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Economical evaluation of the spillway modifications in order to meet the requirements of the design flood

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INTRODUCTION

Swedish dam safety practise is based on the guidelines, RIDAS, given by Svensk Energi - Swedenergy, which were first published in 1997. The consequences in the case of the dambreak determine the dam risk class. The risk classes are 1A, 1B, 2 and 3 and the risk class 1A corresponds to most severe consequences. The design flood is specified according the guidelines of Flödeskommittén 'The Guidelines for the Calculation of the Design Floods for Dams', issued in 1990.

Laforsens hydropowerplant is situated in the central part of Sweden. The powerstation and the dam were completed in 1953 and upgraded with third unit in 1966. The powerstation has maximum turbine capacity of 200 m^3/s, the head of 35 m and and installed capacity of 57 MW. The spillway has four Tainter gates with the width of 16 m and the crest is at the elevation +208,00 m. Two of the gates have a heating system and they can be operated during the winter.

The catchment area at Laforsen is 11 366 km^2. The highest measured discharge (HHQ) has been approx. 1540 m^3/s and mean annual flow (MQ) is 155 m^3/s. The dam is the risk class 1B dam and the design flood is calculated to 3030 m^3/s. The reservoir volume is small compared to the design flood that it will not reduce the required spillway capacity. The spillway capacity at the highest regulated water level (HRWL) of +214,50 m (RH00) was calculated to be approx. 2100 m^3/s. The need for the additional spillway capacity is approx. 930 m^3/s.

The alternatives for increasing the spillway capacity were (Figure 1):
- new spillway at the Left Bank or
- the lowering of the crest elevation of the present spillway opening and installation of the new Tainter gate.

The preliminary calculation with the conservative discharge coefficient showed that the rehabilitation work can be done in one spillway opening and the high flood level (HFL) of 215,0 m is utilized. The design of the embankment dam allows the use of HFL (the top of the diaphragm wall of the embankment dam is at the elevation +215,5 m and the freeboard is sufficient). The crest elevation has to be lowered 6,4 meters, to the elevation 201,6 m. The uncertainties of the preliminary design was checked with the hydraulic model study.

The cost estimation of the new spillway at the Left Bank was approx. 5,8 M€ and it was not attractive solution.

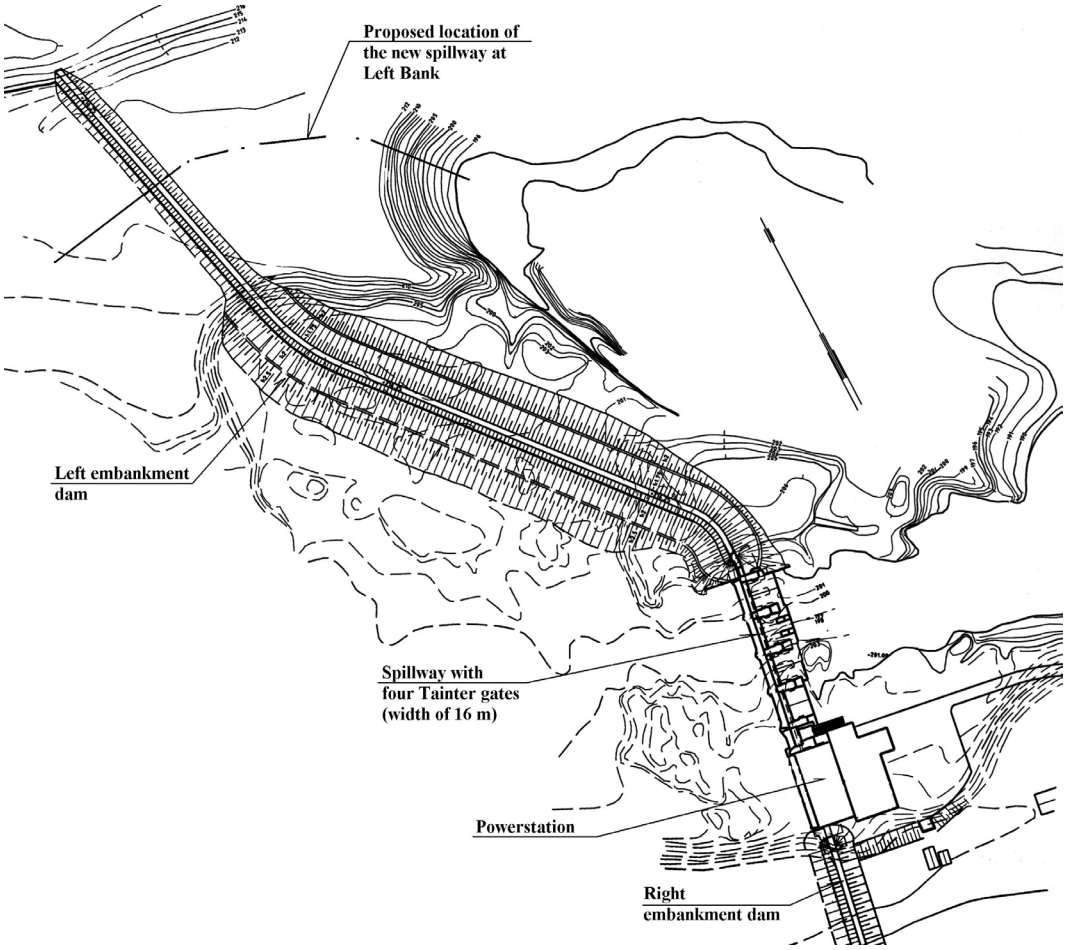

Figure 1. The site map.

THE RESULTS

The model testing was carried out in the Hydraulic Laboratory at the Helsinki University of Technology. One spillway opening was tested in the flume of 1,0 m width. The model scale was 1:30. The present spillway capacity was also tested and the increase was approx. 6 % compared to the estimated value.

Two feasible solutions were found in the hydraulic model study:

Alternative 1: The crest will be lowered to the elevation +203,2 m and the water level in the reservoir under the flood is +215,0 m (the rising of 0,5 m).

Alternative 2: The sill will be lowered to the elevation +201,6 m and the water level in the reservoir under the flood is at HRWL (+214,5 m).

The rehabilitation work will be done behind the stoplogs. The construction work and the installation of the Tainter gate will be done from the downstream side of the dam. New site access road is needed and it will be constructed at the toe of the left embankment dam. Later it will be used for the maintenance and for the dam inspections. The cost estimation for Alternative 1 is approx. 2,6 M€ and approx. 2,85 M€ for Alternative 2.

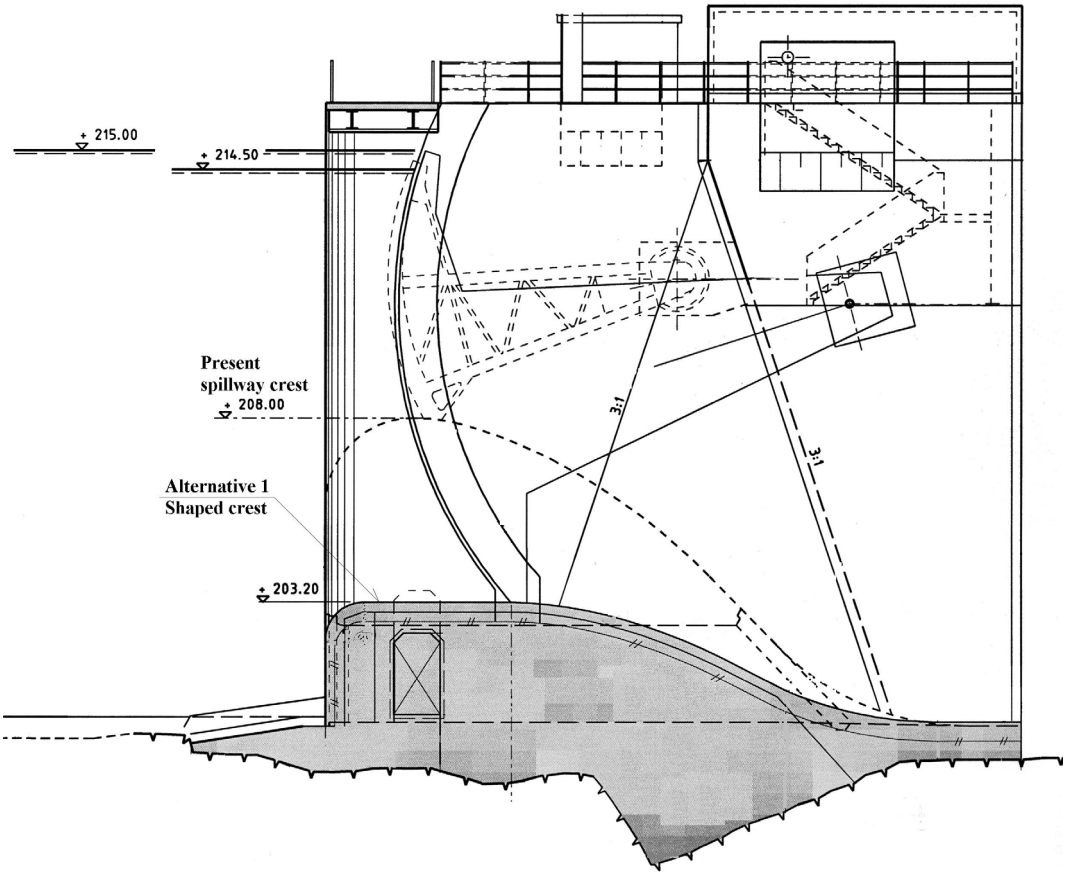

Figure 2. The proposed alternative.

CONCLUSIONS

The dam risk classification is based on the consequences, if the dambreach occurs. Nowadays the dam safety requirements for the spillway capacity (design flood) may be different than during the construction. The design flood for the dam is determined by the dam safety law or by the guidelines. Additional spillway capacity may be required in many cases. The rehabilitation work will not increase the revenues of the company, but on the other hand the consequences due to the overtopping without any modifications will be more costly. Therefore the costs of the spillway rehabilitation should be minimized.

Alternative 1 is proposed for further development (Figure 2). The cost savings is 0,25 M€ compared to the Alternative 2, which was obtained with the desk study. The cost of the hydraulic model study was less than 10 % of the cost savings. The advantages of the hydraulic study were the correct and better discharge coefficients (present and modified spillway opening) and the higher crest elevation will also make the rehabilitation work easier. The cost is approx. 4700 € per additional m^3/s.