

# Finite Element Calculation of Reinforced Concrete Rib Arch Aqueduct

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**Abstract**—Guanping aqueduct is located at main canal of reservoir's irrigation district in the Dayong county, Hunan province, this aqueduct is reinforced concrete rib arch aqueduct, main arch ring is variable cross-section reinforced concrete double rib structure, arch axis is suspension of attachment, reinforced concrete bent supports double cantilever u shaped aqueduct, aqueduct adopts reinforced concrete rib arch structure. Static analysis of aqueduct structure is the foundation of design and construction of aqueduct structure, through static analysis of aqueduct structure, we can get the change law of stress and displacement of the aqueduct structure. The aqueduct structure is thin-walled concrete structure, structural analysis is of great significance to study the safety the aqueduct structure. This paper uses universal finite element software to simulate and analyse Guanping reinforced concrete rib arch aqueduct, and gives stress and deformation distribution of aqueduct during construction and operation period, and researches rationality of aqueduct structure design scheme. Analysis results show that Guanping reinforced concrete rib arch aqueduct structure is reasonable, stressing definite, can meet design requirements.

**Keywords**—Guanping aqueduct; Finite element method; Stress analysis; Stress distribution; Operation period.

## I. INTRODUCTION

Guanping aqueduct is located at main canal of reservoir's irrigation district in the Dayong county, Hunan province, design discharge is  $4.0 \text{ m}^3/\text{s}$ , longitudinal slope is 1/500, total length is 469 m[1]. This aqueduct is reinforced concrete rib arch aqueduct, main arch ring is variable cross-section reinforced concrete double rib structure, arch axis is suspension of

attachment, clear span is 48 m, rise-span ratio is 1/3.2, width-span ratio is 1/20, reinforced concrete bent supports double cantilever u shaped aqueduct, cantilever of both ends is 20 m, length of each span is 20 m, inner diameter of aqueduct is 1.0 m, clear height is 1.6 m, wall thickness is 0.1 m[2]. Aqueduct adopts reinforced concrete rib arch structure, cross section size at the top of the arch rib is  $0.40 \text{ m} \times 0.98 \text{ m}$ . Concrete strength grade of aqueduct body is C30, concrete strength grade of bent and arch rib is C15, reinforced strength grade is II[3].

## II. CALCULATION MODEL

### A Model Parameters.

Concrete strength grade of Guanping aqueduct is C30, elastic modulus of concrete is 30 GPa, poisson's ratio of concrete is 0.167[4], bulk density is  $24 \text{ kN/m}^3$ . Concrete strength grade of bent and arch rib is C15, elastic modulus of concrete is 22 GPa, poisson's ratio of concrete is 0.167[5], bulk density is  $24 \text{ kN/m}^3$ .

### B Element Selection and Model Size.

Aqueduct structure are simulated by using eight node isoparametric brick element[6-7], the element with 8 nodes is used in the 3 d model of the entity structure, have the characteristics of plasticity, creep, expansion, stress stiffening, large deformation, large strain, etc. The element has 8 nodes, each node has three translational degrees of freedom[8-9]. Finite element calculation model of aqueduct structure shows in Fig .1.

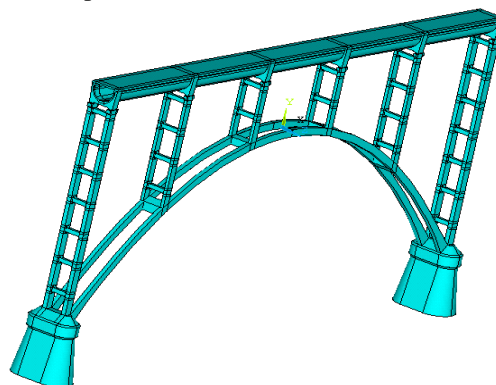


Figure 1. Calculation model of aqueduct structure

### C Calculation Cases.

Based on mechanical characteristics of aqueduct structure during construction and operation period[10],

mainly consider the following 4 kinds of calculation cases: case 1, dead weight; case 2, dead weight and half aqueduct water level; case 3, dead weight and full

aqueduct water level; case 4, dead weight and half aqueduct water level and seismic action.

### III. STRUCTURE ANALYSIS OF AQUEDUCT

Stress Analysis. Longitudinal stress nephogram of aqueduct and bent and arch rib shows in from Fig .2 to Fig .9.

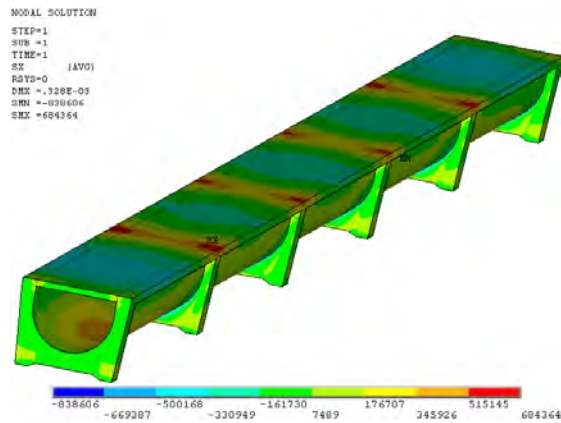


Figure 2. Longitudinal stress nephogram of aqueduct under case 1 (Pa)

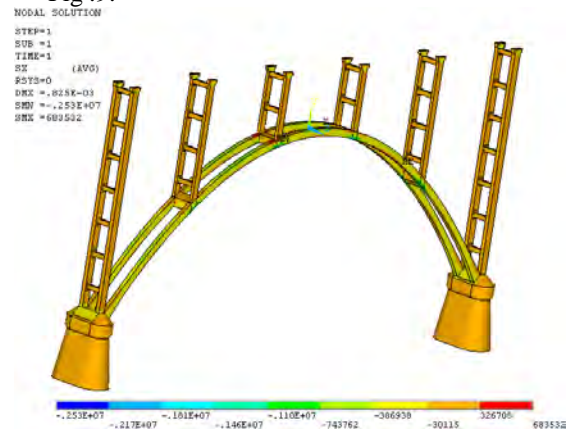


Figure 3. Longitudinal stress nephogram of bent and arch rib under case 1 (Pa)

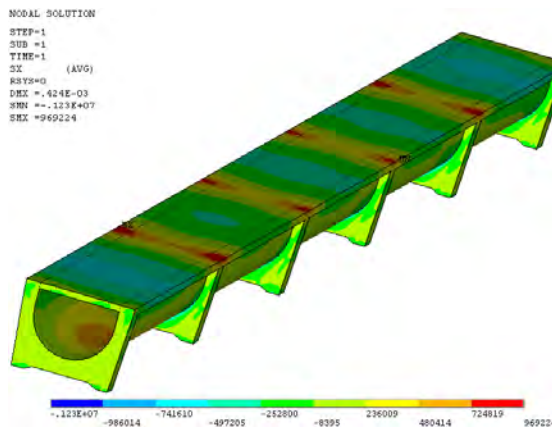


Figure 4. Longitudinal stress nephogram of aqueduct under case 2 (Pa)

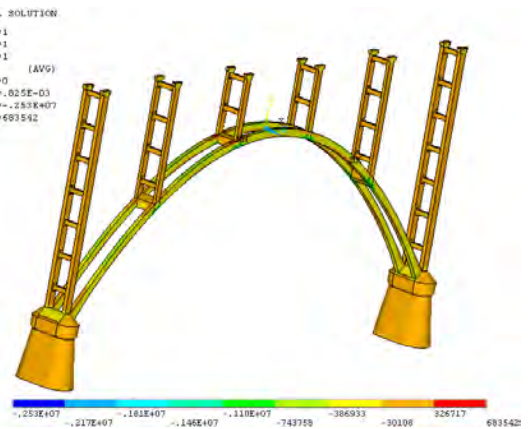


Figure 5. Longitudinal stress nephogram of bent and arch rib under case 2 (Pa)

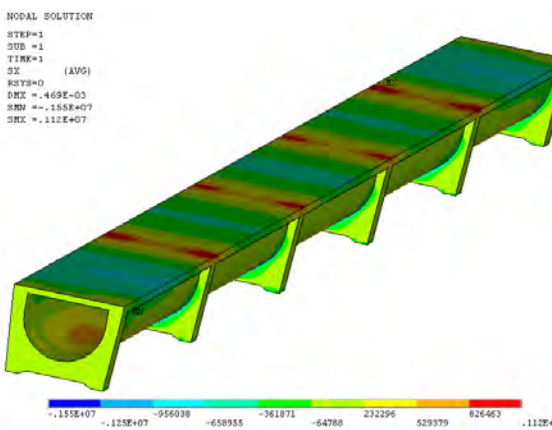


Figure 6. Longitudinal stress nephogram of aqueduct under case 3 (Pa)

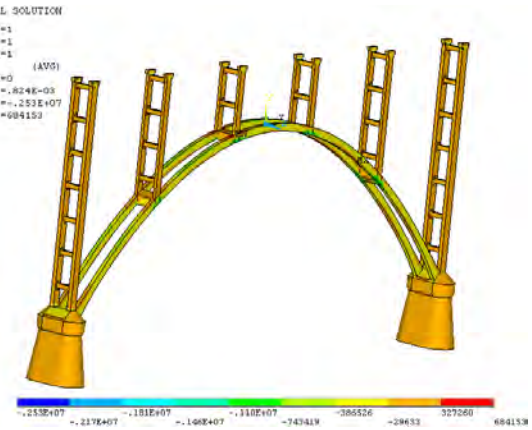


Figure 7. Longitudinal stress nephogram of bent and arch rib under case 3 (Pa)

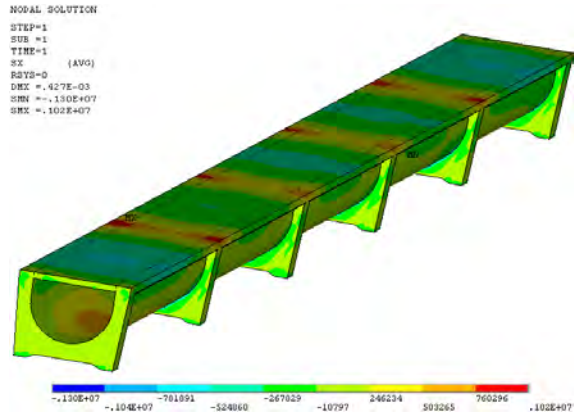


Figure 8. Longitudinal stress nephogram of aqueduct under case 4 (Pa)

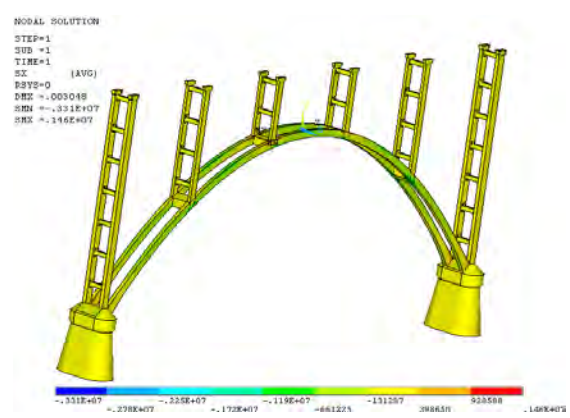


Figure 9. Longitudinal stress nephogram of bent and arch rib under case 4 (Pa)

As can be seen from Fig .2 to Fig .9, under different cases, maximum longitudinal stress of aqueduct mainly appears in the junction of support and aqueduct wall, which is mainly because stress concentration phenomenon. Longitudinal stress value gradually increased with the increase of water pressure, seismic action has small impact on longitudinal stress. Longitudinal stress of bent and arch rib mainly appears in the junction of bent and arch rib, which is mainly because stress concentration phenomenon. Under case 1,

maximum longitudinal stress of aqueduct is 0.68 MPa, under case 2, maximum longitudinal stress of aqueduct is 0.97 MPa, under case 3, maximum longitudinal stress of aqueduct is 1.12 MPa, under case 4, maximum longitudinal stress of aqueduct is 1.02 MPa.

#### A Deformation Analysis.

Vertical displacement nephogram of aqueduct under different cases shows in from Fig .10 to Fig .13.

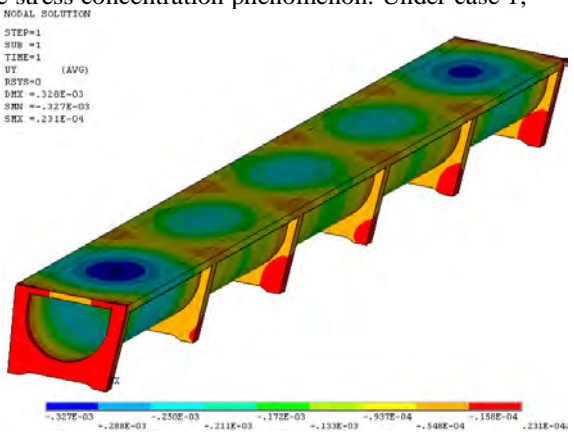


Figure 10. Vertical displacement nephogram of aqueduct under case 1 (m)

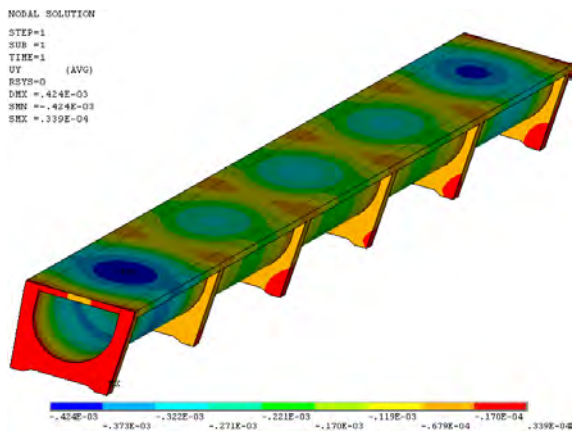


Figure 11. Vertical displacement nephogram of aqueduct under case 2 (m)

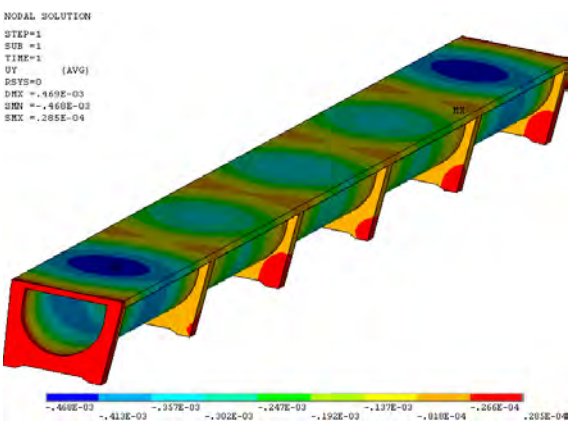


Figure 12. Vertical displacement nephogram of aqueduct under case 3 (m)

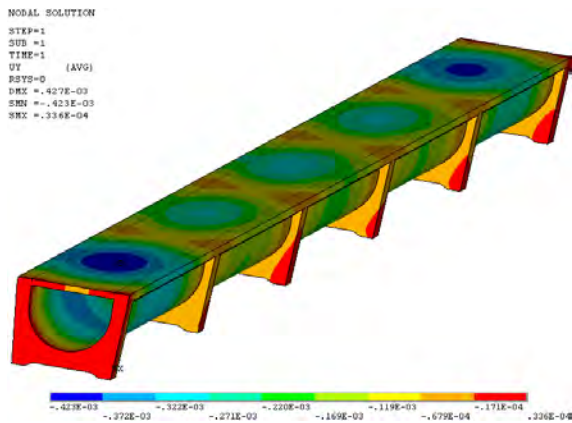


Figure 13. Vertical displacement nephogram of aqueduct under case 4 (m)

As can be seen from Fig .10 to Fig .13, under case 1, vertical displacement of aqueduct is small, maximum vertical displacement occurred in the central of aqueduct's short span. Under case 1, maximum vertical displacement of aqueduct is 0.33 mm, under case 2, maximum vertical displacement of aqueduct is 0.42 mm, under case 3, maximum vertical displacement of aqueduct is 0.47 mm, under case 4, maximum vertical displacement of aqueduct is 0.42 mm. Seismic action has small impact on vertical displacement.

#### IV. CONCLUSION

In conclusion, Guanping aqueduct adopts reinforced concrete rib arch scheme is reasonable. Tensile stress value of aqueduct during operation period is small, can satisfy the strength requirement, the structure is safe and reliable. Its vertical displacement value is small, can meet stiffness requirement.

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