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A historical glance over Fierza dam, Shkoder, Albania

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ABSTRACT: *Is it about energy?!*
This paperconsists in the analyses of the construction of the Fierza's dam, built on the Drinriverbedin 1978. During the study of the dam construction scheme and laterduring the design of the projects, variousproblemsweretakenintoaccount, such as: the geological conditions of the area where the hydropower plants waserected, the construction materials, the mostsuitable solution of the type of dam, the auxiliary woks, their construction, sequence and time.
For centuries, the world's water resources have been developed to benefitmankind. The construction of dams in order to createreservoirs has served for manypurposes. These are somecommon uses such as: water supply, hydroelectric power, flood control, irrigation, navigation.
The dams are alsoused to regulate the flow of water in rivers. Water can bereleasedfrom the reservoirduringdrierseasons to support wildlife and the environmentdownstream, and to provide a resource for human uses.
Dams have long been viewed as a symbol of humaningenuity and amongthemis the Fierza's dam, one of the greatestachievements in Albania.
During the period of the construction of the dam, Albaniawas in difficulty to finance the design and the implementation of suchworksthatenvisaged large dams. Regardless of everything, the small state of Albaniamanaged to buildmagnificenthydropowerworkswithgreateconomic value and a high technical and scientificlevel, such as the Fierza'shydropower plant.
The aim of thispaperis to show the importance of the construction of the Fierza's dam in the production of energy in the country with an annualaverage output of 1,330 GWh. Also, the importance of Fierza, besidesenergy production, relates to the capacity of itslake, whichregulates the annualinflows, increasing the efficient use throughout the cascade.
KEYWORDS *-dam, flood control, hydroelectric superpower, geological conditions, water supply,materials of construction*

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I. INTRODUCTION

Our country is a very rich one with water resources that can be used primarily for the production of electricity, as well as for other purposes. The water quantity that can be used for energy purposes reaches an average of about 20 billion KW/h per year. Half of this water quantity is part of Drin's river with an average of about 6.7 billion KW/h per year.

II. History of Dam construction

Relying on these data, in Albania during 1962-1963 drew up the project for the energy use of the Drin's River cascade, where the most important design of the project was Fierza's dam, which led in 1978 to the utilization of the Fierza's hydropower plant.[1]

After many discussions, the engineers of the Institute of Studies and Designs No. 3 undertook to design and build the embankment dam.

Embankment dams are water impounding structures which are constructed of naturally available material (soil or rock) without addition of any binding material. These materials are usually obtained at or near the dam site. These materials form a relatively flexible structure which can slightly deform conform to the

foundation deflection without causing deflection failure. This makes the construction of embankment dams possible on any type of foundation.[2]

The history of embankment dams is much earlier than that of concrete dams. It is evident that some simplest embankment dams were constructed about 3000 years ago in the cradles of ancient cultures such as Egypt, Indian, Sri Lanka, Peru, China, and other countries.[3]

But the main reason that led to this solution of Fierza's Dam was financial savings.

The construction of safe and cost effective dams is important for the development of sustainable cultures and economies. In areas with scarcity of water, dams are required for water storage during dry periods. However, a dam construction and operation, has some serious consequence potential, for instance, costs, environmental impact and risk of loss of lives and properties in the downstream area. Overtopping is the primary cause in 31% of embankment dam failures, and is a secondary cause in 18 % of failures (ICOLD, 1995) Overtopping may happen for different reasons, such as insufficient spillway capacity, blocked spillways, wind and landslide generated waves, settlement etc. The most important parameter to prevent overtopping is thus the freeboard; the vertical height between the water surface and the dam crest.[4]

Regardless of these known and unknown technical problems, the construction of the Fierza's dam came to life.Furthermore, Fierza's dam plays an important role in the use, regulation and safe operation of the cascade.

- The construction of Fierza's dam started in 1970.
- In 1978, the first unit came into operation.
- In 1980, the plant was fully operational and at full capacity.
- The construction of Fierza's dam was done with equipment from China, but based on the concepts of Albanian engineers.

Fierza's hydropower plant consists of the following main works: a 167 m high earth dam, water intake works for the turbines and four metal tunnels with a diameter of 5.2-7.2 m, the power plant building, two discharge tunnels for large flows up to 5000 m3/sec,electrical substation etc.

In particular, the massive minimums for the production of rock material for the construction of the dam should be mentioned, where the greatest contribution was given by Edmond Pingu together with his staff.[5] The technicians and specialists who had worked on the study, design and construction of the so called "Vaute Deja" hydropower plant, as well as many others, worked with high dedication in the design and implementation stage of the Fierza's dam.

Fig. 1 – Fierza's Dam [6]

Fierza HPP was built with equipment mostly from China but on the concepts of Albanian engineers. Around 14,000 workers, engineers and specialist were involved in the construction of the plant.[5]Regarding the construction technology of this dam, many discussions were held by Albanian engineers and it was decided that this dam would be built with a mechanical mixture of clay and gravel, which would have a cement curtain and a concrete base. This theory is supported by numerous laboratory tests as we have to bear in mind that at that time

Albania was an isolated country and there was only one dam of this type in Europe which was located in the south of Serbia which nowadays belongs to the region of Kosovo, precisely in its north, in Lake Ujman, Mitrovica. Being in these conditions Albanian engineers were forced to rely only on their engineering training to accomplish this work. As mentioned above, after the laboratory tests that have showed optimal parameters on the work front, many machines and human personnel were sent in the area.

III. FIERZA'S AND UJMANI'S DAM

Fig. 2 –Ujmani's Dam,a rock-filled embankment dam on the Ibar River in the District of Mitrovica,Kosovo[6]

The dam shown in the photo above is the only dam similar to the Fierza's dam at the time it was built. This type of dam is definitely dealing with different geological conditions, with different reservoir volumes and with different volumes of materials used as in the foundation and also in its core, which are going to be explained.

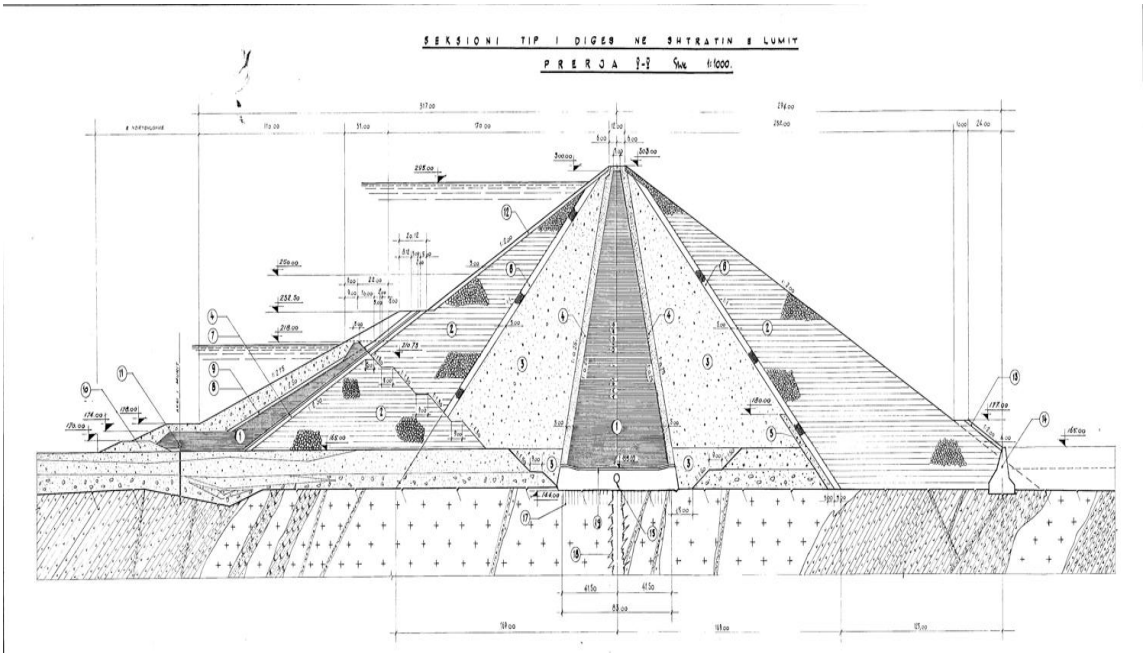

Fig. 3 - The original section. of the Fierza' Dam[7]

The Ujman dam has a height of 101 m while that of Fierza has a height of 167 m. Also, a big difference can be seen between the volumes of the created reservoirs where the Ujman dam has a reservoir with a total volume of 370000000 m^3 while the Fierza reservoir has a total volume of 28000000000 m^3. It is observed that the differences are significant. In the engineering point of view this difference will create different stresses in the dam screen.

The volumes of excavations and fillings of the Fierza's dam as seen in Table 1. let us know about of the intensity of the works carried out, always taking into account the conditions at that time.

Nr	The definitions of materials	Units	Volumes
DEFINITIVE DAM IN THE UPPER STRIP			
1	Engraving on The Rock	m^3	15,000
2	Engraving In Gravel	m^3	10,000
3	Torcretion	m^2	4,500
4	Filling With Thrown Stones	m^3	591,000
5	Screen Clay Filling	m^3	122,500
6	The First Layer Of The Opposite Filter	m^3	15,000
7	Layer Of Thick Gravel	m^3	23,000
8	Layer Of Fine Gravel	m^3	20,000
9	Filling With Any Kind Of Excavation Material	m^3	200,000
THE BODY OF THE DAM			
1	Engraving on The Rock	m^3	209,000
2	Engraving In Gravel	m^3	260,000
3	Torcretion	m^2	50,000
4	Surface Cementation	ml	88,000
5	Concrete And Reinforced Concrete	m^3	52,000
6	Filling With Gravel	m^3	1,645,000
7	Filling With Thrown Stones	m^3	3,579,000
8	Core Clay Filling	m^3	1,146,500
9	The First Layer of The Opposite Filter	m^3	383,000
10	The Second Layer Of The Opposite Filter	m^3	23,000
11	Transitional Area	m^3	308,000
12	Layer With Selected Stones	m^3	10,000

Table 1 - The original table of volumes of engravings, fillings and layers [7]

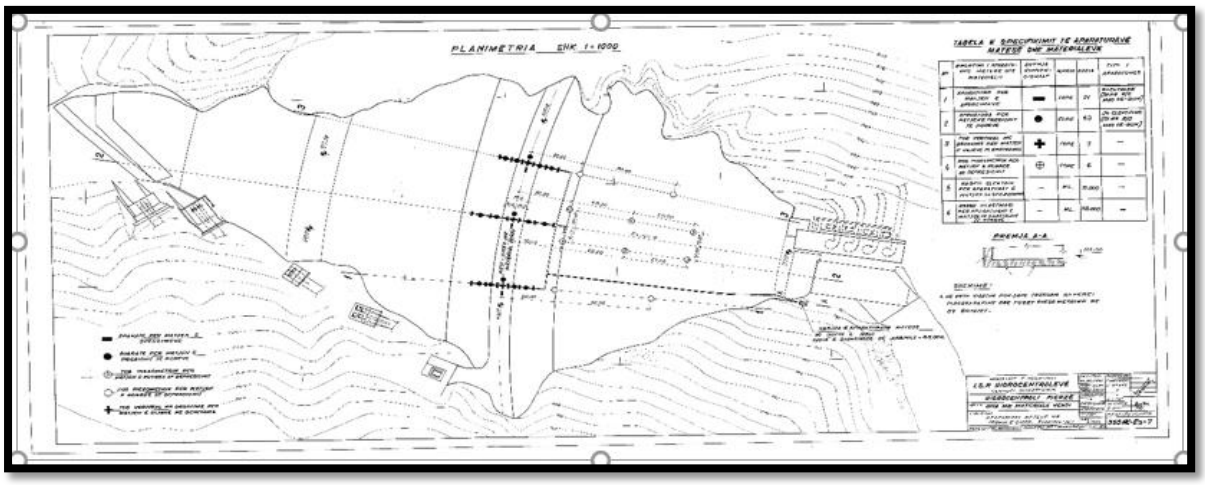

Fig. 5 – The original plan of Fierza's Dam[7]

IV. TECHNICAL UTILIZATION PARAMETERS OF FIERZA'S DAM

Fierza's Dam was the second highest in Europe related to its height.

The total volume of the dam is 8 million m3.The dam has created a reservoir with a volume of 2.7 billion m3 and a surface of 72 km2.Fierza's lake is also the largest artificial lake in the country and the useful volume of the reservoir is 2.3 billion m3.Its dam is designed for peak flow calculated for 1 in 1,000 years (6,100 m3/sec) and maximum control flow during the rainy season for 1 in 10,000 years (9,600 m3/sec). [5]

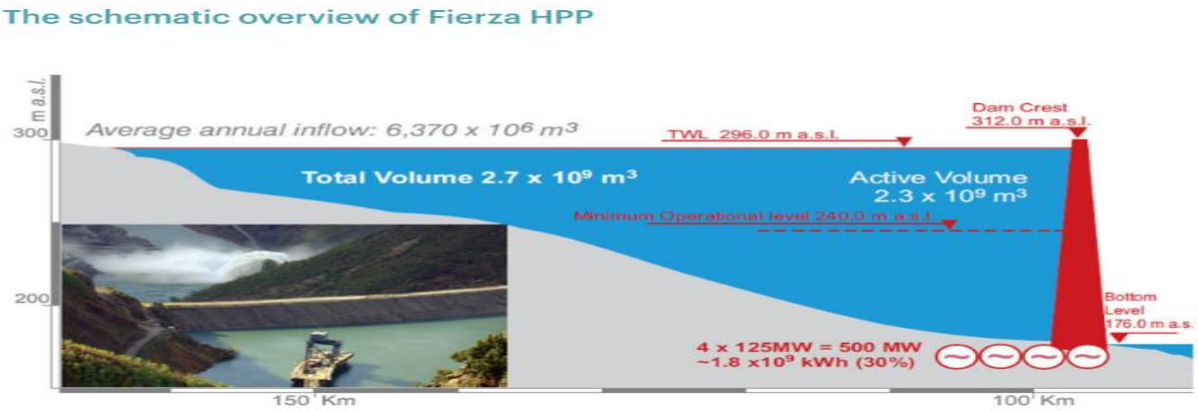

Fig. 6 – The schematic overview of Fierza HPP [5]

Mean Annual Flow	
Since entry in operation	196 m³/s
Average (1994-2014)	183 m³/s
Average (2004-2014)	193 m³/s
Mean Top Water level	
Average of last 20 years	280.68 m
Average of last 10 years	282.31 m
Minimum (December 1994)	245.96 m
Maximum (May 2013)	296.91 m

Table 2 - Data of Fierza's flow in different time frames[5]

V. TUNNELS OF DAM

The Fierza's Dam and the diversion of the water flow is carried out through the excavation tunnels as follows:

- Tunnel 4-capacity 890 m3/sec.
- Tunnel 3 - capacity 1780 m3/sec. Total water discharge capacity at 296 m a.s.l. is 2670 m3/sec.

Total water discharge capacity at 296 m a.s.l. is 2670 m3/sec. The Intake System was built to supply water to the plant from the lake.
The intake system transports water through tunnels to 4 turbines of the power plant building. The capacity of the transportation system is up to 500 m3/sec. The four units installed in the power plant have "Francis" vertical turbines, with a power of 125 MW each; 3-phase synchronous generators of voltage 13.8kV; and 13.8kV / 242kV step-up transformers for connection to the substation. The total installed power and HPP is 500 MW.
The plant building contains auxiliary and monitoring equipment as well. The substation with its transmission, control and protection equipment enables the connection to the Electric Power System through four 220 kV lines (Fierzë-Tirana, Fierzë-Koman, Fierzë-Elbasan, Fierzë-Prizren) and two 110 kV lines (BajramCurri-Fierzë, Fierzë – FusheArrez). The annual production of Fierza HPP is 1,330 GWh on average. [5]

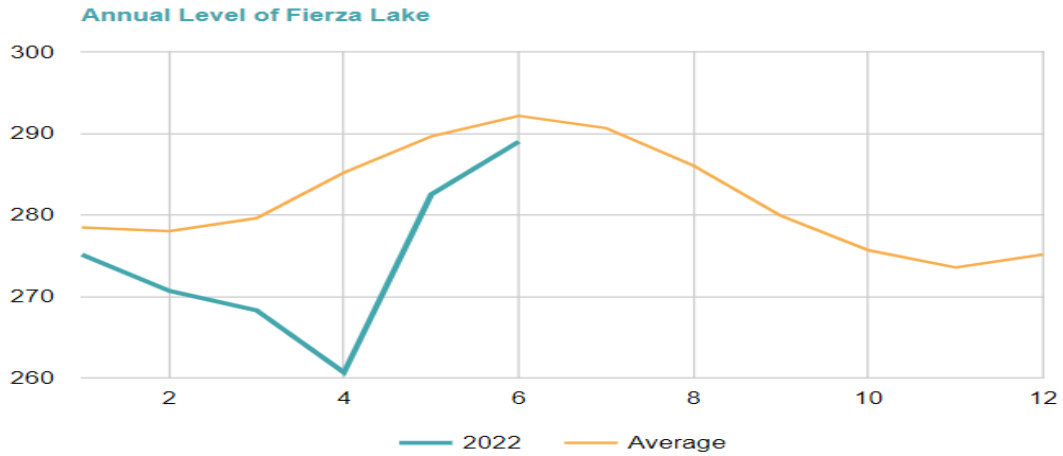

Fig. 7 – Annual Level of Fierza's Lake [5]

Building materials

For the construction of dams, a variety of materials are included, such as soil, rocks, waste from mines, concrete, masonry and steel, wood and any combination of these materials.
It is worth mentioning that this depends on the size of the dam and economic issues.
Most of the large dams are mainly made of concrete with steel reinforcement.
A very large volume of works was carried out for the construction of the Fierza's hydropower plant. In the table below are listed some of the construction works and the materials used: [4]

Open excavations	2000000 m^3
Underground excavations	1000000 m^3
Concrete and reinforced concrete	1115000 m^3
Filling materials for the dam	8000000 m^3
Drilling and cementing	80000 ml
Metal pipe assemblies	8.500 ton

Table 3 – Construction works and materials table[5]

VI. CONCLUSION

After the historical overview carried out on the construction of dams in the world and Europe and also on the Fierza's dam, some conclusions were reached focusing on the importance of dam construction. Despite built in a difficult period, the Fierza's dam has played and continues to play a very important role in almost all aspects of the Albanian energy market.

The construction of the Fierza's dam has brought a number of economic, environmental and social benefits such as: The dam helps prevent property losses caused by flooding. Flood control dams trap floodwaters and divert water for other uses. It creates reservoirs that supply water for many uses, including industrial, municipal and agricultural purposes. The Fierza's Dam plays the main role in the supply of energy throughout Albania. Hydropower systems are part of renewable energies and do not contribute to global warming. They offer greater environmental protection, such as keeping hazardous materials and harmful sedimentation. Fierza's dam is one of the most important construction ever built in Albania up to this moment

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