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Simulation and Analysis of Hydraulic and Structural Design of Aqueduct under Static Loading

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Abstract

A living testament to the treatment of the Mediterranean region from ancient times are the historical fossils of the Roman aqueduct. Hippocrates, the founder of Greek medicine, is said to have related good water quality to health a few centuries earlier with the development of the first water filtration device, a fabric made of cloth (Sklivaniotis and Angelakis, 2006). Today, water in the Mediterranean region appears to be at the center of development problems. Water is considered a similar problem in an area where distinct borders intersect - politically, socially, culturally and economically. This has facilitated the development of advanced technical skills, but in order to counter the general future of diminishing water supply, they are not always accompanied by the right consumer practices. The area can be characterized by various climatic conditions, each influenced by rainfall variability. In comparison to the arid regions in Spain and on the eastern and southern coasts of the Mediterranean Sea, there are waterfalls in Northern Italy, southern France, the coast of the Balkans and selected areas in Turkey. The strain on water supplies in the Mediterranean region is rising in terms of geomorphology, climate and population density. The water level and the scale of the Mediterranean area should be treated equally. An aqueduct system is initially constructed manually based on certain input parameters. The hydraulic properties and strengthening measurements of the aqueduct system are measured in this manual design. The unsustainable use of groundwater, which is the key source of water for domestic and agricultural purposes in the area, has led to the depletion of water tables, the removal of wetlands and the infiltration of coastal marine waters. The reinforcement measurement on the wall, beam as well as on software is measured manually. In both cases, the necessary reinforcement is identical. Often, it defines the trough wall and slab thickness. The displacement without a tie beam in the aqueduct is almost 7 times the tie beam subjected to static load. Compared to Static Load, deflection and stresses in the system due to dynamic forces are more pronounced. Owing to hydrodynamic forces, deflection and stresses applied to the joints are roughly 2.4 times and 3.8 times greater due to hydrostatic loads, respectively. The deflections in the center are very wide and the stresses at the end of the structure are strong.

Keywords: Area, Politically, Socially, Culturally And Economically.

Introduction

The historical fossils of the Roman aqueduct are a living testimony to the care of the Mediterranean region from ancient times. A few centuries earlier, Hippocrates, the father of Greek medicine, is said to have linked the good quality of water to health with the construction of the first water filtration system, a fabric made of cloth (Sklivaniotis and Angelakis, 2006). Nowadays, water continues to be at the heart of development problems in the Mediterranean region. In a region where different boundaries meet - politically, socially, culturally and economically - water is considered a similar challenge. This has encouraged the development of advanced technological skills, however, they are not always supported by the right consumer practices to address the general future of declining water availability. The region (Figure 1) can be characterized by different climatic conditions, each affected by the variability of rainfall. There are waterfalls in Northern Italy, southern France, the coast of the Balkans, and selected areas in Turkey as opposed to arid regions in Spain and on the eastern and southern shores of the Mediterranean Sea. Geomorphologic, climate, and population density that pressure on water sources in the Mediterranean region is increasing. The water level and size of the Mediterranean region should be considered equally. Excessive use of groundwater, a major source of water for domestic and agricultural purposes in the region, has led to the depletion of water tables, the removal of wetlands and the infiltration of seawater into coastal waters. The situation is likely to be tense. Indeed, temperatures in the Mediterranean region have experienced an increase of about 2 ° C since 1900 and the Intergovernmental Panel on Climate Change (IPCC) estimates that the region will be more affected by extreme climate change (Falloon and Betts, 2010 ; IPCC, 2007; Calbo, 2010; García-Ruiz et al., 2011).

Fig. 1 Examples of Roman aqueducts (a) The Gorze Canal near Metz, France. (b) Nemausus canal above Pont du Gardbridge. (c) The canal of the Gier River near Chaponost, France, provided the Roman city of Lugdunum (Lyon, France). Color type is available in the Appendix. (d) Pena Cortada canal near Chelva, Spain. Color type is available in the Appendix. (Source:L. W. Mays)

Literature Review

WANG Bo, XU Jian-guo (2000) In this paper, depending on the feature of the aqueduct structure with a base layer, a lighted spring model is used to mimic soil interactions. The Shell-beam Element model has been used to mimic a water body, which looks at the structural features of the folding curve, preventing the distortion of the body of the open-shell canal

BAI Xin-li, HUANG He-fa, LIU Yan-ling, ZHAO Xin-ming (2001) The continuous U-type water channel is analyzed with the popular nonlinear F.E. ADINA. Standing analysis results are listed and defined waves and modeshapesThe results show that the moment of bending down removes the pressure down the continuous channel, and that the maximum pressure, maximum pressure and total displacement are all below the design value. Finally, conclusions and suggestions are given in the original construction.

Menglin Lou, Danguan Pan (2002) According to the theory of possible flow and vibration of the structure, the 'water' (water) wave test formulas and beam-supported canal mode conditions are obtained by simplified fluid analysis.

XU Jian-guo, WANG Bo (2002) to analyze the structural properties of the aqueduct and provide strong support for engineering projects. Drainage canal is analyzed and calculated by the strong response of one of the canals to schemes to divert water from the south to the north by an earthquake.

Wenyi Chen and Hong Hao (2004) discusses that almost every year in southern China the Yangtze River floodplain, while at the same time water allocation policy has to be applied in northern China due to the drought.

Methodology

Manually and modeling methodology

Initially, an aqueduct structure based on certain input parameter is designed manually. This manual design is performed to calculate the hydraulic properties and reinforcement calculation of aqueduct structure. Following are the initial parameters:

S.No.	Item	Value	Unit
1.	Full Supply Discharge	0.9825	cumecs
2	Full Supply Level	560.259	m
3.	Canal Bed Level	559.499	m
4	Canal Water Depth (D)	0.76	m
5	Canal Bed Width (B)	0.80	m
6	Rugositycoff for concrete (n)	0.016	
7	side slope	1.5	
8	bed slope	1800	
9	free board	0.4	

Ater, manual design of aqueduct the structure is imported in STAAD Pro for the analysis. In the software the aqueduct is designed with and without tie beam. Deflection, shear stress and normal stress of aqueduct structure is determined through the software and comparison on these properties with and without tie beam is also presented.

After static analysis, the aqueduct structure is designed for the seismic loading. Seismic response analysis of a proposed aqueduct in the middle route crossing a seismic zone will be performed. Particular effort is devoted to find a suitable numerical model that can accurately represent the proposed aqueduct design, water-structure interaction, and the effects of bearing properties of the aqueduct supports on its responses to seismic ground excitation. Numerical model is validated by comparing the simulated results with independently obtained test results. Spatially varying seismic ground motions are stochastically simulated and used as input in the analysis. It is found that using isolated bearing in the design can significantly reduce the aqueduct responses, as compared to the hinge support design option. However, the lateral stiffness of the bearing should be properly designed to avoid resonance between the aqueduct and water mass in the aqueduct.

Result and Discussion

Manual Design of Aqueduct

Aqueduct Trough Design

S.No.	Data	Value	Unit
1.	Discharge	.9825	Cumec
2.	Bed Width	.80	m
3.	Water Side Slope	1.5:1	m
4.	F.S.D.	.76	m
5	Free Board	.40	m
6	Bed Slope	1 in 1800	
7	C.B.L.	559.499	m
8	F.S.L.	560.26	m
9	M.W.D.	1.16	m
10	Span	10.00	m
11	Concrete	M-20	
12	Steel	150	
13	Water	9800	Kg/m^3
14	Reinforcement (in wall)	10mm-90 mm spacing	
15	Reinforcement (in wall Beam)	16 mm-110 mm spacing	
16	Distribution (in wall Beam)	twolgd. Strrirps 8mm-300 mm spacing	
17	Trough Wall thickness	270 mm	
18	Trough Slab thickness	300 mm	

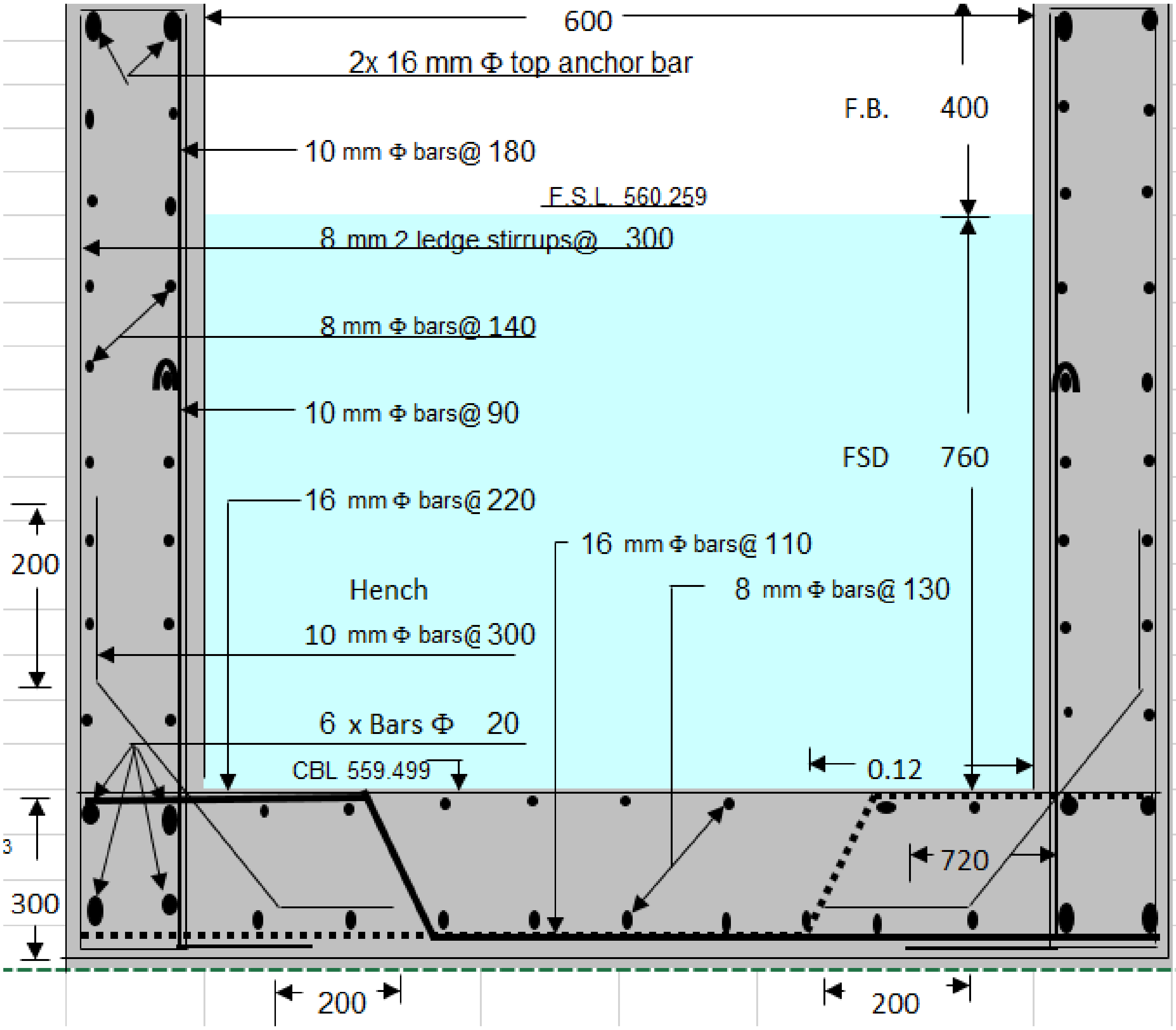


Fig. 2: Reinforcement detailing of aqueduct

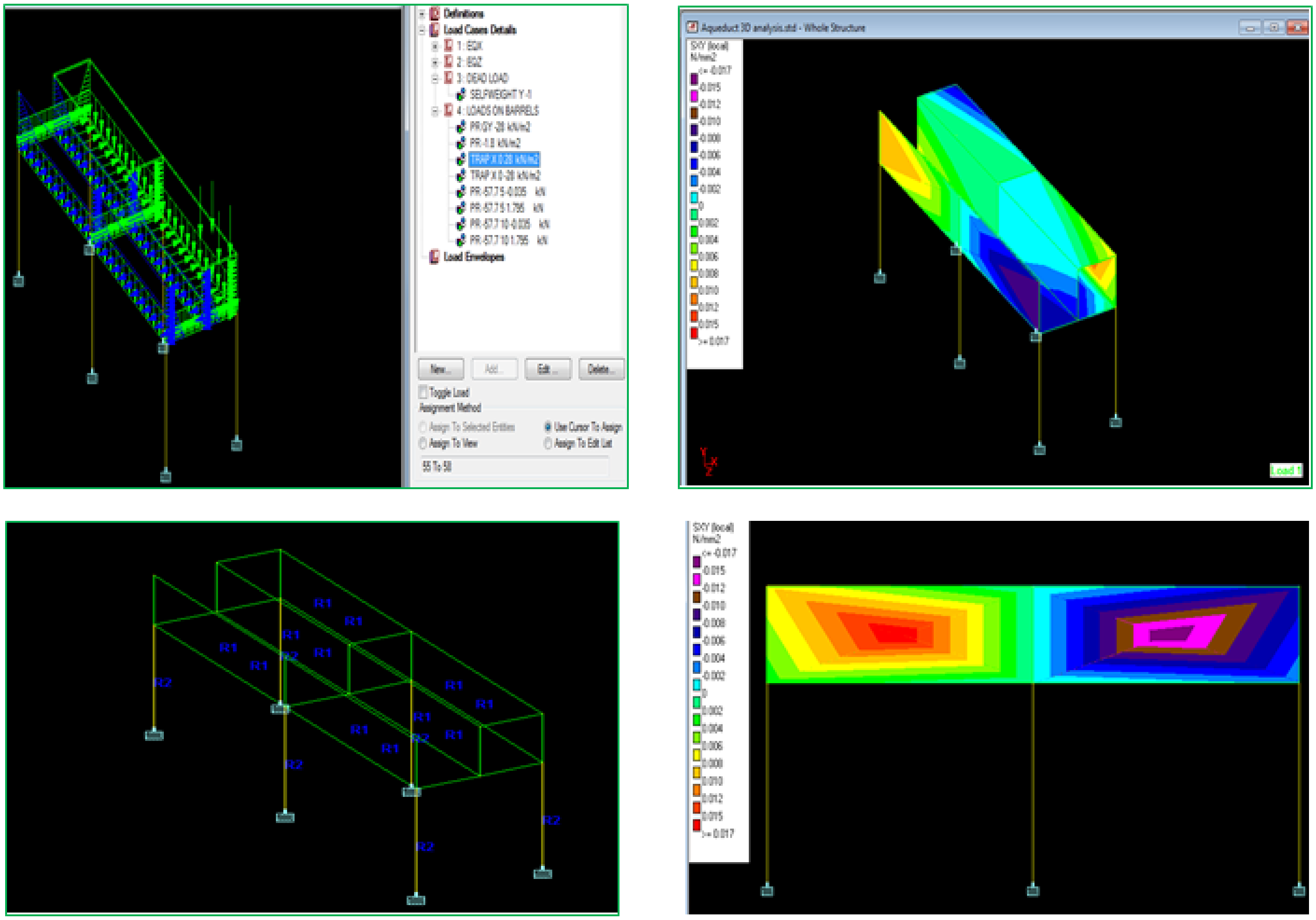
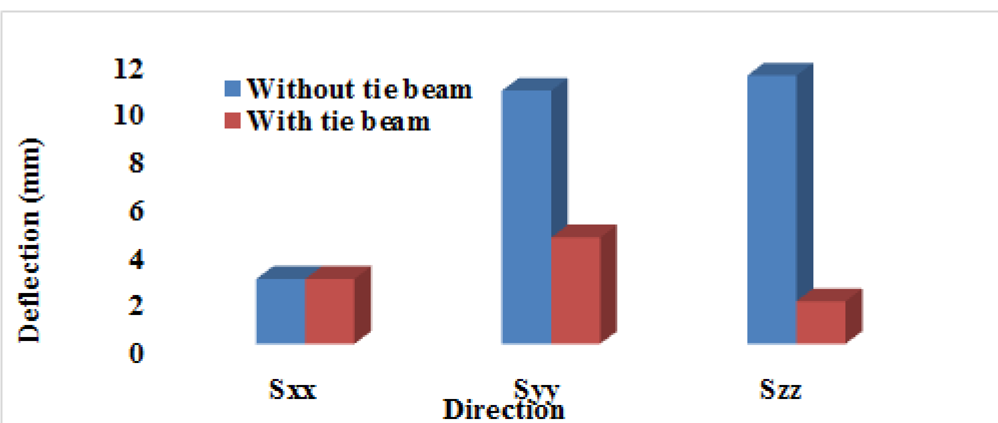
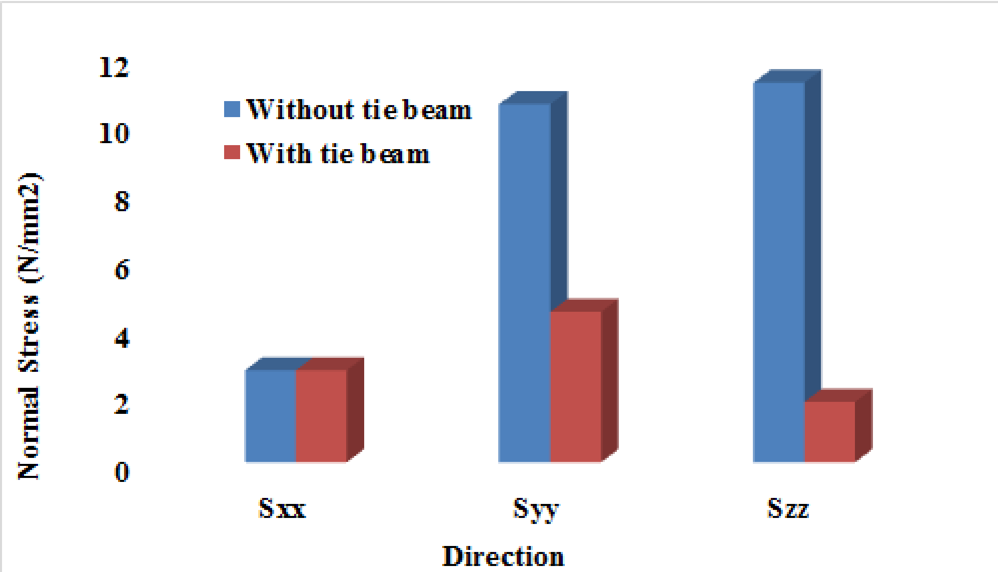


Fig.3: Structural modeling of aqueduct structure

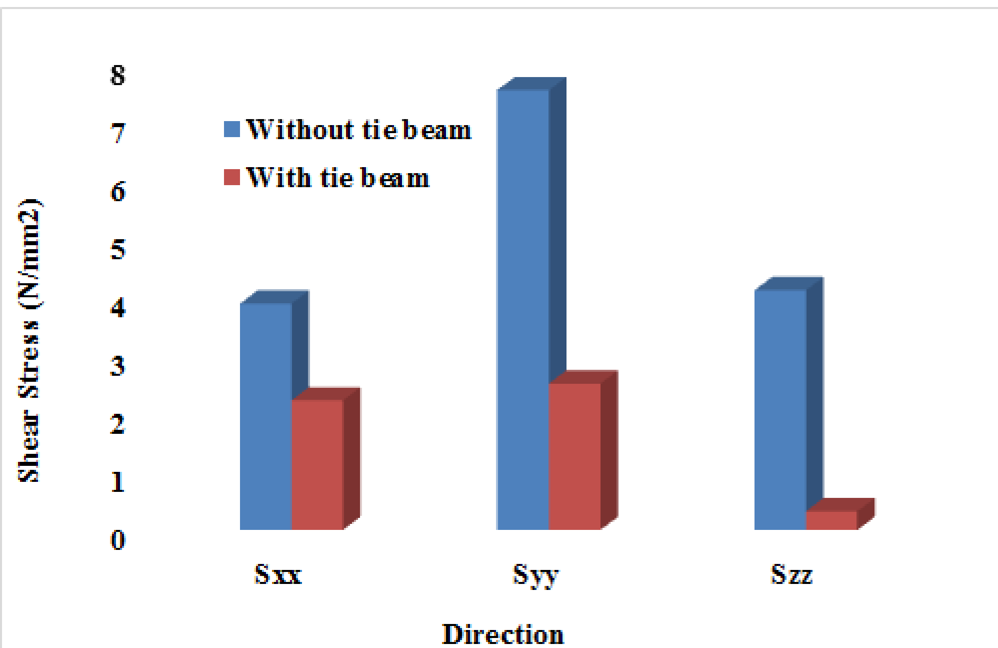
Comparison on deflection of aqueduct with and without tie beam



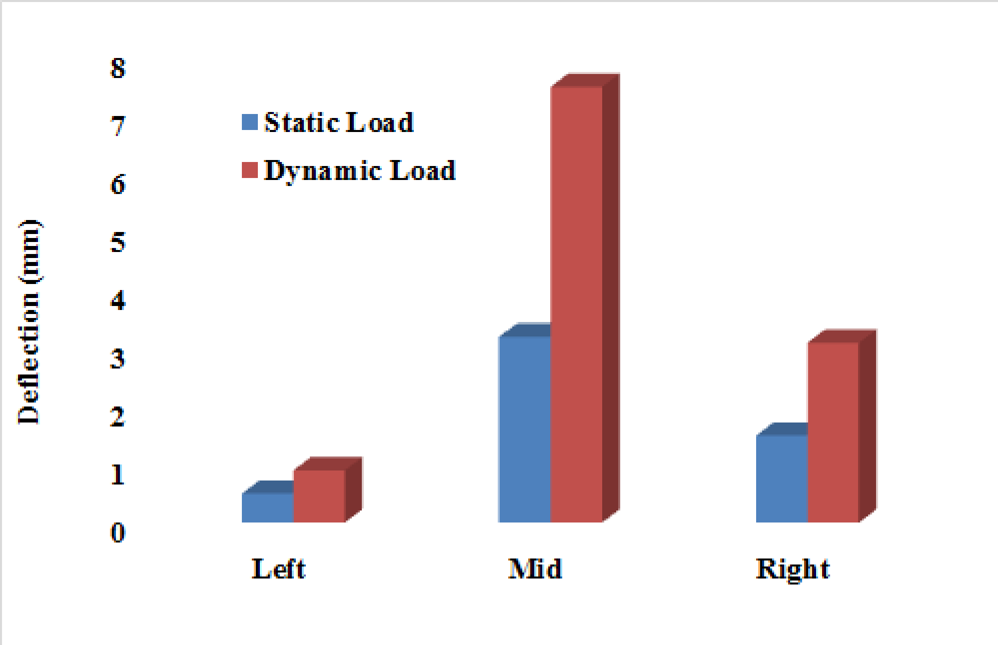
Comparison on normal stresses of aqueduct with and without tie beam



Comparison on shear stresses of aqueduct with and without tie beam



Comparison on deflections due to static and dynamic load



Conclusion

Following important conclusions that are drawn from the analysis:

1. The reinforcement calculation on wall, beam is calculated manually as well as on software. The required reinforcement is similar in both the cases. Also, the trough wall and slab thickness is determined.
2. The displacement in the aqueduct without tie beam is almost 7 times the tie beam subjected to static load.
3. Deflection and stresses in the structure due to dynamic forces are more pronounced compared to Static Load. Deflection and stresses applied to the joints due to hydrodynamic forces are approximately 2.4 times and 3.8 times higher due to hydrostatic loads respectively. The deflections very large in the middle and the stresses are high at the end of the structure.

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