Simulation Analysis of Feisha Reinforced Concrete U-shaped Section Aqueduct

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Abstract—**Feisha aqueduct is located at west main canal of irrigation district in the Xinjin county, Liaoning province, the aqueduct is reinforced concrete rib arch aqueduct, arch centering is variable cross-section reinforced concrete double rib structure, arch axis is parabola, clear span is 33 m, rise-span ratio is 1/3. Aqueduct is a important conveyance structure, this paper uses three dimensional finite element method to simulate and analyse Feisha reinforced concrete U-shaped section aqueduct, and researchs stress and deformation distribution of aqueduct during construction and operation period. Research results show that Feisha reinforced concrete U-shaped section aqueduct structure is reasonable, stressing definite, can satisfy engineering requirement. Feisha aqueduct adopts reinforced concrete rib arch scheme is reasonable. Aqueduct structure is stressing definite, simple, convenient for construction. Vertical displacement of aqueduct structure is small, can meet stiffness requirement.**

Keywords- Reinforced concrete aqueduct; Finite element method; Simulation analysis; Stress distribution; Calculation model.

I. INTRODUCTION

Feisha aqueduct is located at west main canal of irrigation district in the Xinjin county, Liaoning province, design discharge is 6.0 m³/s, longitudinal slope is 1/850, total length is 840 m. This aqueduct is reinforced concrete rib arch aqueduct[1], arch centering is variable cross-section reinforced concrete double rib structure, arch axis is parabola, clear span is 33 m, rise-span ratio is 1/3. Reinforced concrete single bent and aqueduct bracket on the arch, maximum height of bent on the arch is 8.51 m. Aqueduct body is equal span double cantilever wire mesh concrete U-shaped section aqueduct, length of each span is 8.75 m. Concrete strength grade of aqueduct body is C30, concrete strength grade of bent and arch centering is C20, reinforced strength grade is II[2].

II. CALCULATION MODEL

A   Model Parameters.

Concrete strength grade of Feisha aqueduct is C25, elastic modulus of concrete is 28 GPa, poisson's ratio of concrete is 0.167[3-4], bulk density is 24 kN/m³. Concrete strength grade of bent and arch is C20, elastic modulus of concrete is 25.5 GPa, poisson's ratio of concrete is 0.167[5-6], bulk density is 24 kN/m³..

B   Model Element.

Aqueduct structure model adopts SOLID95 element, the element has 20 nodes, each node has three translational degrees of freedom[7]. The element allows irregular shape, and will not reduce calculation accuracy, especially suitable for curve boundary model, at the same time, compatibility of migration shape is good[8-9]. Finite element calculation model of aqueduct structure shows in the Fig .1.
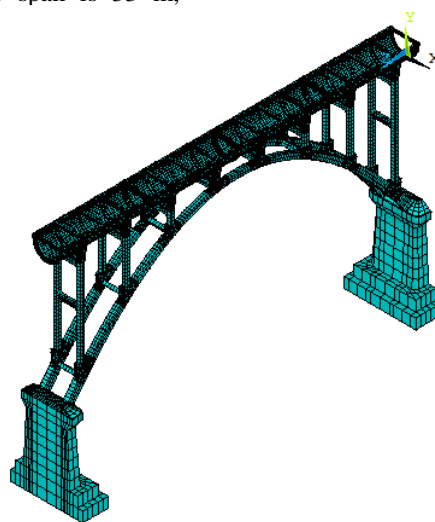

Figure 1. Finite element calculation model of aqueduct structure

Based on mechanical characteristics of aqueduct structure during construction and operation period[10], mainly consider the following 5 kinds of calculation cases: case 1, dead weight; case 2, dead weight and half aqueduct water level; case 3, dead weight and design water level; case 4, dead weight and full aqueduct water level; case 5, dead weight and design water level and seismic action.

III.   STRUCTURE ANALYSIS OF AQUEDUCT

A   Stress Analysis.

Through three-dimensional finite element simulation analysis of reinforced concrete rib arch aqueduct structure, can get stress nephogram of aqueduct structure during construction and operation period, that shows in Fig .2 to Fig .11.
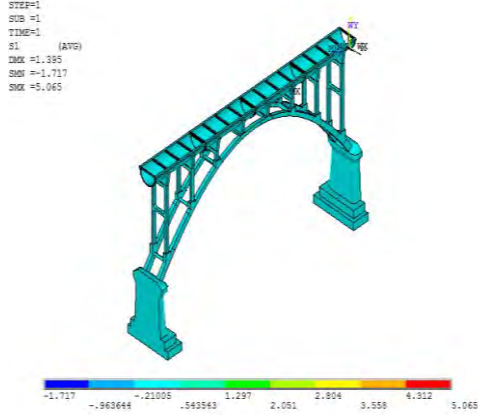
Figure 2. The first principal stress nephogram of aqueduct under case 1 (MPa)
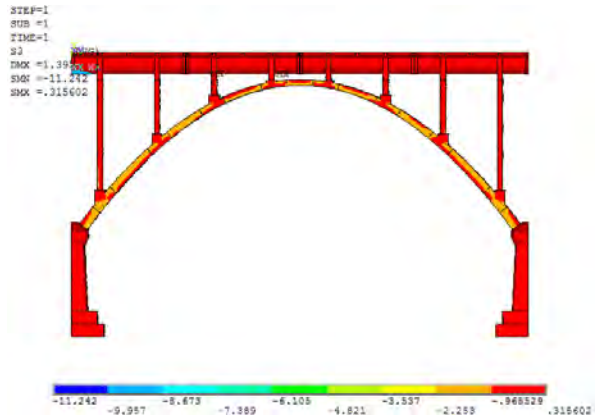

Figure 3. The third principal stress nephogram of aqueduct under case 1 (MPa)
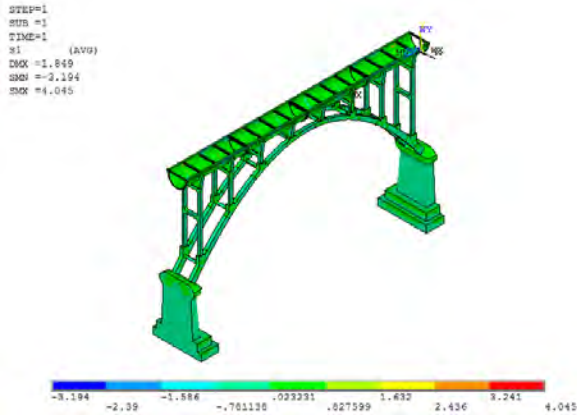

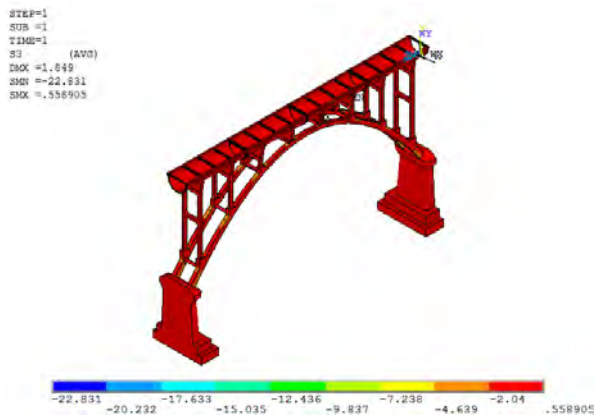Figure 4. The first principal stress nephogram of aqueduct under case 2 (MPa)

Figure 5. The third principal stress nephogram of aqueduct under case 2 (MPa)
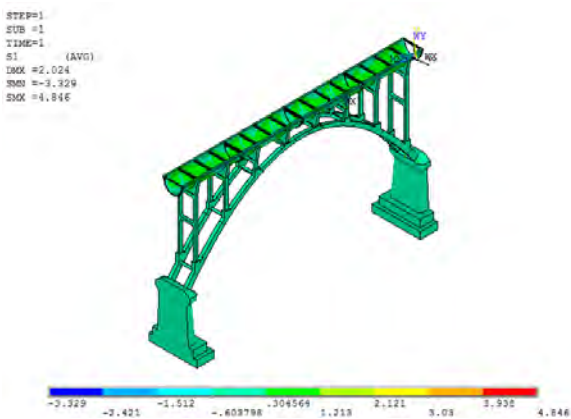

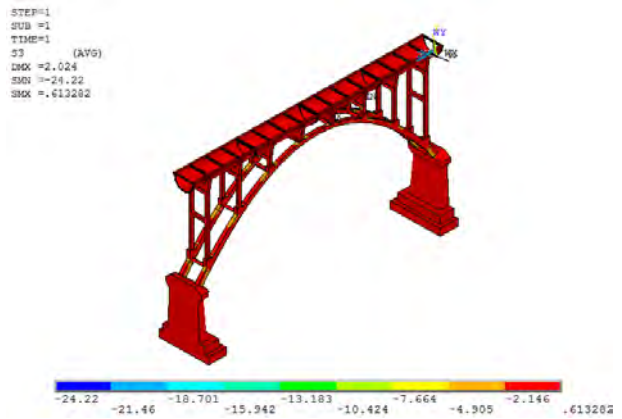Figure 6. The first principal stress nephogram of aqueduct under case 3 (MPa)

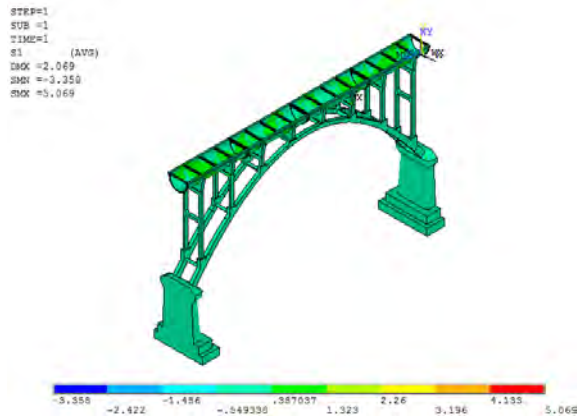Figure 7. The third principal stress nephogram of aqueduct under case 3 (MPa)

Figure 8. The first principal stress nephogram of aqueduct under case 4 (MPa) \
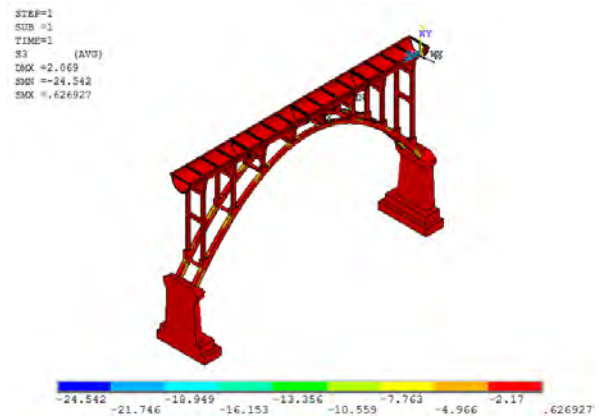

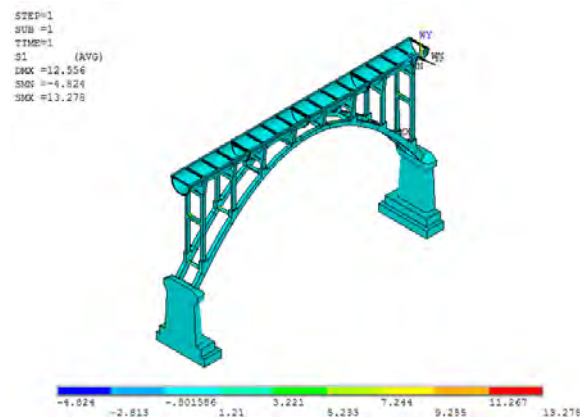Figure 9. The third principal stress nephogram of aqueduct under case 4 (MPa)

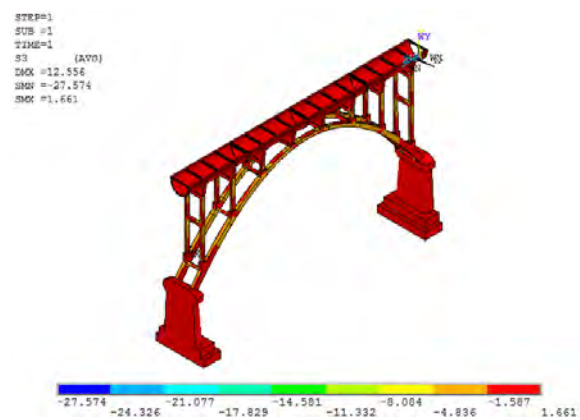Figure 10. The first principal stress nephogram of aqueduct under case 5 (MPa)

Figure 11. The third principal stress nephogram of aqueduct under case 5 (MPa)

As can be seen from Fig .2 to Fig .11, under different cases, the first principal stress of aqueduct gradually increased with the increase of water pressure, maximum stress value of aqueduct mainly appears in the junction of bent and arch, seismic action has large impact on stress. The maximum first principal stress is 13.28 MPa, which appears in the junction of bent and arch under case 5. The maximum third principal stress is -27.57

MPa, which appears in the junction of bent and arch under case 5.

B   Deformation Analysis.

Based on deformation analysis of reinforced concrete rib arch aqueduct structure, can get displacement change rule of aqueduct structure under different cases, total displacement nephogram of aqueduct structure under different cases shows in from Fig .12 to Fig . 15.
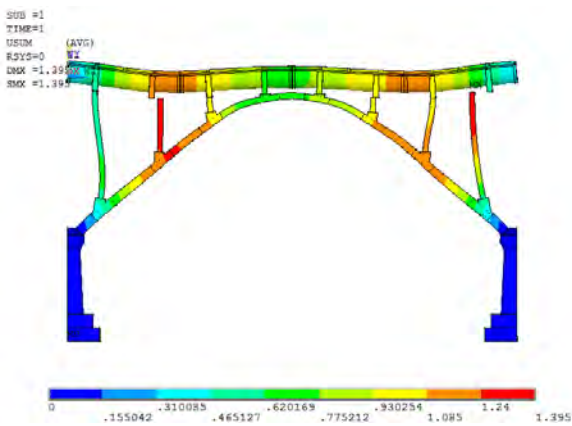

Figure 12. Total displacement nephogram of aqueduct under case 1 (mm)
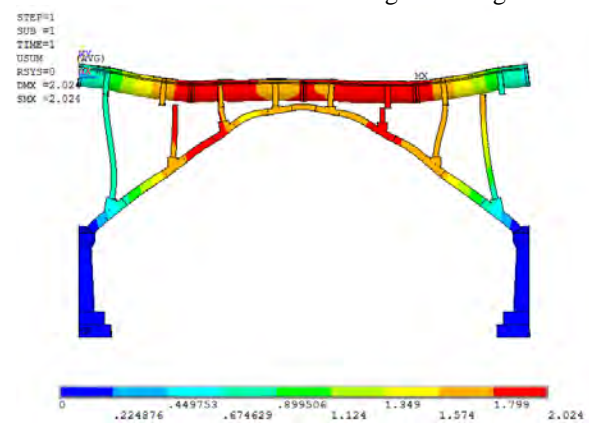

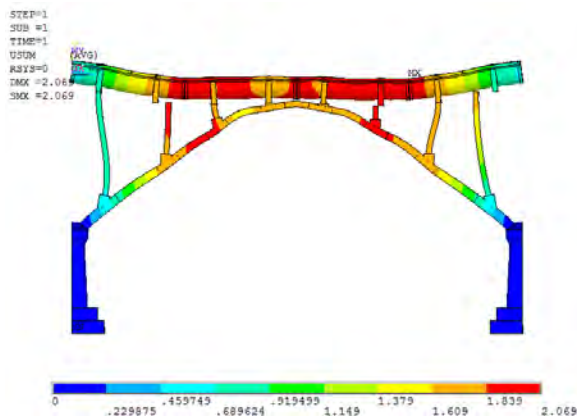Figure 13. Total displacement nephogram of aqueduct under case 3 (mm)

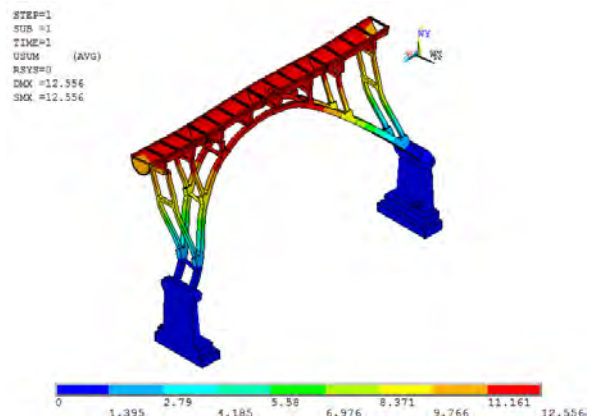Figure 14. Total displacement nephogram of aqueduct under case 4 (mm)

Figure 15. Total displacement nephogram of aqueduct under case 5 (mm)

As can be seen from Fig .12 to Fig .15, total displacement value of aqueduct under different cases is small, water pressure has large impact on total displacement value of aqueduct, seismic action mainly produces horizontal displacement, which lead total displacement values to increase sharply. Under case 1, the maximum total displacement of aqueduct is 1.40 mm, under case 3, the maximum total displacement of aqueduct is 2.02 mm, under case 4, the maximum total displacement of aqueduct is 2.07 mm, under case 5, the maximum total displacement of aqueduct is 12.56 mm.

IV . CONCLUSION

In conclusion, Feisha aqueduct adopts reinforced concrete rib arch scheme is reasonable. Aqueduct structure is stressing definite, simple, convenient for construction. Vertical displacement of aqueduct structure is small, can meet stiffness requirement.

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