Capacity Improvement of Spillway using Arc Shaped Control Structure, Results of a Case Study

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Abstract

For spillway design, engineers always look for optimizing tools to enhance both economical and technical characteristics of the projects. To come with this aim, capacity-increasing using arced shape control structure is an efficient and possible way. This idea can lead to lower level of reservoir water level for a given spillway dimension, or smaller dimension of spillway for a given flood, both are economically interested. A brief description of a case study including physical and numerical modeling resultswill be presented along with the saved volumes.

Key words: Spillway, arced shape control structure, physical model, 3D numerical model.

1. INTRODUCTION

Sardashtstoragedam is located on Kelas river in west of Iran. This dam is constructed mainly on purpose of supplyingof hydroelectric energy.

In detailed design phase of the project, the spillway width and the dam crest elevation were determined as 21 m and 1043 m a.s.lrespectively. The spillway drawings were prepared and excavation activities has been terminated based on the foresaid figures. During the complementary studies, normal water level of the reservoir has been increased by 3 m. Also, the power plant capacity was modified and in result of revision on amount of inflowfloods, the spillway width was increased to 30 m. To prevent from any modification in excavations, an arced spillway with 30 m width was deployed instead of the primary design.

This paper aimed to represent a brief report from the related studies and investigation results of the spillway performance, which was implemented by mathematical and physical models.

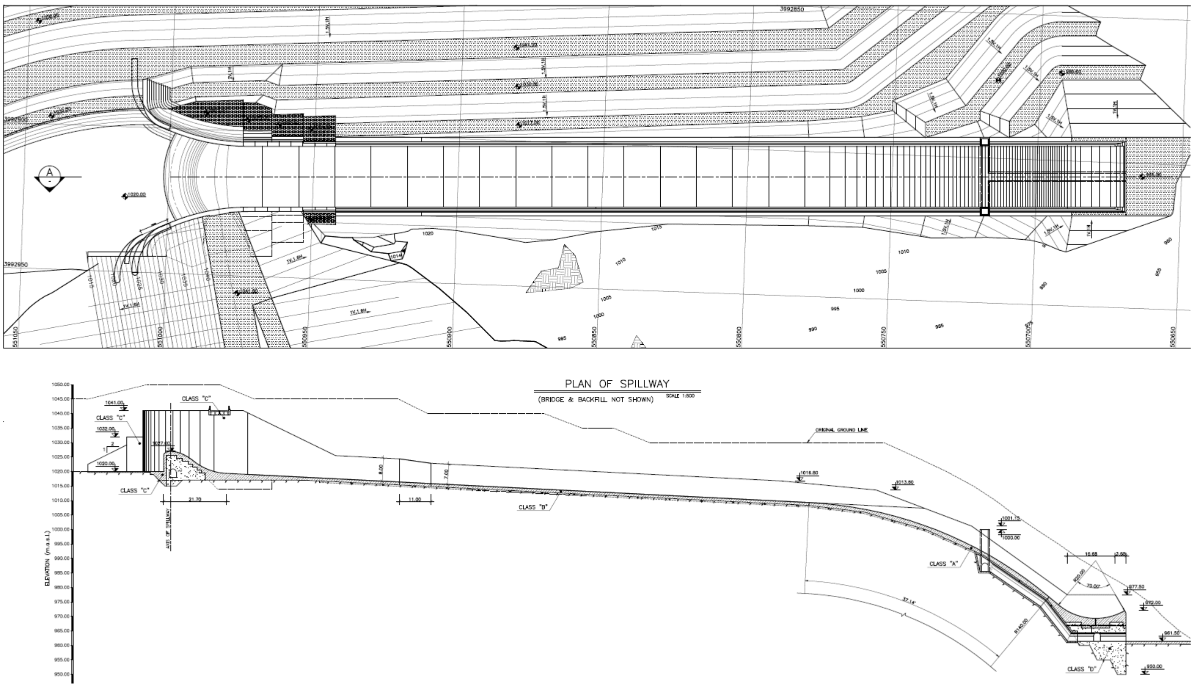

Figure 1: Plan and longitudinal profile of Sardashtspillway

2. MATHEMATICAL MODELING

Numerical modeling of the spillway is implemented considering the symmetric geometry of it as depicted in figure 2. A part of the reservoir and the chute system is considered in modeling procedure intentionally to capture guiding walls effect. The applied boundary conditionsarerepresented in figure 3.

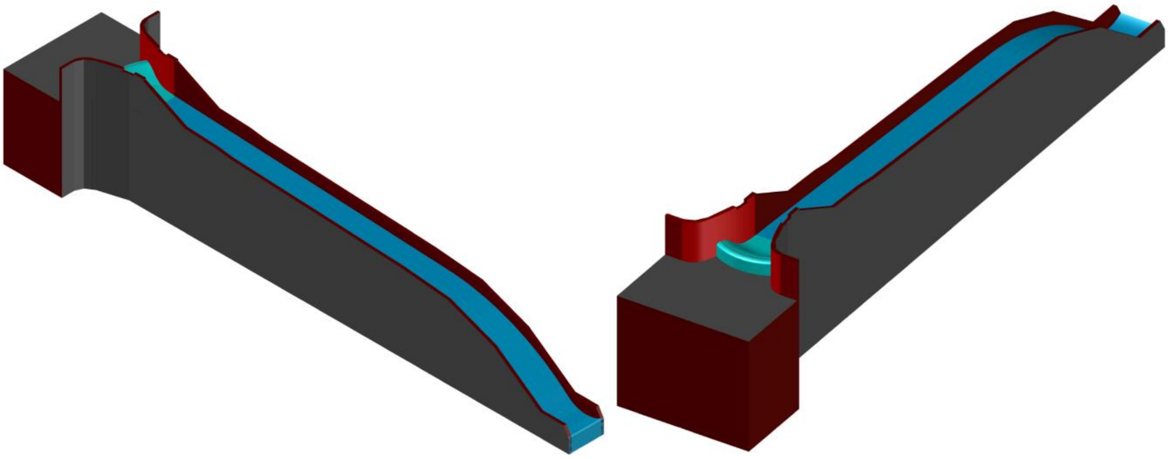

Figure 2: Numerical 3D model geometry for Sardasht dam

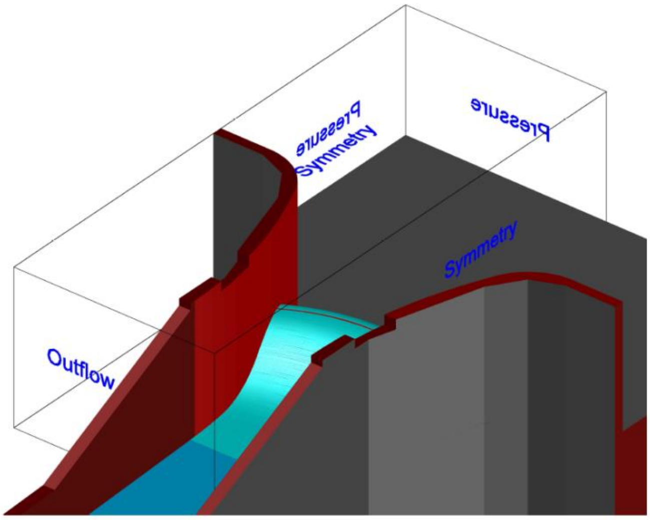

Figure 3: Applied boundary condition on numerical model, P: pressure border by determined flow depth, S: symmetric border, O: border of flow outlet

3. CALIBRATION AND VERIFICATION OF THE MATHEMATICAL MODEL

To verify the numerical model results, the standard USBR spillway model was established with 21 m width with the normal straight spillway chute and the obtained discharge results were compared by theoretical relations output, as illustrated in figure 4.

The calculation domain includes a single mesh block withcell dimension of 0.25 m, after several sensitivity analysis manipulation. The LES model is applied in calculations as turbulence model.

Figure 4shows good agreement between numerical and theoretical results.

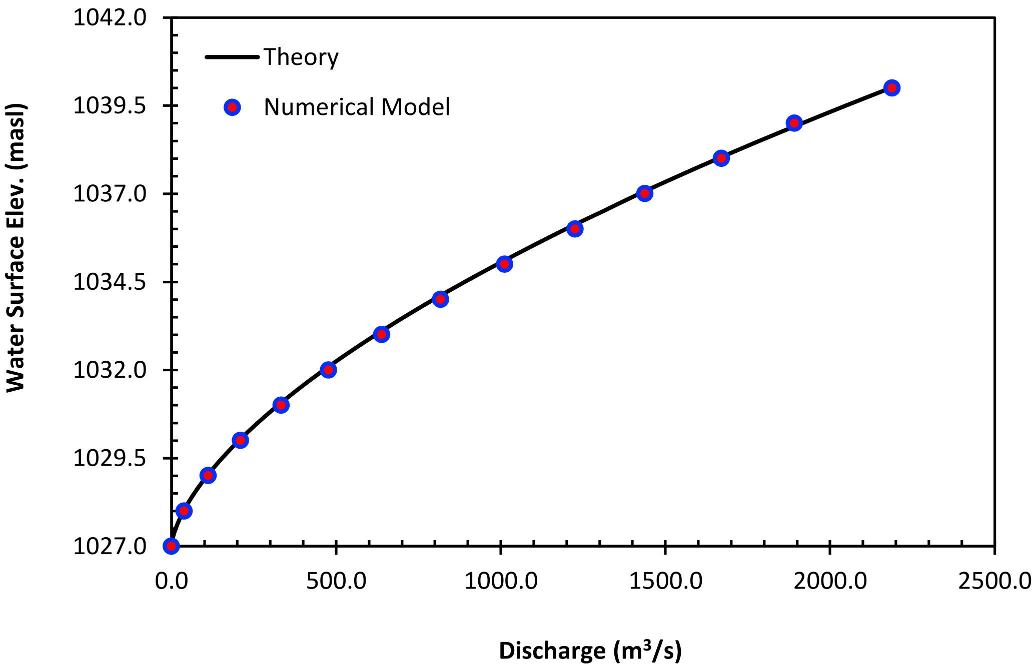

Figure 4: Discharge results in 3D numerical model and theoretical calculation

4. ARCED CONTROL SECTION SPILLWAY MODELING

According to obtained reliable results from established model for straight spillway section, the initial and boundary conditions similar to the mentioned model are applied on 3D model of arced spillway, as shown in figure 5. It should be mentioned that analogous calculation network specifications are used in both models. The spillway capacity results obtained by numerical model and correspondent physical model are represented and compared in the next section.

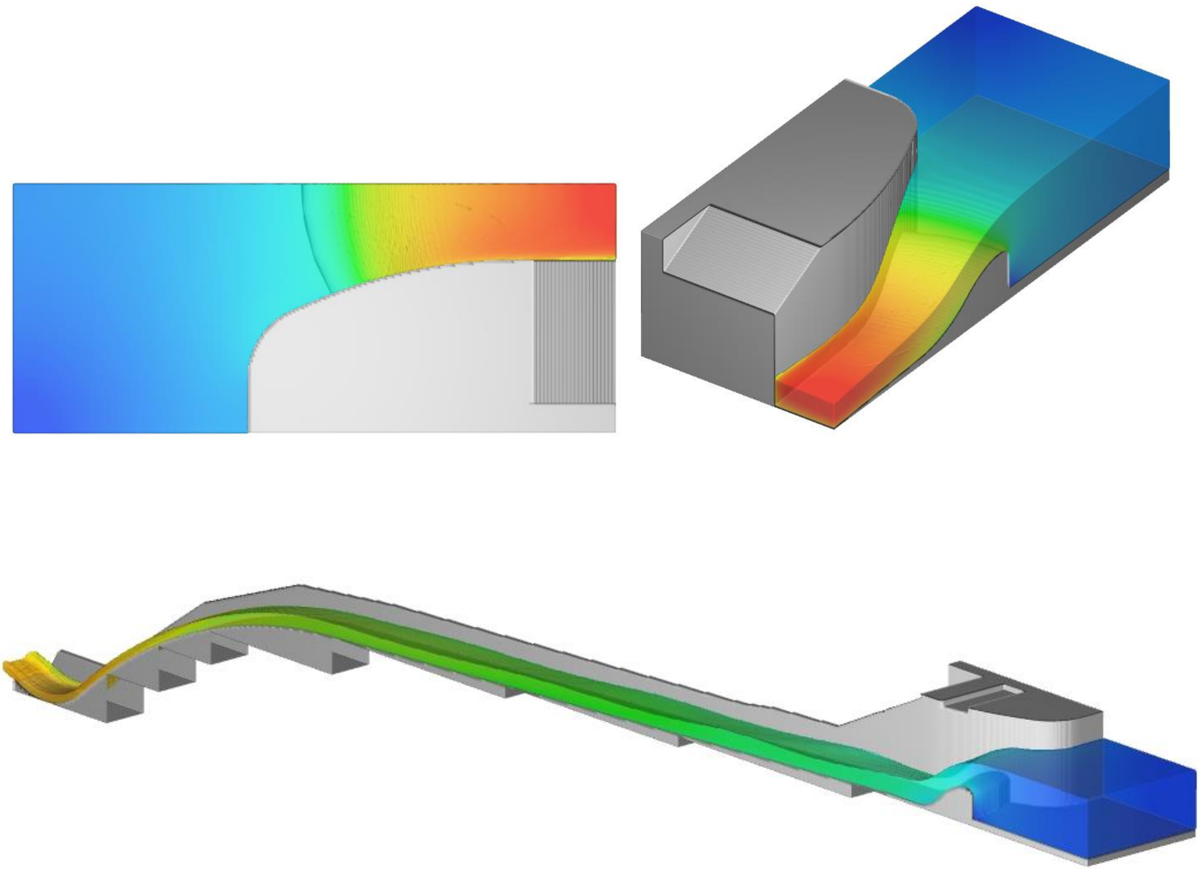

Figure 5: 3D model profile of the spillway

5. COMPARISON TO PHYSICAL RESULTS

A physical model with the scale of 1:40 is constructed to investigate hydraulic performance of the spillway experimentally (see figure 6 and figure 7). The spillway discharge capacityin both 3D numerical model and physical modelare compared in figure 8.

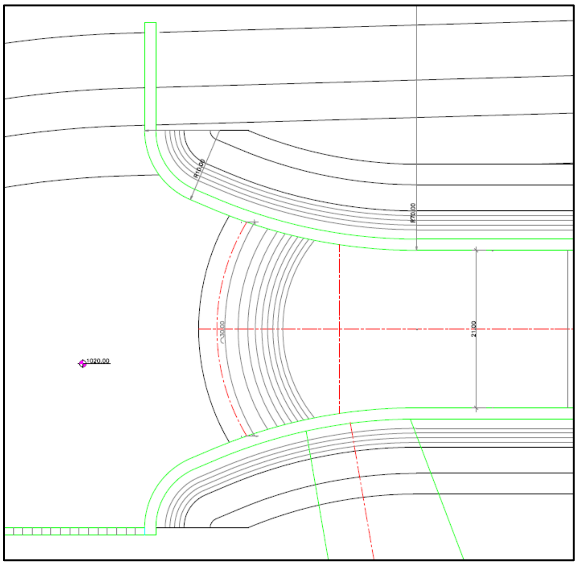

Figure 6: The arc shaped spillway in plan and profile

Figure 7: Physical model set-up

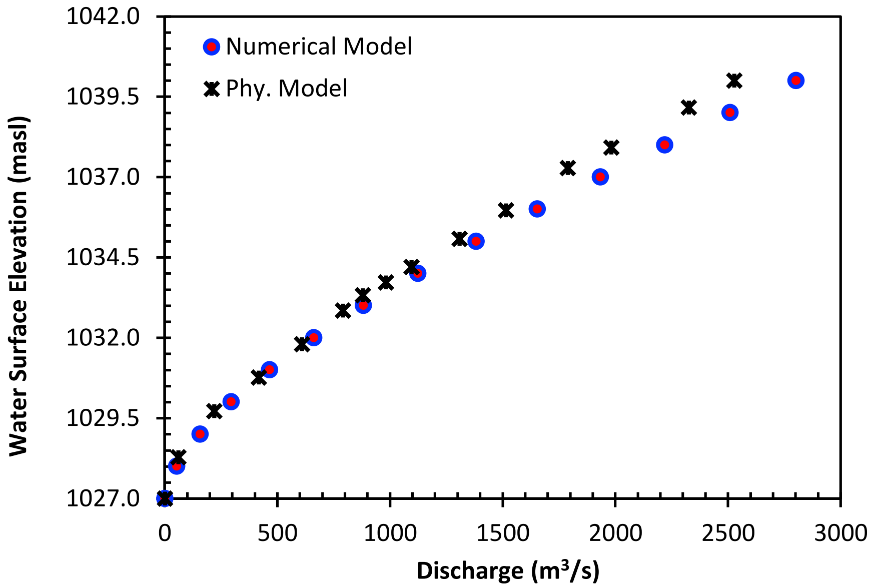

Figure 8: Comparison between discharge results in numerical and physical models

Comparison between physical and numerical models indicates that calculated discharge from two models are conforming together while the water elevation doesn't exceed from 1034.5 m. The difference between two model results increases gradually as the elevation exceeds from foresaid index.

In table 1, the comparison between spillway discharge is represented in various water elevations between straight primary ofL=21 m and modified curved shape of L=30 min same chute width conditions. The results show significant increment in spillway capacity due to applied modifications in its geometry.

Table 1: Comparison between discharge results between straight and arced- shape spillways

ELEVATION (masl)	Discharge (cms)		
	Theoretical Linear – L = 21 m	Physical Model L = 30 m	Q (L=30m)/Q (L=21m) %
1027.00	0.0	0.0	0
1028.00	36.9	47.5	128.7
1029.00	108.6	140.2	129.1
1030.00	205.7	272.9	132.7
1031.00	324.9	461.5	142.1
1032.00	464.2	643.9	138.7
1033.00	622.7	820.3	131.7
1034.00	798.8	1047.5	131.1
1035.00	992.9	1289.2	129.8
1036.00	1201.8	1521.9	126.6
1037.00	1425.7	1730.4	121.4
1038.00	1665.9	2004.4	120.3
1039.00	1921.9	2281.8	118.7
1040.00	2191.3	2526.8	115.3

6. CONCLUSION

In figure 10, the related excavation plan is represented for Sardasht dam spillway. According to its arced shape, the excavation volume is estimatedas 1.2 million cubic meters, which would have been increased by 40% if the straight alternative had been selected. This would be happened because of the subsequent increment in chute width. Moreover, concrete volume in case of arced shape spillway was decreased by approximately4%.(~2000 cubic meters)

To sum up, the implemented alternative of Sardashtdam spillway completely satisfies the required conditions and supplies acceptable hydraulic behavior. Adopting this shape of spillway brought a considerable cost saving in the project.

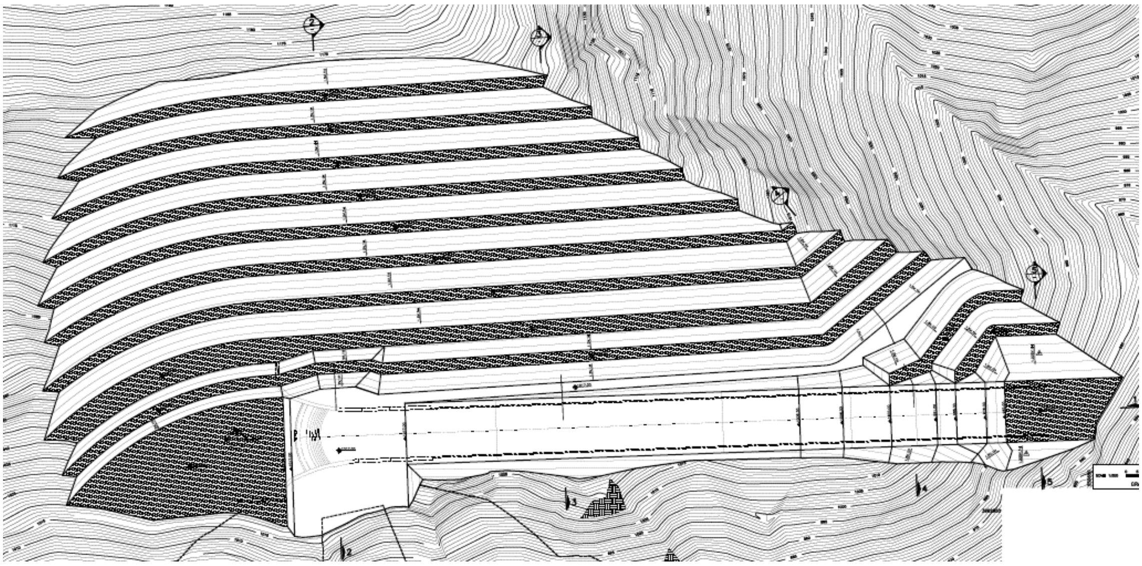

Figure 10: Excavation plan for spillway of Sardasht dam

7. REFERENCES

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