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The Proper Option for Discharge the Turbidity Current and Hydraulic Analysis of Dez Dam Reservoir

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Abstract: A big problem concerning the Dez dam located in Khouzestan is the annual 15 million ton sedimentation most of which cased by the Turbidity current entering the dam reservoir. Currently, 24% of the reservoir is filled with sediments. Also, passing Turbidity current from the powerhouse equipments leads to severe erosion and if Deposits sediments entrance to the power tunnels then decrease the economical efficiency of the powerhouse. More over, despite high sedimentation of the basin, this dam does not have bottom outlet equipments. All Practical measures have been ineffective and all studies conducted by consulting companies only resulted in two tunnels on right abutment of the dam. Therefore, because of its aging and the stability of the dam's body and its abutment, any changes can be highly risky. In this study, we made use of the available space and little structural operations to develop a strategy for discharge turbidity current which imposes the least degree of risks and requires the least amount of study and construction expenses and execution time. In addition, we used the hydraulic flow 3d software to determine the hydraulic characteristics of the Turbidity current discharge channel. Results show that with the increase of the reservoir head from the 300 level to 320 levels, the outlet Turbidity current discharge rises by 32.4% and the pressure imposed on the upper section of the channel entrance rises from 407.9kpa to 651.5kpa. Moreover, with the increase of the reservoir head from 300 levels to 352 levels, the outlet turbidity current discharge rises by 78.2% and the pressure imposed on the upper section of the channel entrance rises from 407.9 kpa to 915.4kpa.

Key words: Turbidity current · Dez dam · Flow 3D Software

INTRODUCTION

Sedimentation in dam reservoirs decreases the useful age of the reservoir and creates a number of problems for the bottom equipment of the dam such as intakes, gates and other buried equipments. 90% of dam reservoir sedimentations are due to inlet turbidity currents [1]. Sedimentation has always been the most serious problem especially for dam reservoirs in mountainous basin. The most important step to prevent reservoir sedimentation on has been watershed management and erosion control measures.

Although taking these steps seems necessary, they are not sufficient achieve goals such as maintain sedimentations balance and prolonged protection of the reservoir extra volume. In fact, the sedimentation management strategy which includes all strategies to maintain sedimentation balance is acceptable [2]. Therefore, strategies like tailing dams and hydraulic methods like bottom outlet equipments in dam reservoirs required. This equipment plays an important role in discharge sediments close to the dam and particularity preventing the penetration entrance of sediments into power tunnels of the power planet.

The first observations of turbidity current were recorded by researcher called Farll (1885) in the Geneva Lake in Switzerland. His observations showed that the sediments of the Ren River pouring into the Geneva Lake cause turbidity current. Bell (1942) conducted some experiments in a flume and focused on the effect of turbidity current on sedimentations in reservoirs [3]. Grover and Howard (1938), too, conducted valuable observations of different dam reservoirs around the world [1]. Their studies were carried out in the Mead River and the Hoover Dam Reservoir and the Colorado River in America. Results revealed that turbidity current with heavy sedimentation loads including a lot of silt result in sedimentation in reservoirs. These results were obtained

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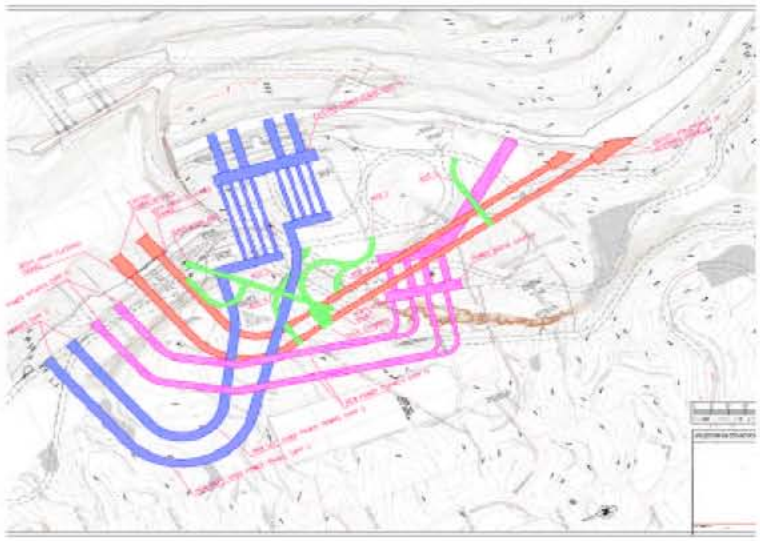

Fig. 1: Tunnels in the right abutment of Dez dam

through the analysis of the data from sediment samples, water quality of the sample and the outlet sedimentations discharge from the dam after turbidity current enters the reservoir. During one year, they reported three occurrence of turbidity current and found that 90% of turbidity current included particles 20 microns or less thick and their specific gravity was 0.995 to 1.008 characterizing a 1.76% dense solution. Ramezani and Gomeshi (2009) investigated the effect of turbidity current on sedimentations in the Sefidroud Dam Reservoir using the TCM model [4]. Result of this study demonstrated a 30% decline in efficiency of reservoir trapping in the Qezel Ozen branch and a 20% decline in the Shahroud branch.

In the Dez Dam, based on hydrographic result and experts observations from the operation company which confirmed the approach of the sedimentation level to inlet of power tunnel and penetration of turbidity current with a lot of sediments into the power tunnel of power plant, the officials installed three outlet irrigations at 222 levels in the dam body and conducted sediment flushing operations in the years 1988, 1994, 1995, 1996, 1997, 2000 and finally 2001 to prevent erosion of hydroelectric equipments. However, the extraction of sediments through these channels leads to many problems in the environment downstream and they were removed in 2001 as a result.

Result of the studies to design a bottom outlet gave rise to a strategy. This plan included the construction of two tunnels in the right abutment of the dam. The inlet of the tunnels was between the old and the new power plants and their diameters were 10 meters and they were 1022 meters long and their outlet was freely located downstream of the dam [5]. Figure (1) shows this plan. In this plan, drilling started from the end section and the explosion method (knows as the final explosion method) was used about 5 meters before construction to reservoir.

In the present study, investigating present conditions, we attempt to develop a strategy to extract turbidity current in a way that little problems arise for the dam structure and downstream environment and also least amount of expenses and time will be spent. Also, it will impose little threats to the workers and equipments. After word, we conduct a hydraulic analysis of the proposed strategy and use the Flow3D software in this regard.

MATERIALS AND METHODS

The Dez dam was constructed in 1970 on the Dez River 25 kilometres north of Khouzestan. The Dam is 203 meters high and is two arc dam type. The Dam is built in a Canyon 500 meters deep. The crest of the Dam is 212 meters long and 4.5 meters wide. A major problem of the dam is the annual 15 million ton sedimentation and due to lack of bottom outlet, the level of the Sediments deposited is getting very close to the intake of power tunnels and is less than 8 meters which is decreasing by 0.75 to 1 meter every year [6]. If the sediments enter to the intake of power tunnel, erosion in the hydroelectric equipments will be so high that the power plant will become uneconomical and the reservoir volume will decrease as well.

In order to build the bottom outlet, it should be considered that this dam is more than 40 years old and being aging Dam which makes any change in the dam structure and abutment risky particularly with a huge

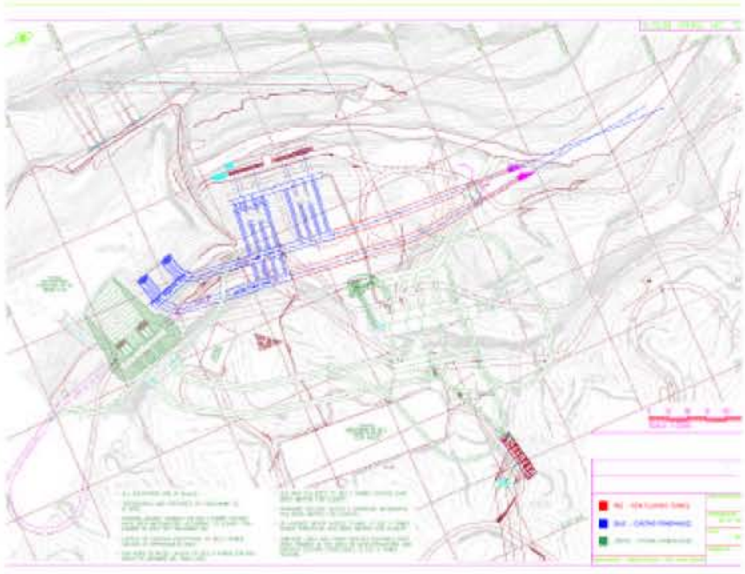

Fig. 2: Overall picture of proposed plan

volume of reservoir which requires a great deal of attention construct the structure. Therefore, if we decide to follow the consultants, plan to build two 10 meter wide tunnels in the right abutment, we have to accept the high expenses and risks of the non-explosion method. Because it brings about instability in the right abutment because of intensive drilling for primary construction operations and the drillings for connecting the tunnels to the reservoir through the explosion method. Hence, it is necessary to develop a strategy with at least fewer problems then the one proposed by the consultants and offering better conditions. As a result, an economical option with maximum use of the present condition of the dam.

It is important to note that this strategy decreases drilling operations so that the need to new long tunnels, interference with the plan for the second power plant of the dam, prolonged operational time, etc. will be dispensed with, the second strategy (proposed strategy) suggests the use of power tunnels, when they are needed to discharge turbidity current. We should mention that these tunnels were directed outside the right abutment through the available adit without the turbidity current passing through the hydroelectric equipments.

The Proposed Option: In this strategy, power tunnel no 1 and no 2 will be used for both discharges turbidity current (when it occurs) and producing power (at other time). At the end of power tunnel no 1 and 2 (with 10 meter inlet diameter) downstream; there will be passage for discharge turbidity current. Through using adits at the end of these tunnels and with the increase in the adits diameters (10 meters), the turbidity current can be easily directed downstream. The outlets of these tunnels based on the adits will be almost in front of the spillway outlets. Figure (2) depicts an overall picture of this plan.

Maximum Dischargeable Flow: The safe discharge of the Dez dam downstream region is 1665 m^3/s and it is 600 m^3/s based on the old power plant discharge after improvement and the new power plant discharge is 492 m^3/s. thus, the maximum dischargeable flow for turbidity current will be 573 m^3/s [7].

Feeding the Flow 3D Software with Necessary Data for Hydraulic Analysis: When entering the data, the main point is how to enter the geometry of the power tunnel. Power tunnel no 1 and 2 are rather similar are not much different in terms of angles, length, diameter and slope. The Flow 3D software has a simple design tool and we should use the AutoCAD Software and tree dimensional area for designing intricate geometrics of flow passage such as the Stream bed. Because of adaptability of the flow 3D area with AutoCAD, it is possible to enter the data. Therefore due to the complexity of the power tunnel inlet, the AutoCAD way used to design whole intake tunnel and then was feed into hydraulic analysis software. According to USBR designing guidelines for designing under pressure tunnels and tunnel spillways, the minimum roughness coefficient required for hydraulic analysis was set as 0.008 and maximum roughness coefficient of 0.013 was used.

For viscosity of the fluid used in model, the average density obtained by calculating the turbidity current by water researched institute of power ministry in 2003 was used [8]. Therefore the measured section closest to the power plant inlet was considered as the selected viscosity. On the basis of the minimum operation level of 300, the maximum operation level of 352 and the power tunnel intake level of 270, we conducted the hydraulic analysis of the tunnel discharge of turbidity current at there levels of 30,55 and 82 meters.

RESULTS

The final explosion method proposed by the consultants was very risky and it was very likely to result in negative consequences. Also, the final explosion method has never been used for construction of a bottom outlet or flushing tunnel. Moreover, to discharge the turbidity current from the dam, the inlet area required for the bottom outlet is much larger than the area we can obtain through this method. However, the new proposed strategy does not bring about any problems about high level of water when the tunnel is connected to the reservoir and there is no need to final explosion operation because there are stop log gate equipped with water stop seal in the power tunnel inlets. In addition, because of the dams aging, this proposed strategy has little effects on the dam structure. Moreover, due to like lihood of turbidity current in the reservoir caused by heavy rains which begin from October and continue to March (the Dez Dam turbidity current flow report, water research institute of the power ministry, 2003), discharge these turbidity current during a 6 month period by constructing two separate tunnels is not proper and economical. According to 1-1-2 section, discharge a maximum amount of 573 M^3/S in a period less than six months by two separate tunnels can not be technicality and economically justified.

The right abutment of the dam holds about 6500 meters of access tunnels, about 460 meters of power tunnel with a 10 meter diameter, 670 meters of diversion tunnel with a 13 meter diameter and power plant yard and also the drillings 8 penstock with a 4 meter diameter and other drilling were performed there (the Dez dam operation report, 1961). As a consequence, any further drillings at right abutment imposes high risks due to instability of the dam and abutment. Additionally, according to Dez dam reservoir turbidity current (water research institute of the power ministry, 2003) the majority of the sediments penetrate into the reservoir by 2 at most 4 floods. S0 to discharge the turbidity current cased by these 4 floods, it is not proper to construct two risky and separate tunnels.

Table (1) illustrates the volumes of construction related to both strategies.

As can be seen in the above table, the excavation and concrete volumes in consultants' strategy are 8.5 times more than the proposed strategy. The overall of weight of steel used in the consultants' strategy is 5.6 times more than the proposed strategy. Above all, there is no need to final explosion method in the proposed strategy.

Moreover, maximum pressure is imposed on the lower section of the inlet because of the water column weight. Therefore, with the increase the head, the pressures rise. The diagram of pressure changes in the lower section of the inlet is presented in Figure (3).

Table 1: Comparison of construction volumes related to the consultants, strategy and proposed strategy

Option Item	Consultants strategy	Proposed strategy	Observation
Lengths of tunnels (m)	1022	612.0	432 meters of tunnel length as power tunnel no 1 and 2
Tunnel Diameter (m)	10	10.0	--------
Excavation volume (m^3)	80268	9425.0	The proposed strategy required only 180 meters of drilling
Concrete volume (m^3)	9921	1165.0	30 centimeters equivalent with the concrete layer thickness
Used steel weight (ton)	793	139.6	The Consultants strategy needs steel 8 times more
The need to final explosion	Yes	No	--------

Table 2: Results of running the model for extraction discharge and velocity and discharge from the tunnel

Extracted discharge from the tunnel (m^3/s)	Outlet section area (m^2)	Average velocity (m/s)	Reservoir water level (m)
689.3	78.5	8.781	30
912.5	78.5	11.624	55
1228.1	78.5	15.645	82

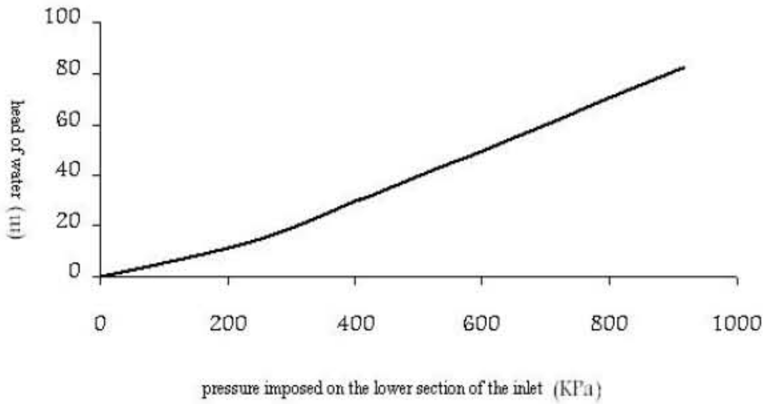

Fig. 3: Diagram of pressure changes in the lower section of the of the inlet channel with respect to water level

With increase in level, pressure on upper section of the inlet is on the decline so that at the 82 meters level, pressure becomes negative at this section. Therefore, it is necessary to install air vent pipes in this section.

Table (2) presents the results of fFlow3D model at three levels.

With regard to the extractable discharge volume for turbidity current amounting to 573 m^3/s and the result presented in table (2-3), the proposed strategy can extract this discharge in all situations. Besides, the conducted analysis is only about one tunnel and thus the turbidity current flow can be extracted from the reservoir making changes in one tunnel.

CONCLUSION

The result of this study show that the use of power tunnels' power plant with drilling and concrete volumes of 9425 meters and 1165 meters respectively were more useful than the volume in the consultants strategy which were 80268 and 9921 respectively. The maximum time for the formation of turbidity current in the reservoir was 6 months by 2 to at most 4 floods; therefore, because the dam aging, it is not economically and technically proper to drill two separate tunnels. One of the serious problems we encounter in the consultants' strategy is that there are a number of different technical intricacies caused by the high level of water when we want to connect the tunnel to the reservoir; however, this problem is resolved in the proposed strategy through closing stop log of power tunnels. The hydraulic analysis performed by the Flow3D Software reveals that a water supply tunnel at the minimum exploitable level of the reservoir with a 30 meter extractable discharge amounts to 689.3 cubic meters and the maximum exploitable level with a 82 meter extractable discharge amounts to 1228.1 cubic meters. According to 1-1-2, the maximum extractable discharge was 573 meters.

REFERENCES

1. Grover, N.C. and C.L. Howard, 1938. The passage of turbin water through Lake Mead, Trans. ASCE, No. 103, pp: 12.
2. Fan, J. and G.L. Morris, 1992. Reservoir sedimentation. I: Delta and density current deposits, J. Hydraulic Engineering, 118(3.9).
3. Bell, H.S., 1942. Density currents as agents for transporting sediments, J. Geol., L5. pp: 10.
4. Ramezani, Yousef and Qomshi Mehdi, 2009. Investigation the effect of turbidity current on sedimentation process in the Sefidrood Dam Reservoir, the Eight International Conference of Civil Engineering, pp: 8.
5. Mahab Ghodss Engineering Consultation Company, 2010. The Dez Dam bottom outlet plan, Khuzestan water and power Authority, pp: 85.
6. Darya Tarsim engineering Consultation Company, 2007. Hydro graphic results of the Dez Dam reservoir, Khuzestan Water and Power Authority, pp: 95.
7. Dezab Engineering Consultation Company, 2010. hydraulic studies report of determining the boundaries and beds Karoon, Arvand, Bahmanshir and Dez Rivers, pp: 110.
8. Research Centre of Power Ministry, 2003. The Dez Dam reservoir Turbidity Current report, Khuzestan Water and Power Authority, pp: 86.