Finite Element Simulation Analysis for Reinforced Concrete Hyperbolic Arch U-shaped Section Aqueduct

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Abstract—**One station on Jinggu river aqueduct whose level is three is located in the channels on Jinggu power station in Yunnan Province, the Aqueduct is the reinforced concrete hyperbolic arch aqueduct, for three main arch rib with double wave and uniform section, the arch axis is parabola. The aqueduct structure is thin-walled concrete structure, structural analysis is of great significance to study the safety the structure, through static analysis, can get the change law of stress and displacement of the structure. Using the general finite element calculation software, one station on Jinggu River aqueduct whose level is three carried out three dimensional finite element analysis .Considering the aqueduct in the process of construction and operation has four cases.We obtained the aqueduct stress distribution and displacement.The results show that one station on Jinggu River aqueduct whose level is three is reasonable structure to meet the design requirements which can provide a theoretical basis for the designed of U-shaped reinforced concrete aqueduct .**

Keywords-U-shaped aqueduct; Beam aqueduct; Simulation analysis; Finite element method; Operation period.

I. ENGINEERING SITUATION

One station on Jinggu river aqueduct whose level is three is located in the channels on Jinggu power station in Yunnan Province whose design flow is 9.0 m³/s and slope is 1/400 and length is 222m[1]. The Aqueduct is the reinforced concrete hyperbolic arch aqueduct, for three main arch rib with double wave and uniform section.The arch axis is parabola, with clear span for 36.44m, span ratio of 1/5, aqueduct wide span ratio of 1 / 9.9 .The reinforced concrete arch stands alone bent, where hold on the reinforced concrete U-shaped Aqueduct[2]. U-shaped Aqueduct inner diameter is 1.30m, with clear height of 2.02m, the wall thickness of 0.10m, reinforced concrete arch rib cross-sectional dimensions of 0.25m × 0.45m, total width of 3.35m, the total height of 0.9m. Trough body strength grade of concrete are C30, bent and arch concrete strength grade are C20 and reinforced steel hot rolling class is II[3].

II. CALCULATION MODEL

A Model Parameters

One station on Jinggu River aqueduct whose level is three uses the concrete strength class C30,elastic modulus $E_1 = 30$ GPa,poisson's ratio $\mu_1 = 0.167$ [4],bulk density $\gamma_1 = 24$ kN/m³.Bent and arch use the concrete strength class C20,elastic modulus $E_2 = 25.5$ GPa, poisson's ratio $\mu_2 = 0.167$ [5-6],bulk density $\gamma_2 = 24$ kN/m³.

B Model Element

Aqueduct model uses 8-node isoparametric block element. The element is applied to three-dimensional model entity structure,with plasticity, creep, swelling, stress stiffening, large deformation and large strain properties.The element has eight nodes and each node has three translational degrees of freedom[7-8]. Finite element model of aqueduct structure shows in Fig .1.
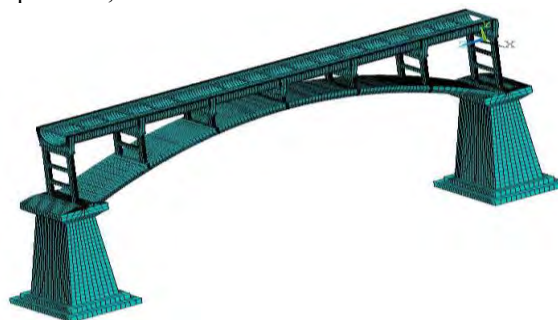

Figure 1.   Finite element model of the aqueduct structural

C Calculation Case

Considering the arch structure during operation of the mechanical characteristics[9-10],the main consideration of the following four kinds of calculation condition is that case1(weight), case2(design water level and weight), case3(full tank level and weight),

case4(design flood level, weight and earthquake response).

III.   AQUEDUCT STRUCTURE ANALYSIS

A   Stress Analysis

After the three-dimensional finite element simulation analysis for one station on Jinggu river aqueduct whose level is three ,we get the results of the aqueduct in the process of construction and operation in terms of the first principal stress and the longitudinal stress cloud shown by Fig .2 to Fig .9 .
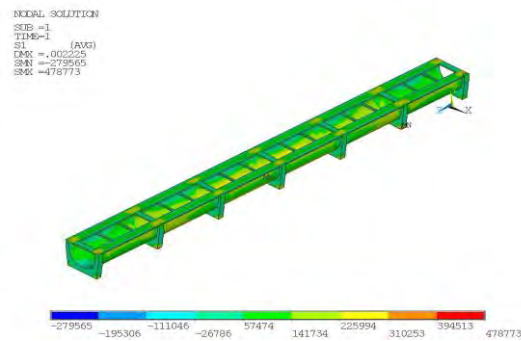

Figure 2.   Cloud map of aqueduct's first principal stress under case 1（Pa）
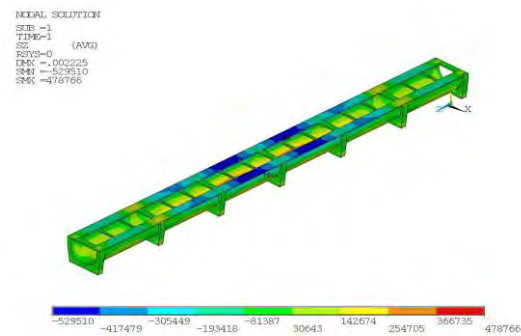
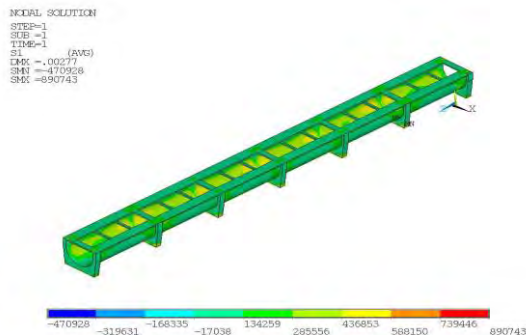Figure 3.   Cloud map of aqueduct's longitudinal stress under case 1（Pa）

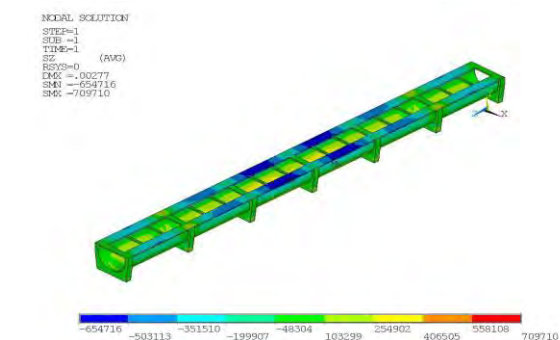Figure 4.   Cloud map of aqueduct's first principal stress under case 2（Pa）

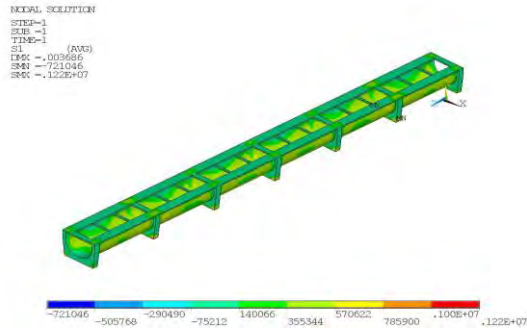Figure 5.   Cloud map of aqueduct's longitudinal stress under case 2（Pa）

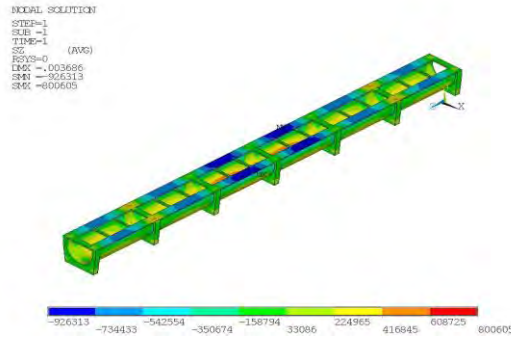Figure 6. Cloud map of aqueduct's first principal stress under case 3（Pa）

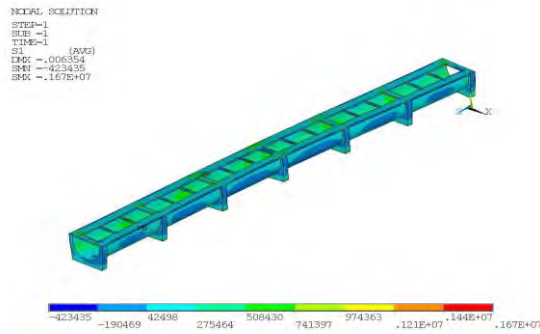Figure 7. Cloud map of aqueduct's longitudinal stress under case 3（Pa）

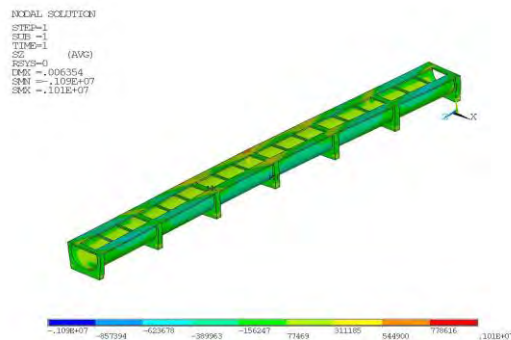Figure 8. Cloud map of aqueduct's first principal stress under case 4（Pa）

Figure 9. Cloud map of aqueduct's longitudinal stress under case 4（Pa）

As can be seen from Fig .2 to Fig .9, in case 1 to case 3, the grooves are completely symmetrical in each stress cloud and YOZ across the plane, which is determined by the geometric symmetry, materials and constraints' consistency.In case 4, the lateral direction loads only cross completely symmetrical. From the case 1 to 3, with increasing water level in each direction tensile, compressive stresses are increased accordingly and a large body of stress affects the water tank load. Case 4, compared with the case 2 ,due to the earthquake in each direction transverse,the maximum tensile stress were significantly increased, indicating that the role of the lateral seismic stress on the body is also a great groove, which is due to too small cross section of the groove body's sake .

B Deformation Analysis

By deformation analysis of the aqueduct,we calculated vertical displacement of each condition maps aqueduct,and the aqueduct vertical displacement cloud shows in Fig .10 to Fig .13.
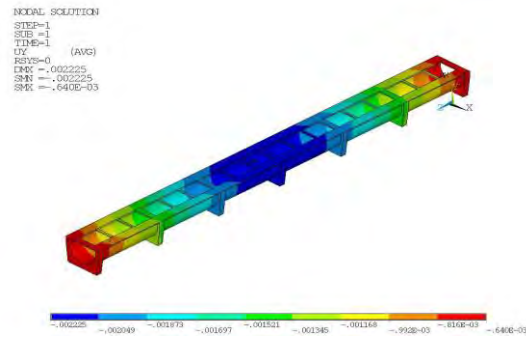

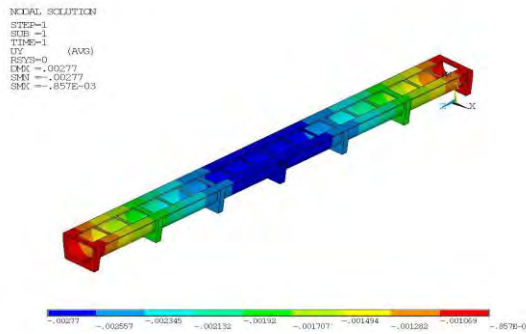Figure 10. Cloud map of aqueduct's vertical displacement under case 1（m）

Figure 11. Cloud map of aqueduct's vertical displacement under case 2（m）

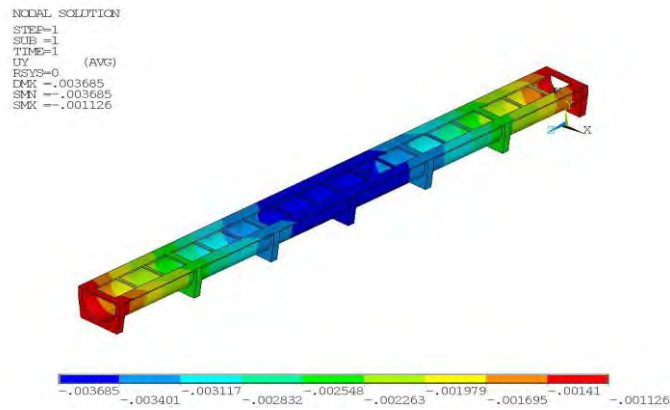
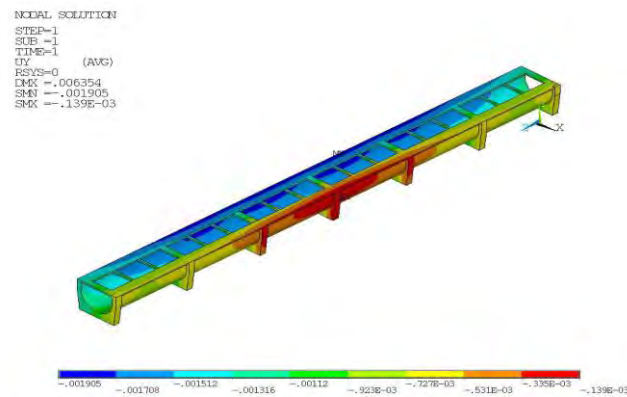Figure 12. Cloud map of aqueduct's vertical displacement under case 3（m）

Figure 13. Cloud map of aqueduct's vertical displacement under case 4（m）

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As can be seen from Fig .10 to Fig .13, case 1 to case 3, with the increase of the water level in each direction corresponding to the displacement is increased, and in vertical displacement on the YOZ cross-symmetrical are of equal size, from the same direction. The maximum vertical displacement at Aqueduct case 1 is 2.23mm and case 2 of maximum vertical displacement of the aqueduct is 2.77mm. Maximum vertical displacement of the working conditions at Aqueduct for 33.69mm, maximum vertical in case 4 under Aqueduct displacement of 1.91mm, both appear in the middle section Aqueduct. Aqueduct ends

of the vertical displacement is small,at the same time vertical displacement values close to zero.

IV. CONCLUDING REMARKS

In summary,the use of the reinforced concrete hyperbolic arch U-shaped section aqueduct in Jinggu river is reasonable.The aqueduct structure forces explicitly, through reinforcement strengthened to meet the strength requirements. Vertical displacement value of the aqueduct is also smaller so that it can live to meet the stiffness requirements.

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