Nonlinear Analysis of Copper Water Stop

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ABSTRACT

Copper water stop is used to prevent water seeping through the dam. To get the stress and strain distribution status of water stop, LS-DYNA was used to make a nonlinear analysis. Experiment results and simulation data were tested to be consistent.

INTRODUCTION

The Chinese Qingjiang reservoir dam in Hubei province is the highest rock fill dam in the world. The higher the dam is, the higher demand for the water prevention measures. As a typical method to stop water, copper water stop was widely applied in the water stop structures around rock fill dams (see figure 1). It is embedded between the faceplate and toe-plate. Serving as the bottom water stop, it will endure displacements of three directions produced by surrounding slot during the movement of the rock fill dam, namely, the relative split•subside and shear. Besides these loads, water stop has to support the high water pressure in case the foreside water stop measure failed. In order to get the stress distribution data after sequential action of tri-directional displacements and hydrostatic pressure. Considering the difficulties of complete experiment, numerical simulation was chosen to make this analysis.

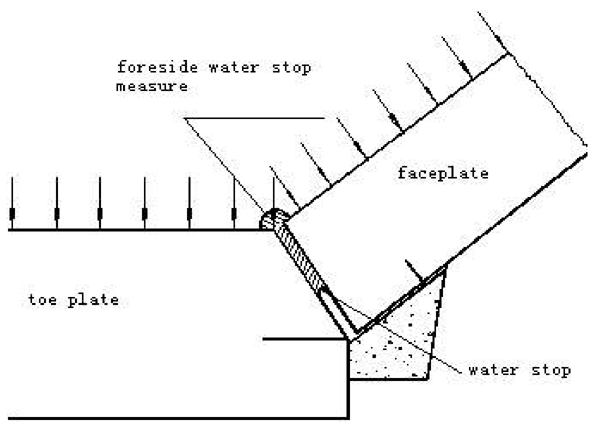


Figure 1. Project sketch map

MODEL

MESH

A finite element model of the water stop and dam were built using ANSYS Version 5.5.The dam used eight nodes Hughes-Liu SOLID element in ANSYS/LS-DYNA. The water stop was modeled with Belytschko-Tsay SHELL element. The whole model was shown in Figure 2. The length of whole model is 2 meters. The edge of shell element is 1cm. There are five integration points through the thickness of shell. Single surface contact was used to avoid excessive distortion.

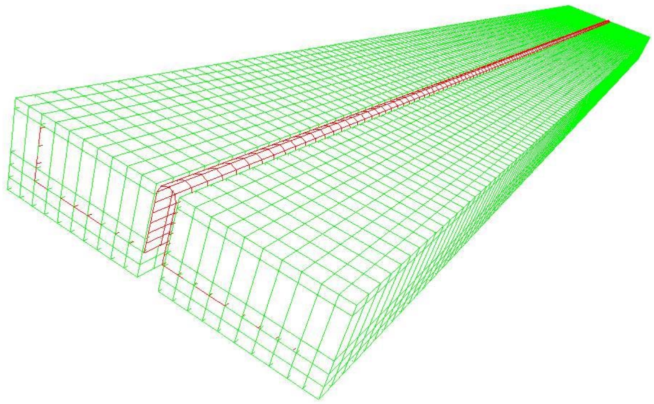


Figure 2. Finite Element Model

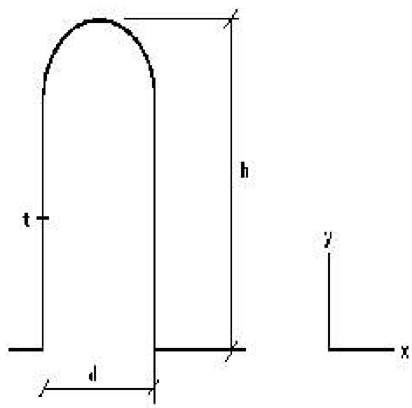


Figure 3.Parameters of the section

Table 1. Section Dimension

No.	h/d	d•cm•	t•mm•
1	1.5	2.0	1.0
2	1.5	3.0	1.2
3	2.5	2.0	1.0
4	2.5	3.0	1.2
5	3.5	2.0	1.2
6	3.5	3.0	1.0
7	4.5	2.0	1.2
8	4•5	3•0	1•0

SIMULATION

CASE 1

In order to optimize the copper water stop section to effectively resist shear force, computations were carried out according to the following cases (see Table1 and Figure 3).

The total shear displacement along z direction in XOZ plane is 6 cm for each case. According to the fact of project and the requirements, we simplified the computation model.

1. Only consider the flex part outside the concrete of the copper water stop.
2. Fix all the boundary nodes of two sides except z displacement.

The finite element model of copper water stop is shown in figure 4.

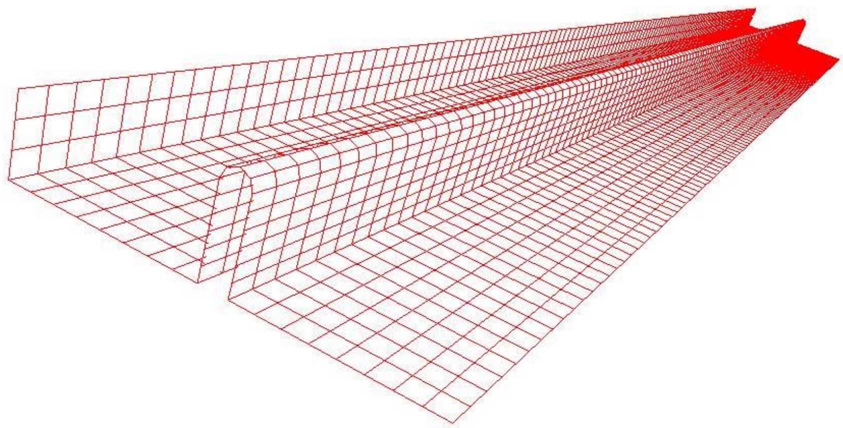


Figure 4. Finite element model of copper water stop

RESULT

After analysis of the Von Mises effective stress and other results, the sixth section dimension is the best choice. Meanwhile, the effects of parameters h/d•d and t on the ability of shear resistance were understood through simulation.

CASE 2

To compare the strength of F and W type copper water stop used in project. Base on the dimensions chosen from case 1, namely, h/d=3.5cm, d=3.0cm, t=1.2mm, further simulation was made.

The copper water stop was glued to different material at various position in faceplate and toe plate and the cohere strengths were also different. The values were measured through experiment and divided into three conditions:

- The cohere strength between concrete and copper is 1.8 Mpa.
- The cohere strength between rubber and copper is 0.02 Mpa.
- The cohere strength between plastic plate and copper is 0.8 Mpa.

The section plane and cohere strength distribution statuses for W and F type were shown in figure 5 and the number with circle represent different cohere strength types.

W TYPE

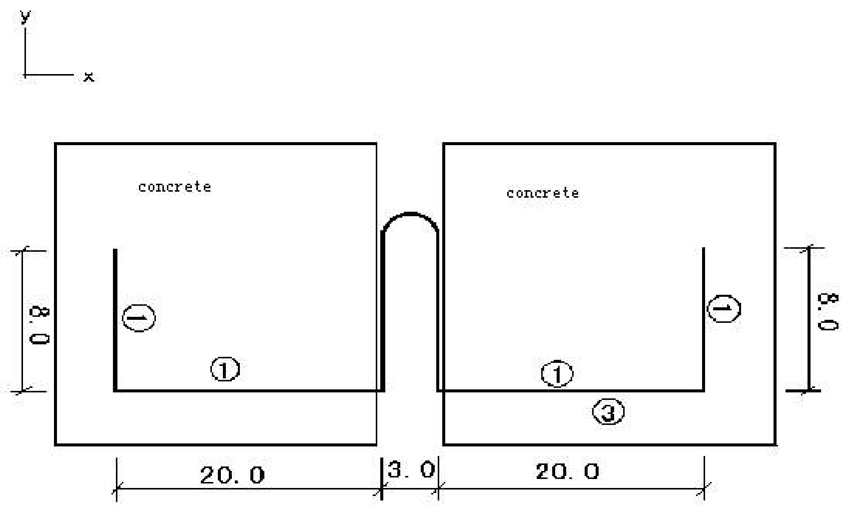


Figure 5. The section plane and cohere strength distribution sketch map of W type

F TYPE:

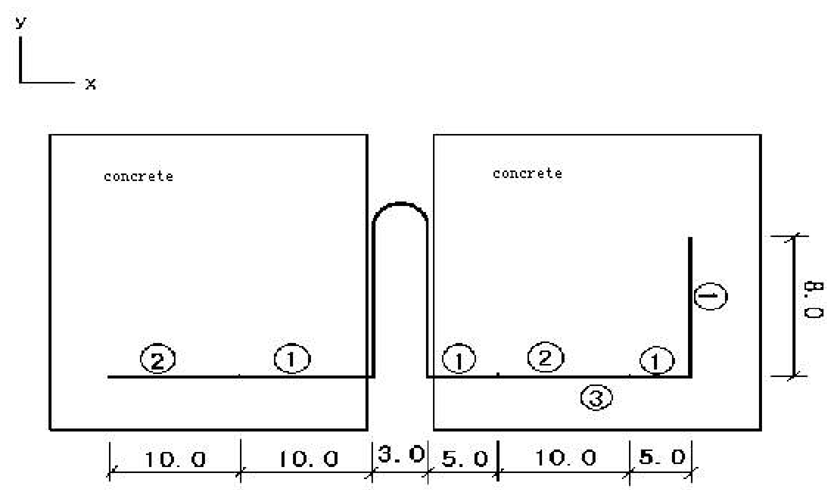


Figure 6. The section plane and cohere strength distribution sketch map of F type

LOAD CASE:

Sequentially add load to two sections in the following turn:

1. Increasing the relative displacement Ux, Uy, Uz from (0,0,0) proportionally to (5,10,5) cm. (Ux: the split distance along x direction. Uy: the subside displacement along y direction; Uz: the shear displacement in z direction).

2. Apply hydrostatic pressure onto the deformed copper water stop outside; the value changes from 0 to 2.3 Mpa.

RESULT

1. The stress fringe results of two section types after tri-directional displacement are shown in figure 7 and 8.

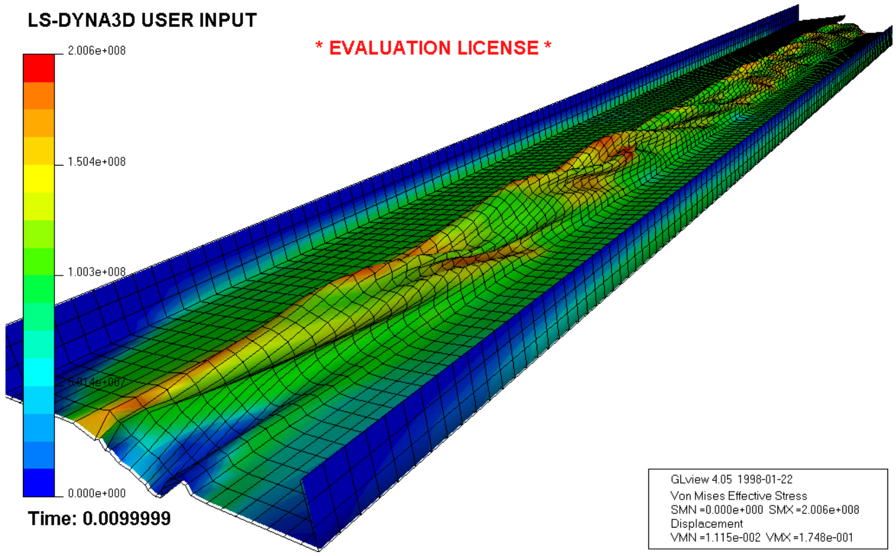


Figure 7. W type

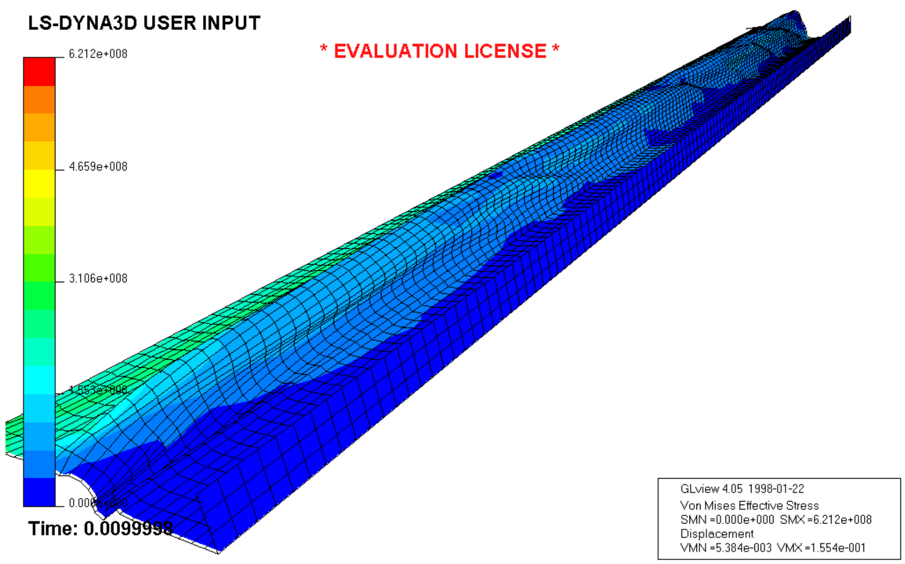


Figure 8. F type

2. The stress fringe results of two section types after 3Mpa hydrostatic pressure

were shown in figure 9 and 10.

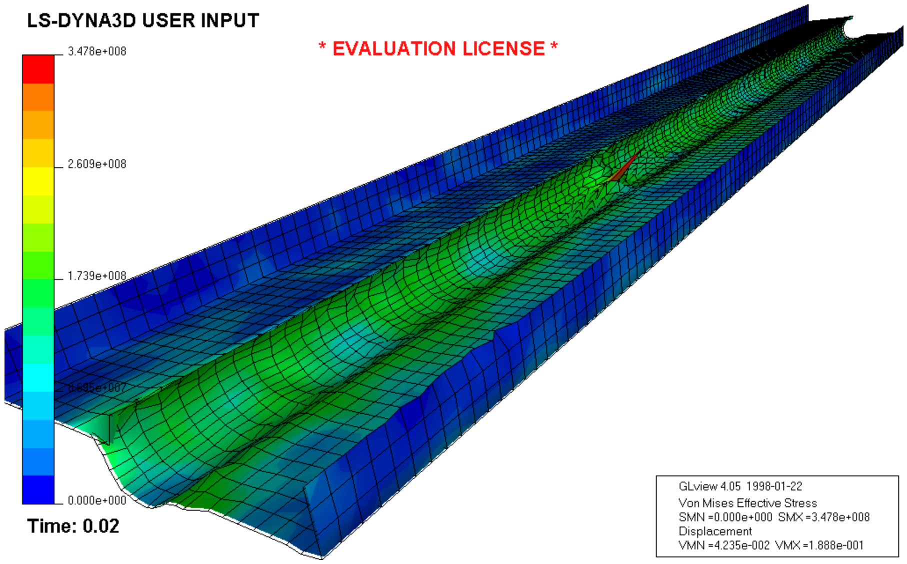


Figure 9. Section stress of W type

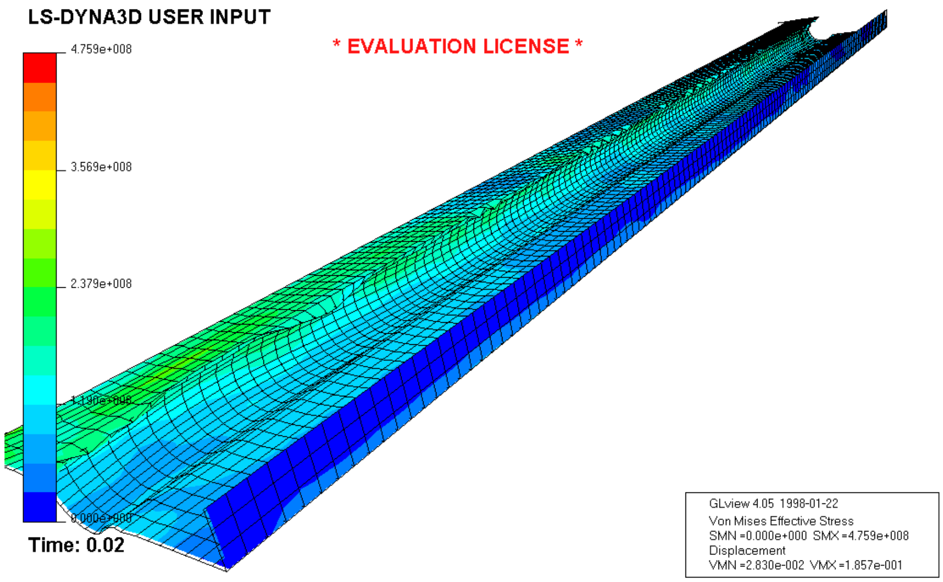
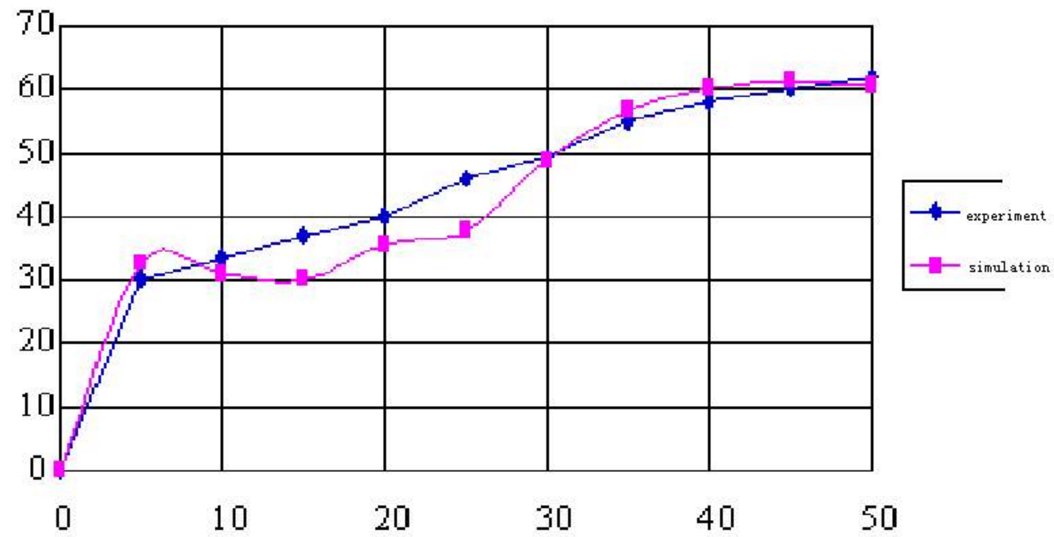


Figure 10. Section stress of F type

The relation between shear distance and average shear stress was tested and simulated and the result contrast is shown in the following figure.



CONCLUSION

Given the same load, the deformation of W type is more severe than that of F type. The stress cutoff of W type is about 300 Mpa while that of F type is 150 Mpa. This is mainly because F type copper water stop will separate with concrete more easily. So F type is suggested to be the better choice in practical project.

REFERENCE

LS-DYNA User Manual, Livermore Software Technology Corporation, LSTC, Livermore, 1998

LS-DYNA Keyword User's Manual. Version 940. Non-Linear Dynamic Analysis of Structures in Three Dimensions. Livermore Software Technology Corporation, LSTC, Livermore, June 1997.