

Finite Element Analysis of Reinforced Concrete Aqueduct During Operation Period

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Abstract—As the south-north water transfer project starts work, construction of aqueduct in China has entered a new period of development. Static analysis of aqueduct structure is the foundation of design and construction, includes the calculation and analysis of stress and strain of aqueduct structure. The stress and strain of aqueduct structure not only are the index of aqueduct structure rigidity, but also are the basis of identifying whether the aqueduct structural damage occur. According to the needs of the actual project, this paper uses large-scale finite element analysis software ANSYS to establish three-dimensional finite element calculation model of aqueduct, and analysis and explain results, and research the changing rule of the stress and strain of aqueduct in different cases. Research results shows that the design of aqueduct is economic and reasonable, can satisfy the strength requirement, its structure is safe and reliable, and can provides certain theoretical basis for design and construction of reinforced concrete aqueduct.

Keywords- Aqueduct; Finite element method; Static analysis; Simulation calculation; Operation period.

I. INTRODUCTION

Aqueduct is overhead conveyance structure that conveying channel flow across canals, roads, valley. Aqueduct in the hydraulic structures is one of the most widely used building interchanges, can deliver water in the distance to town and country that is water shortage for drinking and irrigation. Now many water conservancy projects and water diversion project adopt aqueduct widely, and create many distinctive modern aqueduct[1-3].

II. SUMMARY

Sunjiagou aqueduct is located at southern main canal of Shanchang reservoir irrigation area in Beijing's Miyun county, design discharge is $4.0\text{m}^3/\text{s}$, longitudinal slope is $1/580$, total length is 72m. The aqueduct is simply supported beam aqueduct, aqueduct body is reinforced concrete structure, section of aqueduct body is U-shaped, single span is 6m long, thickness of aqueduct wall is 7cm.

aqueduct body is put on aqueduct bracket which is reinforced concrete structure, and aqueduct bracket is put on reinforced concrete bent or aqueduct piers, maximum height of reinforced concrete bent is 9.6m. Construction of aqueduct body and aqueduct bracket are prefabrication and lifting method, construction of bent and foundation is cast-in-place method, concrete pipe is adopted instead of wood formwork when pouring bent frame column.

III. CALCULATION MODEL

A Model Parameters.

Aqueduct body is 4-span simply supported beam structure, reinforced concrete structures, single span of which is 6m long. The concrete strength grade for aqueduct body of Sunjiagou aqueduct is C40, density is 2500kg/m^3 , elastic modulus of concrete is 43.5GPa, poisson's ratio of concrete is 0.2[4-5].

B Element Selection.

Static analysis of Sunjiagou aqueduct adopts the finite element method, aqueduct body is simulated by using eight node isoparametric brick element[6-8], the element with 8 nodes is used in the 3 d model of the entity structure, each node of which has three translational degrees of freedom, and have the characteristics of plasticity, creep, expansion, stress stiffening, large deformation, large strain, etc[9].

Finite Element Model. This paper adopts the universal finite element calculating software ANSYS to establish finite element calculation model[10], single span aqueduct structure as the research object, finite element calculation model based on aqueduct design drawings, Y direction is aqueduct height direction, Z direction is aqueduct longitudinal direction, X direction is aqueduct transverse direction, finite element calculation model of Sunjiagou aqueduct shows in the Fig.1.

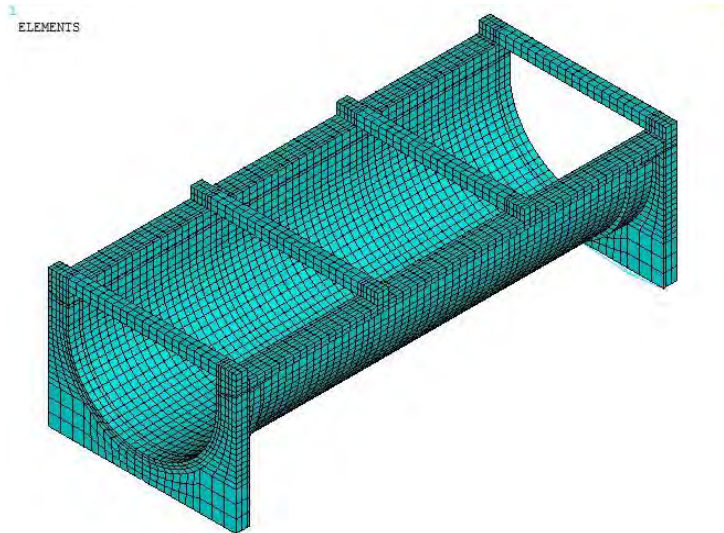


Figure 1. Finite element calculation model of Sunjiagou aqueduct

IV. ANALYSIS OF CALCULATION RESULTS

The calculation consider the following six conditions: the condition 1, aqueduct without water; the condition 2, 3/10 aqueduct water depth (0.41m); the

condition 3, 1/2 aqueduct water depth (0.69m); the condition 4, 7/10 aqueduct water depth (0.96m); the condition 5, design aqueduct water depth (1.30m); the condition 6, full aqueduct water depth (1.37m).

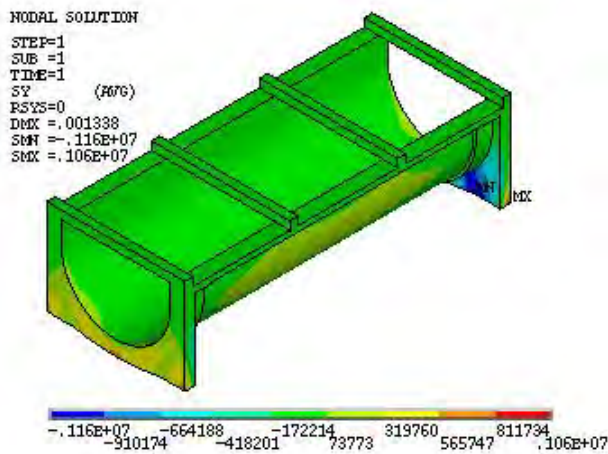


Figure 2. Vertical stress map under case 1

Under case 1, maximum tensile stress of aqueduct in the vertical direction is about 1.06 MPa, can meet the design requirements, stress of aqueduct body is compressive stress basically, stress of aqueduct bracket is

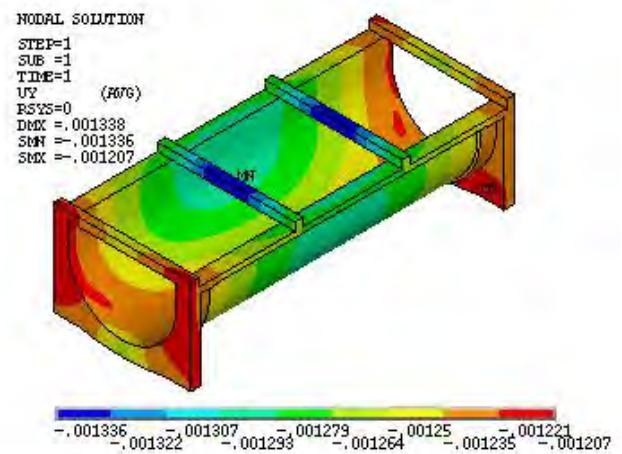


Figure 3. Vertical displacement map under case 1

uniform tensile stress. Displacement of aqueduct in the vertical direction is small, displacement distribution of aqueduct body is complex, maximal displacement occurred in the middle of the tie rod, about 1.3×10^{-4} m.

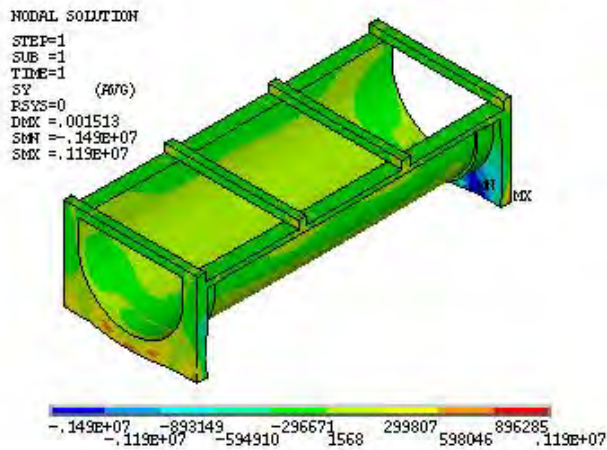


Figure 4. Vertical stress map under case 2

Under case 2, maximum tensile stress of aqueduct in the vertical direction is about 1.19 MPa, can meet the design requirements, stress of aqueduct body at the bottom and top is zero, stress of aqueduct body on the other parts is uniform tensile stress, stress of aqueduct bracket is

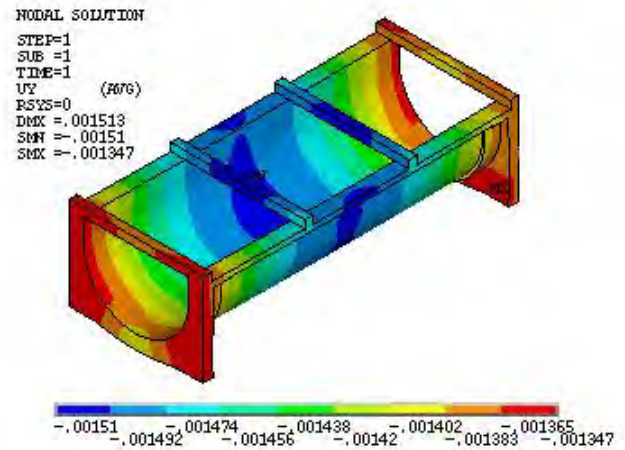


Figure 5. Vertical displacement map under case 2

uniform tensile stress. Displacement of aqueduct in the vertical direction is small, displacement distribution of aqueduct body is complex and increases from both ends to the middle, maximal displacement occurred in the middle of the tie rod, about 1.51×10^{-4} m.

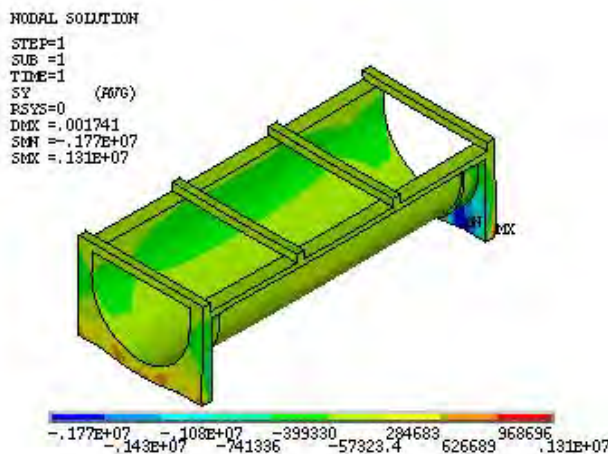


Figure 6. Vertical stress map under case 3

Under case 3, maximum tensile stress of aqueduct in the vertical direction is about 1.31 MPa, can meet the design requirements, stress of aqueduct body at the bottom and top is zero, stress of aqueduct body on the other parts is uniform tensile stress, stress of aqueduct bracket is

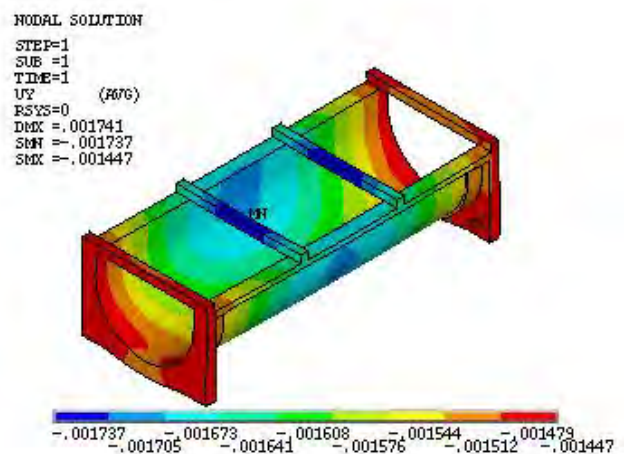


Figure 7. Vertical displacement map under case 3

uniform tensile stress. Displacement of aqueduct in the vertical direction is small, displacement distribution of aqueduct body is complex and increases from both ends to the middle, maximal displacement occurred in the middle of the tie rod, about 1.51×10^{-4} m.

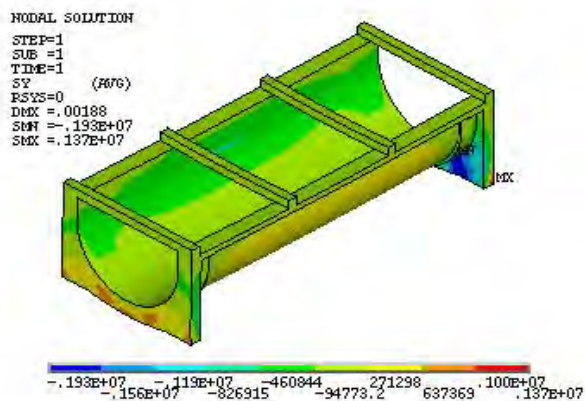


Figure 8. Vertical stress map under case 4

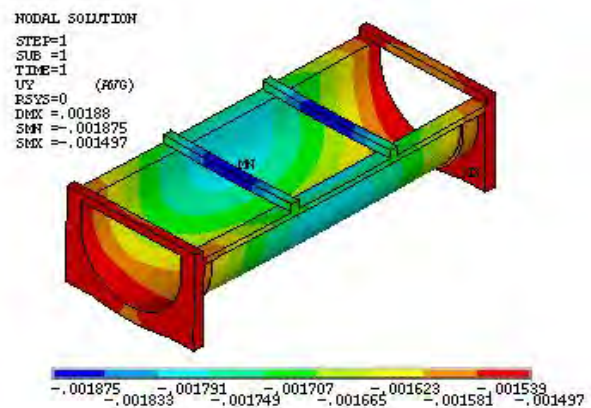


Figure 9. Vertical displacement map under case 4

Under case 4, maximum tensile stress of aqueduct in the vertical direction is about 1.37 MPa, can meet the design requirements, stress of aqueduct body at the bottom and top is zero, stress of aqueduct body on the other parts is uniform tensile stress, stress of aqueduct bracket is uniform tensile stress. Displacement of aqueduct in the vertical direction is small, displacement distribution of aqueduct body is complex and increases from both ends to the middle, maximal displacement occurred in the middle of the tie rod, about 1.87×10^{-4} m.

IV. CONCLUSION

In conclusion, vertical stress value and vertical displacement value of Sunjiagou aqueduct during operating period is small. Along with the depth deepening, displacement and stress increase gradually, displacement and stress in the middle of aqueduct body is maximum. The design of aqueduct is economic and reasonable, can satisfy the strength requirement, its structure is safe and reliable.

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