11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

NUMERICAL STUDY ON THE PROGRESSIVE FAILURE OF GRAVITY DAM FOUNDATION BASED ON DAMAGE THEORY

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Key Words: *Gravity dam, Rock mass, Anti-sliding stability, Damage mechanics, Numerical simulation.*

There are generally some faults, joints and cracks in the foundation of gravity dam. The deep and shallow stability of dam along the weak low-angle structural planes is one of the important problems concerned by engineers at all times. In the current numeric analysis elastic-plastic constitutive equation is usually adopted for rock mass, the brittle broke can not be considered, the destructive extent of rock and structural plane and the failure process of dam due to deterioration of the dam foundation not be obtained. In this paper a numerical model to analyze the damage process of foundation rock mass is established with damage mechanics theory. Based on the damage constitutive relationship and the evolution equation of damage variable, the tensile and shear damage of dam foundation can be found by using the Mohr-Coulomb criterion with tensile cut. The damage variable is denoted by the change of deformation modulus before and after damaging for rock mass. The distribution nonuniformity of deformation modulus in rock mass is considered with Weibull function in which the shape parameter *m* is determined through optimization according to the measured deformation modulus of rock mass in situ.

Then the above model is used in the non overflow dam section No. 3 at left bank of Three Gorges Dam (Figure 1). The nonuniformity of deformation modulus in rock mass is shown in Figure 2. The overloading damage process of the dam foundation was simulated dynamically, and the development of damage zone and the distribution of different damage extent were both presented (Figure 3), and the global stability safety of dam-foundation system is estimated (Table 1).

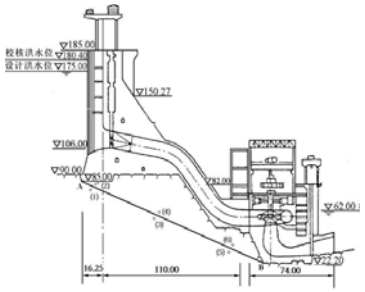


Fig.1 Dam section No. 3 of Three Gorges Dam

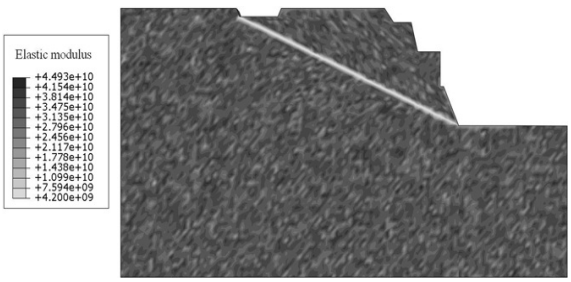
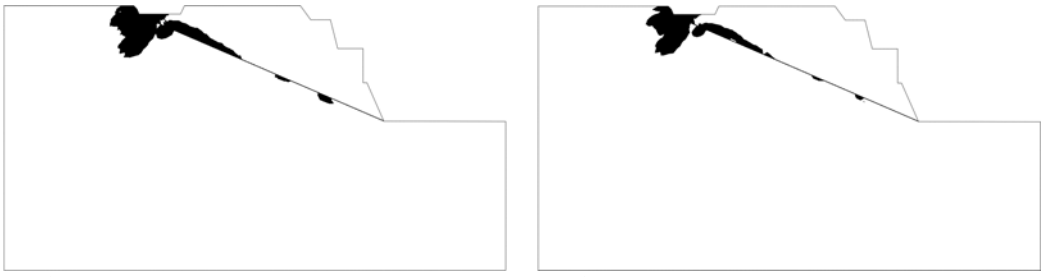


Fig. 2 Nonuniformity of deformation modulus in rock mass



（a）Damage area in foundation when $D > 0.2$ （b）Damage area in foundation when $D > 0.5$

（c）Damage area in foundation when $D > 0.8$ （d）Damage area in foundation when $D = 1.0$

Fig. 3 Distribution of different damage extent for overload coefficient $K = 5$.

Table 1 Safety coefficient of dam-foundation for different method

Method	Rigid limit equilibrium method	Block Element Method [5]	Method in pape	Model test
Safety coefficient	3.0	6.0	5.9	6.0

The obtained results show that they are in consistent with model test results, which indicate the reliability of the established damage model. The model can be used to analyze the breakage mechanism and evaluated the stability safety of rock mass.

This research is supported by the National Nature Science Foundation of China (Grant No. 11132003 and No. 51079045)

REFERENCES

[1] Ren Qingwen, Qian Xiangdong, Zhao Yin, Fu Shuhong. Methods for analyzing sliding resistance stability along the base surface of high arch dam [J]. Journal of Hydraulic Engineering, 2002, 33(2):1-7. (in Chinese)

[2] Weibull, W. A statistical theory of the strength of materials[J]. Ingeniorsvetenskap Akademiens Handlingar, 1939, 151: 1-45.

[3] Mazars, J., Pijaudier-Cabot, G. Continuum damage theory-application to concrete[J]. Journal of Engineering Mechanics, 1987, 115(2): 345-365.

[4] Ren Qingwen, Yu Tiantang, Ma Liangyun. Numerical Analysis and Experiment Study of Stability for Dam Section No. 3 of the Three Gorges Project [J]. Engineering Science, 1999, 1(3):41-45. (in Chinese)