Advanced Materials Research *Online: 2013-02-13*
ISSN: 1662-8985, Vol. 663, pp 202-205
doi:10.4028/www.scientific.net/AMR.663.202

Modal Analysis on Xiluodu Arch Dam under Fuzzy Stochastic Damage Constitution

Wang Ya Jun[1, 2, a], Wang Jin Ting[2,b], Gan Xiao Qing[3,c], Dong Zhi Hong[3,c]

[1]School of Naval Architecture and Civil Engineering, Zhejiang Ocean University, Zhoushan 316000, China

[2] State Key Laboratory of Hydroscience and Hydraulic Engineering, Tsinghua University, Beijing 100084, China

[3] Yangtze River Scientific Research Institute, Wuhan, 430010, China

[a]aegis68004@yahoo.com.cn, [b]Dionysusmug@163.com, [c]aegis68004@163.com

Keywords: Super arch dam of concrete, Modal analysis, Fuzzy-stochastic damage constitution

Abstract. Modal analysis is the important study for high dam seismic design. Lanczos algorithm was used here for iterative computation. The material constitution for structure was established based on fuzzy-stochastic damage mechanics. The result shows that the typical character of Xiludou super arch dam is the unsymmetrical modal shape.

Introduction

Sino-mainland nowadays has established more than 100 super dams whose heights are above 150 m[1]. Meanwhile, the geological conditions of Sino-mainland are also the most abominable ones in the world[2,3]. During the early 20 years of 21st century, the destructive earthquake cases (Ms$\geq$6.5) here are more than 10 times. Xiluodu arch dam is another super concrete dam of above 200m whose site just stands on the great South-Eastern zone of China where is the main source of Sino great earthquakes[4,5].

As for seismic key technology, the modal analysis can offer the primary dynamical character of structures under earthquake loading. Such primary parameters as dynamical coefficients, natural frequency, damping ratio and dynamic magnification parameters etc can be established. [2,3].

During the modal analysis, the constitutive material was founded with generalized damage. The fuzzy stochastic damage index function is expressed in Eq. 1.

$$\varpi_i = \frac{|\sigma_{m_i}|\tan\varphi_i + c_i}{|\bar{\sigma}_i|^{\frac{1}{\lambda}}} \tag{1}$$

where, i indicates the Gaussian integral point; λ is the material parameter got from test and the suggested value is 1.2; c and φ represent the shear strength index, namely, cohesive force and internal friction angle respectively; σ_{m_i} is the hydrostatic pressure on point i; $\bar{\sigma}_i$ designates the stress deviator on point i.

The identification of material damage needs the measured data to describe the strain-stress process. The whole non-linear constitution was adopted here for damage evaluation and the representative test process curve is showed in Fig. 1.

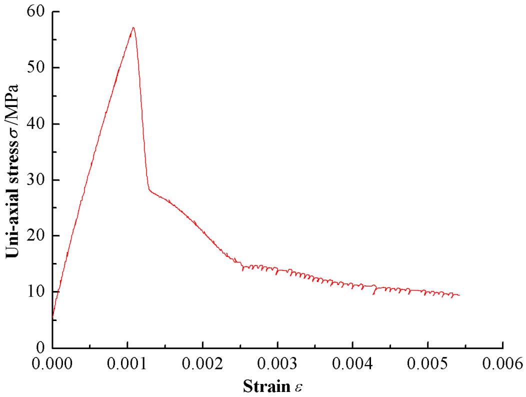

Fig. 1 Uni-axial Compression Test Process Curve

Numerical Results of Modal analysis on Xiluodu Arch Dam

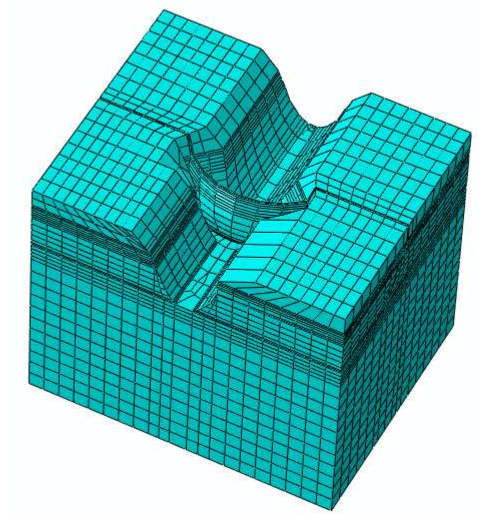

Fig. 2 Numerical Grid Model for Xiluodu Arch Dam Modal Analysis

The finite element gird model is showed in Fig. 2. there live two kinds of element for it, namely, hexahedral element and wedge element. The total number for element is 10 393. The total number for node is 12 238.

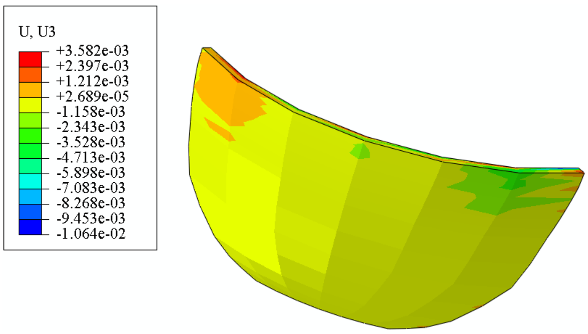

Fig.3 First Order Mode Shape (ω_1 =0.94965)

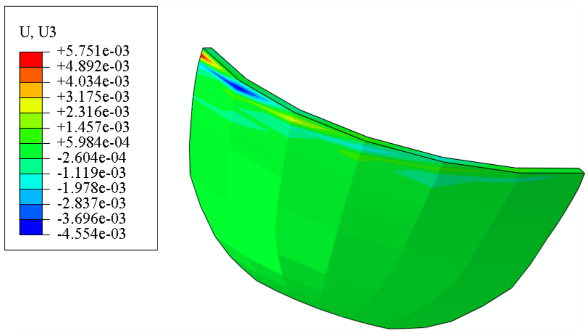

Fig.4 Second Order Mode Shape (ω_2 =0.97830)

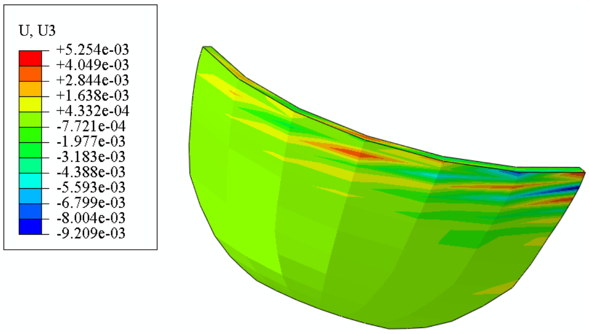

Fig.5 Third Order Mode Shape (ω_3 =0.99742)

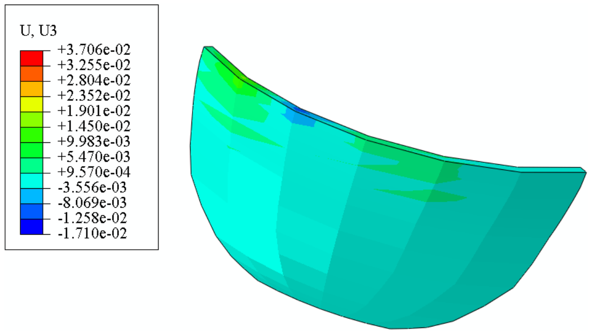

Fig.6 Fourth Order Mode Shape (ω_5 =1.0219)

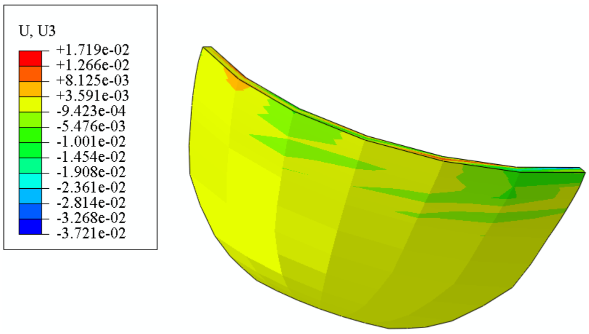

Fig.7 Fifth Order Mode Shape (ω_5 =1.0219)

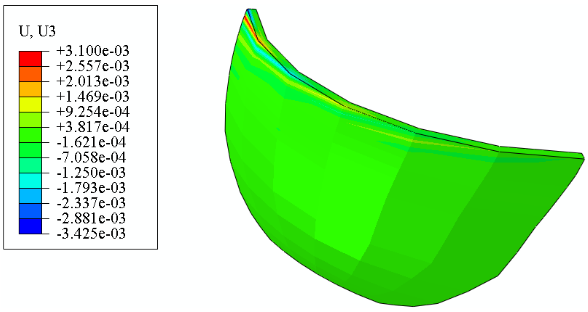

Fig.8 Sixth Order Mode Shape(ω_6 =1.0240)

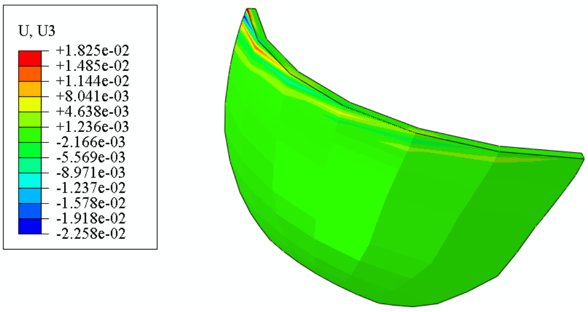

Fig.9 Seventh Order Mode Shape (ω_7 =1.0982)

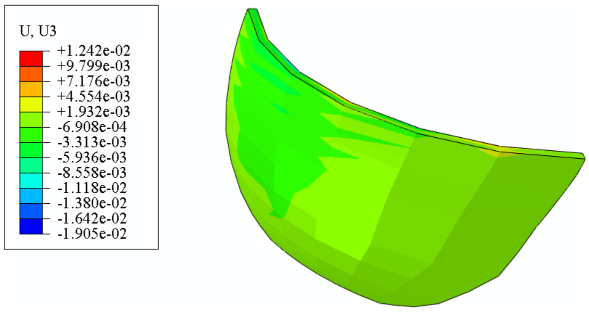

Fig.10 Eighth Order Mode Shape (ω_8 =1.1091)

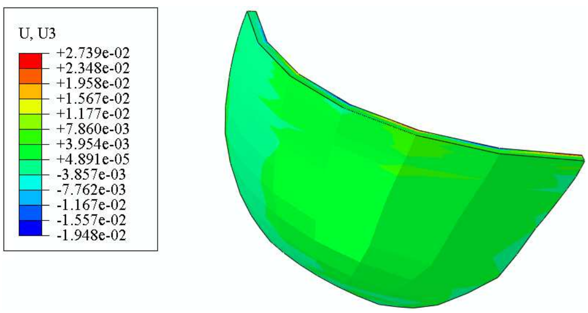

Fig.11 Ninth Order Mode Shape (ω_9 =1.1157)

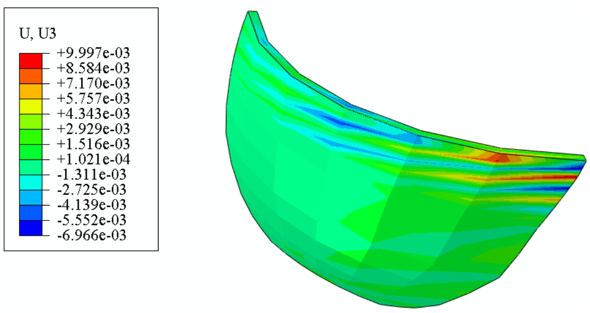

Fig.12 Tenth Order Mode Shape (ω_{10} =1.1177)

The representative modal shape for Xiluodu arch dam is the unsymmetrical one[6,7] (Fig. 3-Fig. 12). The first order mode shows the displacement contour has this character. Particularly, the displacement field at arch dam abutments has almost the same magnitude. The development directions on the displacement, however, are absolutely opposite. This character is the same sign of displacement distribution for modal shapes of 4^{th}, 6^{th} and 10^{th}. So, the conclusion is the typical model shape for Xiluodu arch dam is the unsymmetrical one[8].

Conclusions

Numerical computation was applied for Xiluodu super concrete arch dam. The result is helpful for structure's seismic analysis. Due to the accumulation of dynamic displacement at abutments of arch dam, the modal shape of Xiludo arch dam has the primary character of unsymmetrical distribution.

Acknowledgements

This work was supported by the National Natural Science Funds (Grant No: 51109118), the China Postdoctoral Science Foundation (Grant No: 20100470344), Fundamental project fund of Zhejiang Ocean University (Serial number: 21045032610).

References

[1] Y. J. Wang, Y. Hu, Z. Zuo, L. P. Zhi and H. X. Gao, Crucial Geo-qualities and Predominant Defects Treatment on Foundation Zones of Sino Mainland Xiluodu Arch Dam, Advanced Materials Research. 446 (2012) 1997-2001

[2] J. T. Wang, F. Jin, C. H. Zhang, Estimation Error of the Half-power Bandwidth Method in Identifying Damping for Multi-DOF Systems, Soil Dynamics and Earthquake Engineering. 39 (2012) 138-142

[3] Y. J. Wang, W. H. Zhang, Rock Slope Fuzzy Stochastic Damage Study, Advanced Materials Research. 524-527 (2012) 337-340

[4] Y. J. Wang, W. H. Zhang, Super Gravity Dam Generalized Damage Study, Advanced Materials Research. 479-481 (2012) 421-435

[5] Y. J. Wang, W. H. Zhang, C. H. Zhang and F. Jin, Fuzzy Stochastic Damage Mechanics (FSDM) Based on fuzzy auto-adaptive control theory, Water Science and Engineering. 5(2) (2012) 230-242

[6] C.H. Zhang, O. A. Pekau, F. Jin, G. L. Wang, Application of Distinct Element Method in Dynamic Analysis of High Rock Slopes and Blocky Structures, Soil Dynamics and Earthquake Engineering. 16 (1997) 385-394

[7] F. Jin, G. L. Wang, C.H. Zhang, A Hybrid Procedure of Distinct-Boundary Element for Discrete Rock Dynamic Analysis, Developments in Geotechnical Engineering, 83 (1998) 313-320

[8] F. Jin, H. L. Xin, C. H. Zhang, Q. C. Sun, Probability-based Contact Algorithm for non-Spherical Particles in DEM, Powder Technology, 212 (2011) 134-144