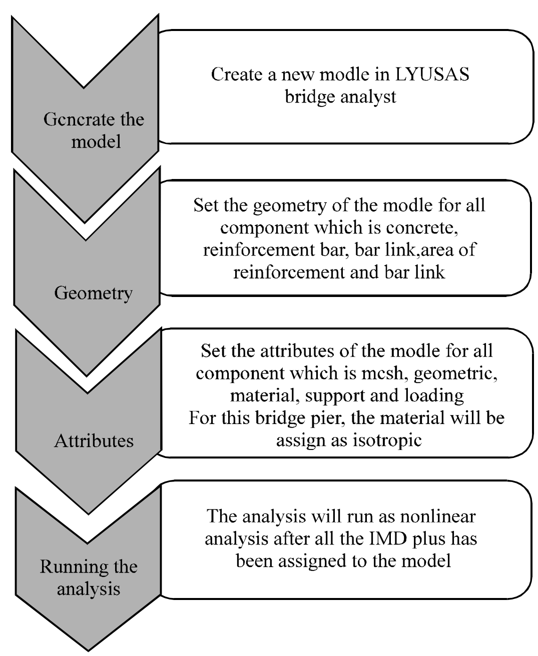

Fig. 3: Flow chart of non-linear analysis

other important information. From this information graphs deformed shapes and other characteristic of a model can be plotted (Fig. 3) The dynamic analysis shows the stress by node in the bridge pier structure when the dynamic loading at the maximum earthquake load. The purpose of this stress analysis is to determine whether the bridge pier will safely resist with the specified forces. The analysis shows the normal stress and shear stress of the bridge pier due to the seismic excitation that determined using time history analysis.

RESULTS AND DISCUSSION

From free vibration analysis, the natural period in 3D analysis and frequency structure can be analyzed as presented in Table 2 for mode 1-4 of the bridge pier. The range of natural period based on Duta Ulu Kelang Expressway (DUKE) is 0.2-3.5 sec. Figure 4-7 show the maximum contour for Mode shape 1-4 respectively. Figure 8 shows the maximum contour of shear stress 5.083 N/mm^{-2} which occurred on top area of the bridge pier.

In this analysis, the effect of time history analysis at surface with PGA 0.012 was applied to three dimensional analyses. The maximum axial, shear and bending moment forces and maximum displacement at bridge pier can be seen in Table 3. The maximum displacements are presented by U1 horizontal displacement (Table 4). Figure 8 shows the behavior of finite element analysis model under seismic load for each natural period due to earthquake effect to the bridge pier using eigenvalue mode. Its shows the different mode shapes for each time period. The deformation shows a four mode shape within 2.09851, 2.09000, 2.08841 and 2.08392 sec.

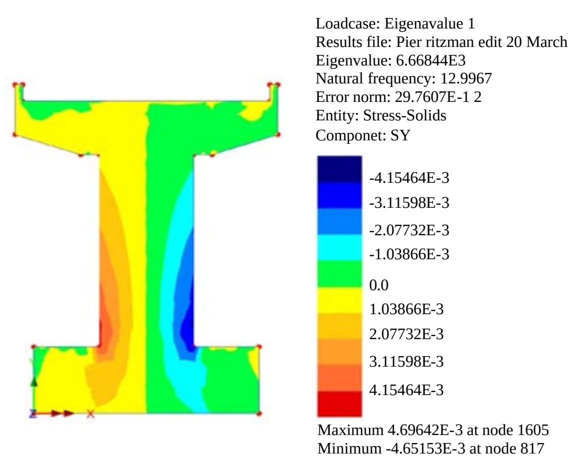

Fig. 4: Maximum contour is 4.696 N/mm^2 Mode 1 (t = 2.09851 sec)

mode. Its shows the different mode shapes for each time period. The deformation shows a four mode shape within 2.09851, 2.09000, 2.08841 and 2.08392 sec.

Table 2: Structural member details

Modes	Shear stress (N/Mm^2)	Natural period (sec)
1	4.696	2.09851
2	5.083	2.09000
3	3.465	2.08840
4	0.021	2.08390

Table 3: The results of 3 dimensional time history analysis

Components	Values
Maximum axial force pier	2816 N
Maximum shear force pier	353 N
Maximum bending moment pier	3.156Nm

Table 4: The maximum horizontal displacement for TH-3D analysis

Descriptions	Elements	Direction	Value
Maximum displacement (mm)	Pier	U1 (horizontal)	6.264

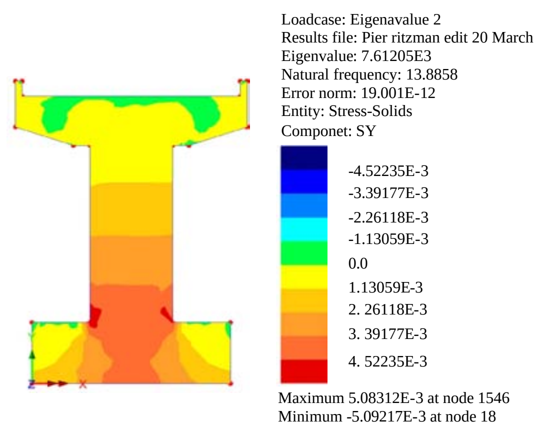

Fig. 5: Maximum contour is 5.083 N/mm^2 Mode 2 (t = 2.09000 sec)

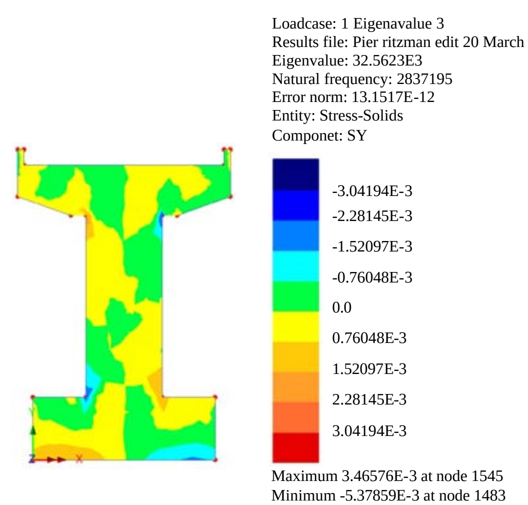

Fig. 6: Maximum contour is 3.465 N/mm^2 Mode 3 (t = 2.0884 sec)

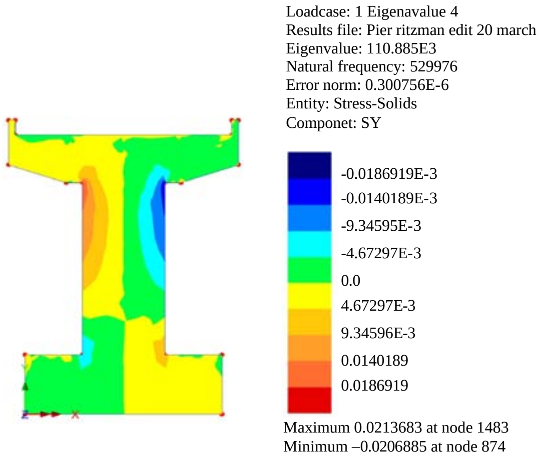

Fig. 7: Maximum contour is 0.021 N/mm^2 Mode 4 (t = 2.0839 sec)

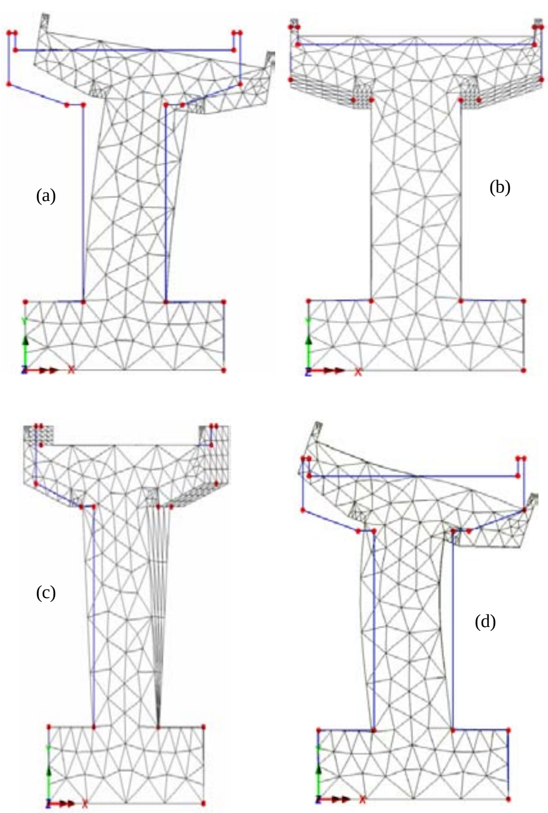

Fig. 8: Mode shape of the bridge pier: a) Mode shape 1; b) Mode shape 2; c) Mode shape 3 and d) Mode shape 4

CONCLUSION

This research is to conduct an analysis of the seismic behavior of bridge pier using real earthquake records from Acheh, Indonesia. From this research, it shows that the bridge pier can resist a variation forces. This can be concluded, since the variation of normal stresses under seismic loading on the bridge pier in longitudinal direction is higher compared to the shear stresses in vertical direction. The result of this analysis shows that the bridge pier suffers some damages but it still remains stable. The result was captured using LUSAS 14.3 Software which means that the software able to analyze a seismic response. The research also provides evidence on a nonlinear analysis that able to capture an extreme loading under seismic excitation which is very reliable in assessing the damage and the stability condition of the bridge pier. Based on thedamages during the analysis under time history, it can be said that Jejambat Kepong, Kuala Lumpur is still save under earthquake load which is the maximum ground acceleration of the earthquake is 0.012g. As a conclusion, this research had met the project's objective in determining the performance and the behavior if the bridge pier under seismic excitation.

ACKNOWLEDGEMENTS

The researchers would like to acknowledge that this research has been carried out as part of a project Science Fund with File No.: 600-RMI/FRGS 5/3 (112/2015) funded by Ministry of Science, Technology and Innovation (MOSTI) and support from Faculty of Civil Engineering Universiti Teknologi MARA (UiTM).

REFERENCES

Adnan, A., I.M. Taib and M. Suhatril, 2008. Seismic performance of sungai merang bridge in terengganu under low earthquake ground motion. Proceedings of International Conference of Earthquake Engineering and Disaster, April 14-15, 2008, Jakarta, Indonesia, pp: 1-8.

Ismail, R., A. Ibrahim, H.A. Hamid, T.A. Majid and A. Adnan, 2016. Seismic Site Classification of JKR Bridge at Sungai Sepang Using Multichannel Analysis of Surface Wave (MASW). In: InCIEC 2015, Yusoff, M., N.H.A. Hamid, M.F. Arshad, K.A. Ahmad and R.M.R. Ahmad et al., (Eds.). Springer, Singapore, ISBN:978-981-10-0155-0, pp: 159-167.

Johnson, N., M.S. Saiidi and D. Sanders, 2009. Nonlinear earthquake response modeling of a large-scale two-span concrete bridge. J. Bridge Eng., 14: 460-471.

Lin, Y.H., 1994. Vibration analysis of Timoshenko beams traversed by moving loads. J. Mar. Sci. Technol., 2: 25-35.

Khoury, O.E., C. Kim, A. Shafieezadeh, J.E. Hur and G.H. Heo, 2016. Mitigation of the seismic response of multi-span bridges using MR dampers: Experimental study of a new SMC-based controller. J. Vib. Control, 18: 684-695.

Liu, Z.J., Y.F. Xing and Y. Wan, 2012. Random Seismic Response Analysis of Long-Span Bridge Structures. In: Applied Mechanics and Materials, Yang, W. and L. Qiusheng (Eds.). Trans Tech Publications, Switzerland, pp: 2157-2161.

Tubaldi, E., A. Dall?Asta and L. Dezi, 2015. Seismic response analysis of continuous multispan bridges with partial isolation. Shock Vibr., 2015: 1-15.

Wang, Y.P., L.L. Chung and W.H. Liao, 1998. Seismic response analysis of bridges isolated with friction pendulum bearings. Earthquake Eng. Struct. Dyn., 27: 1069-1093.

Xu, Q., Z. Sun, H. Wang and A. Shen, 2009. Laboratory testing material property and FE modeling structural response of PAM-modified concrete overlay on bridges. J. Bridge Eng., 14: 26-35.

Zeng, Q. and E.G. Dimitrakopoulos, 2015. Seismic response analysis of a coupled (curved railway) bridge-train system under frequent earthquakes. Proceedings of the 6th International Conference on Experiments Process System Modelling Simulation Optimization IC-EpsMsO, November 6-8, 2015, Bloomsbury Publishing, Sydney, Australia, pp: 1-8.