Application of the PKW spillway in South Africa

Presented by: Adam Botha

INTRODUCTION

- In 2011, Ingerop South Africa was appointed by the Department of Water Affairs (DWA) to raise the wall of the Hazelmere Dam, increase the storage – in order to increase the yield of the dam
- Thanks to the DWA, ISA has had the opportunity to conduct this research, which will allow South Africa to boast the largest Piano Key Weir (PKW) system in the world
- The main purpose of our research paper is to demonstrate the aspects that were considered to decide on the use of PKW spillways at both the Hazelmere and Tzaneen dams
- This presentation highlights the key points covered in the paper, such as the background of the dam, the theoretical considerations and challenges – specifically at the Hazelmere Dam.

BACKROUND ON THE PKW STUDY

- The original design for raising the wall of the Hazelmere Dam, in KZN, was to make use of radial gates to increase the FSL by 7 meters to meet increasing water demands of certain Durban North areas
- However, this design posed certain limitations in terms of installation, operation and maintenance requirements
- As a result new alternatives, such as labyrinth fuse gates, were also investigated
- The use of radial gates was also too expensive to operate in the long term and it could compromise the safe operation of the dam, should gates not be opened in time to pass a flood.
- This led to the introduction of the PKW, one of the main features of this design is to minimise the head required to pass flood waters through a given spillway without human intervention

PARAMETERS FOR DESIGN CRITERIA

Four basic parameters were then assumed to define the design criteria for the Hazelmere Dam PKW structure:

i. The **1:100 year flood** must pass through the spillway section without overtopping the existing non overspill crest (NOC) section of the dam.

ii. Floods with a return period as large as possible, preferably the Regional Maximum Flood (RMF), should be passed over the PKW structure without overtopping the existing 1.5 m parapet wall on the NOC section.

iii. The Safety Evaluation Flood (SEF) must be safely routed over the spillway with limited overtopping of the NOC and the parapets on the NOC, and without major damage to the dam wall.

iv. Under the above circumstances, the dam wall stability criteria must not be compromised.

FINAL OUTCOME

The main relevant characteristics of the proposed PKW are as set out below:

- Existing spillway length is **103 m** consisting of **6** blocks **15 m** wide, and a spillway center block **13 m** wide, separated by vertical construction joints.

- The raising of the FSL above the existing ogee crest is **7 m**.

- **1:100 year flood** to at least be passed without overtopping the NOC is **1360 m³/s**.

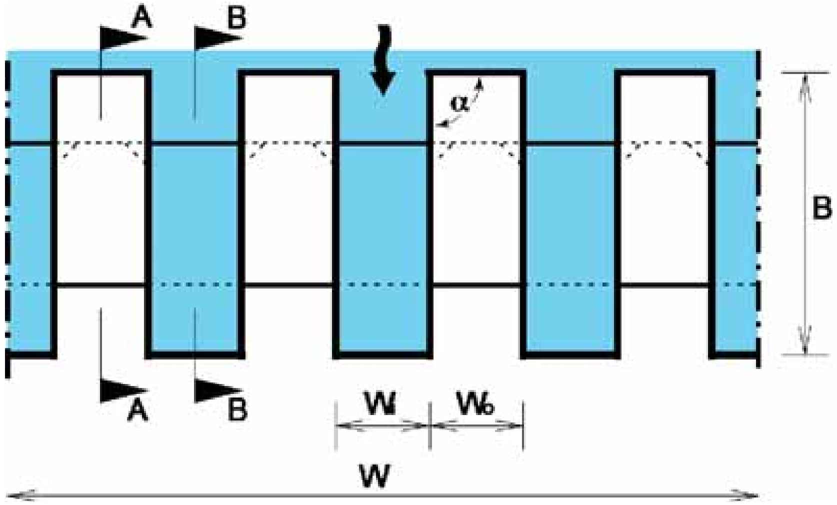


Figure 1: Typical PKW plan view to illustrate symbols

- **W = 13 m** center block and **7.5 m** for the remaining 6 blocks in to accommodate the fixed block widths and vertical construction joints (should have been 10.8 m)
- **Wi/Wo = 1.315** where W_i and W_o are the internal widths of the inlet and outlet keys respectively.
- **B = 21.6 m.**
- **L/W = 6.46** where W = width of the spillway
  L = effective length of top of the PKW walls on their center lines.

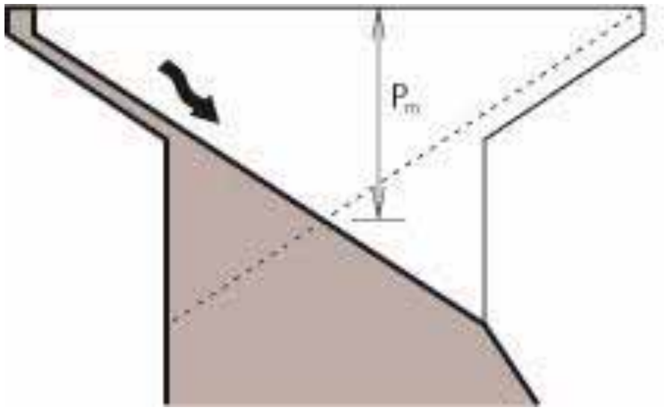


Figure 2: Section A-A

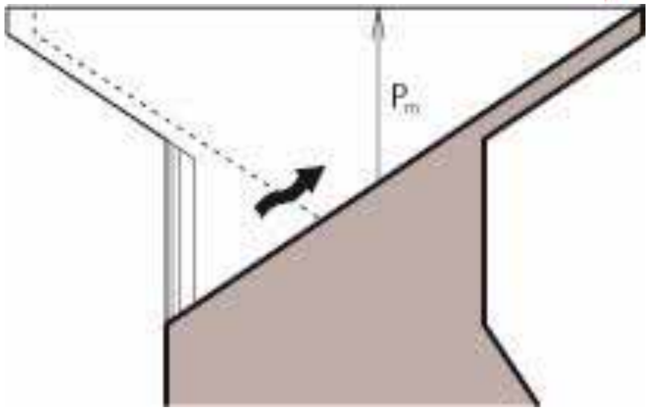
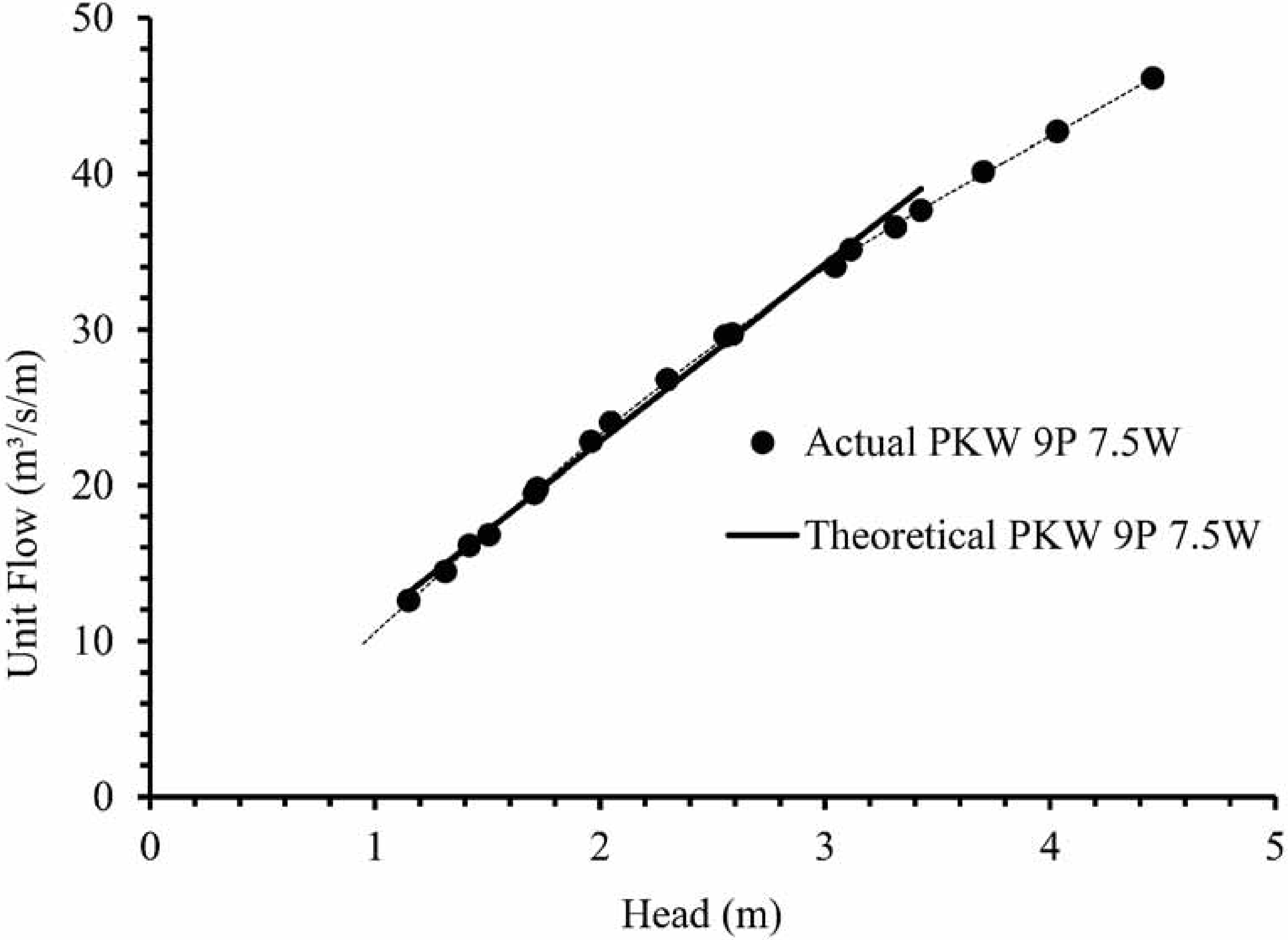


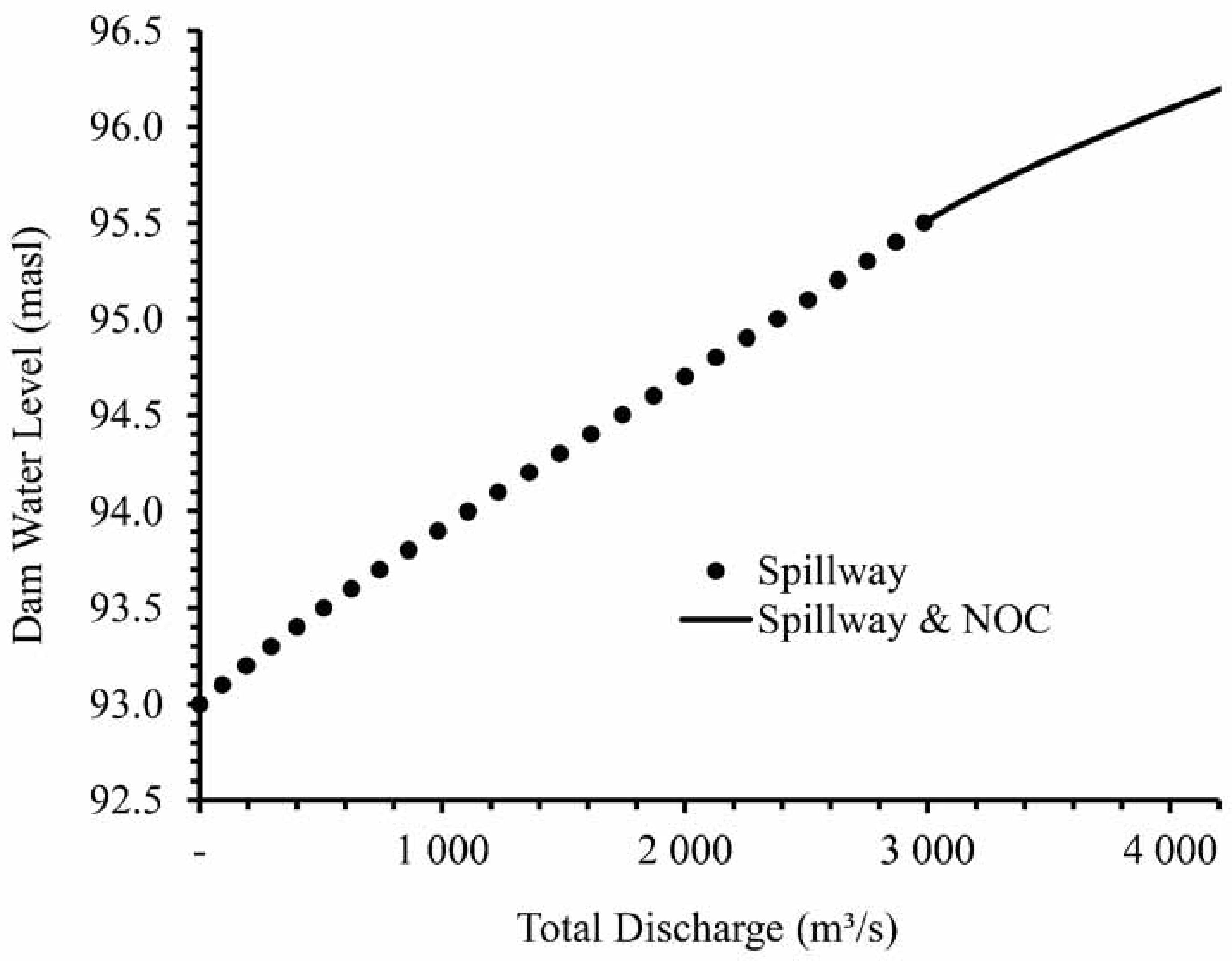
Figure 3: Section B-B

- ❑ **P = 9 m**
- ❑ **P_m = 6 m**
- ❑ **H/P = 0.356** where H = height of the dam water level above the PKW spillway level.
- ❑ The wall thickness at the top of the walls is **0.5 m.**
- ❑ The above mentioned parameters were then applied and tested in a physical hydrauli model at the water laboratory of DWA in Pretoria.

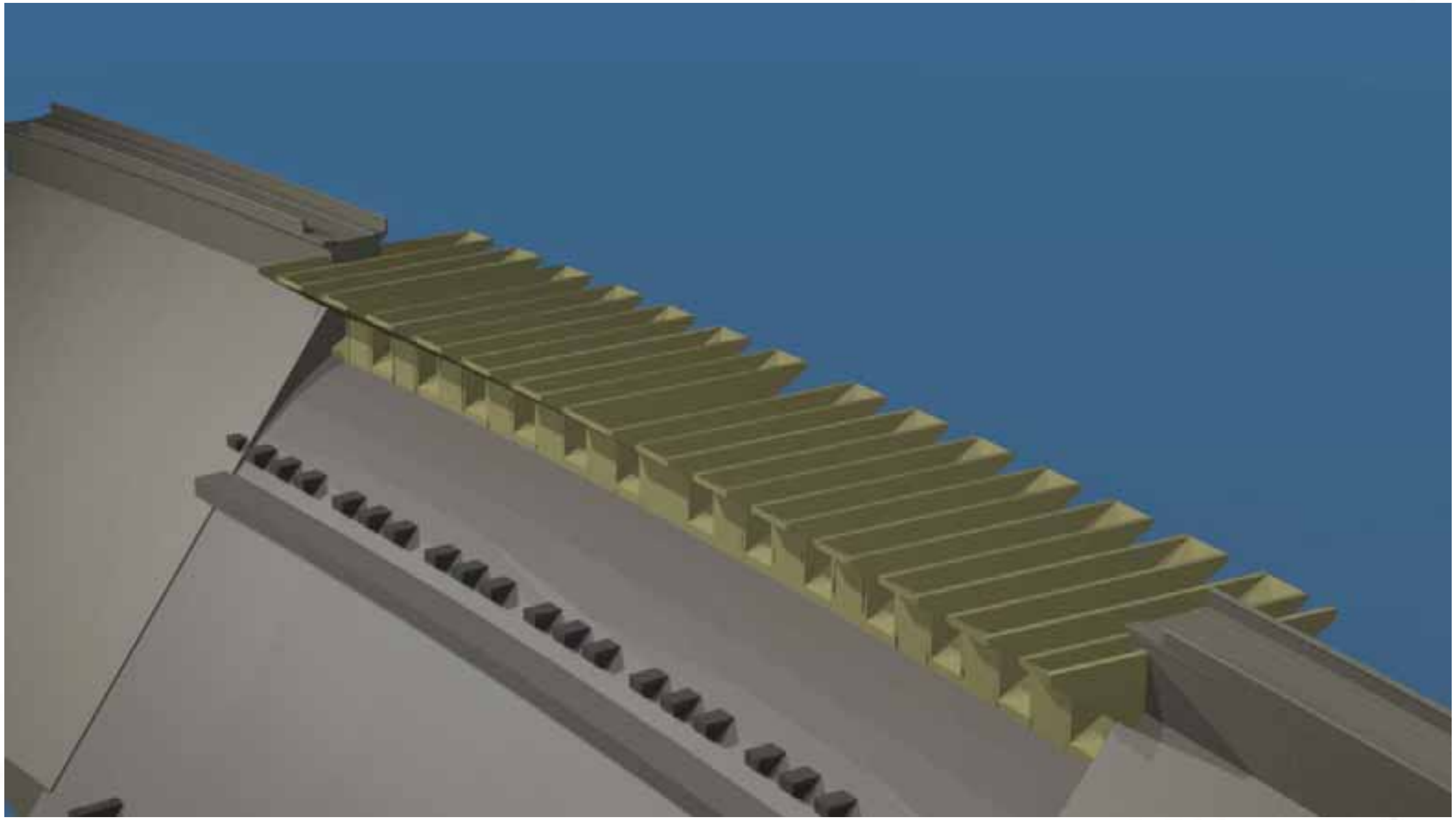
7,5 m cycle width all data

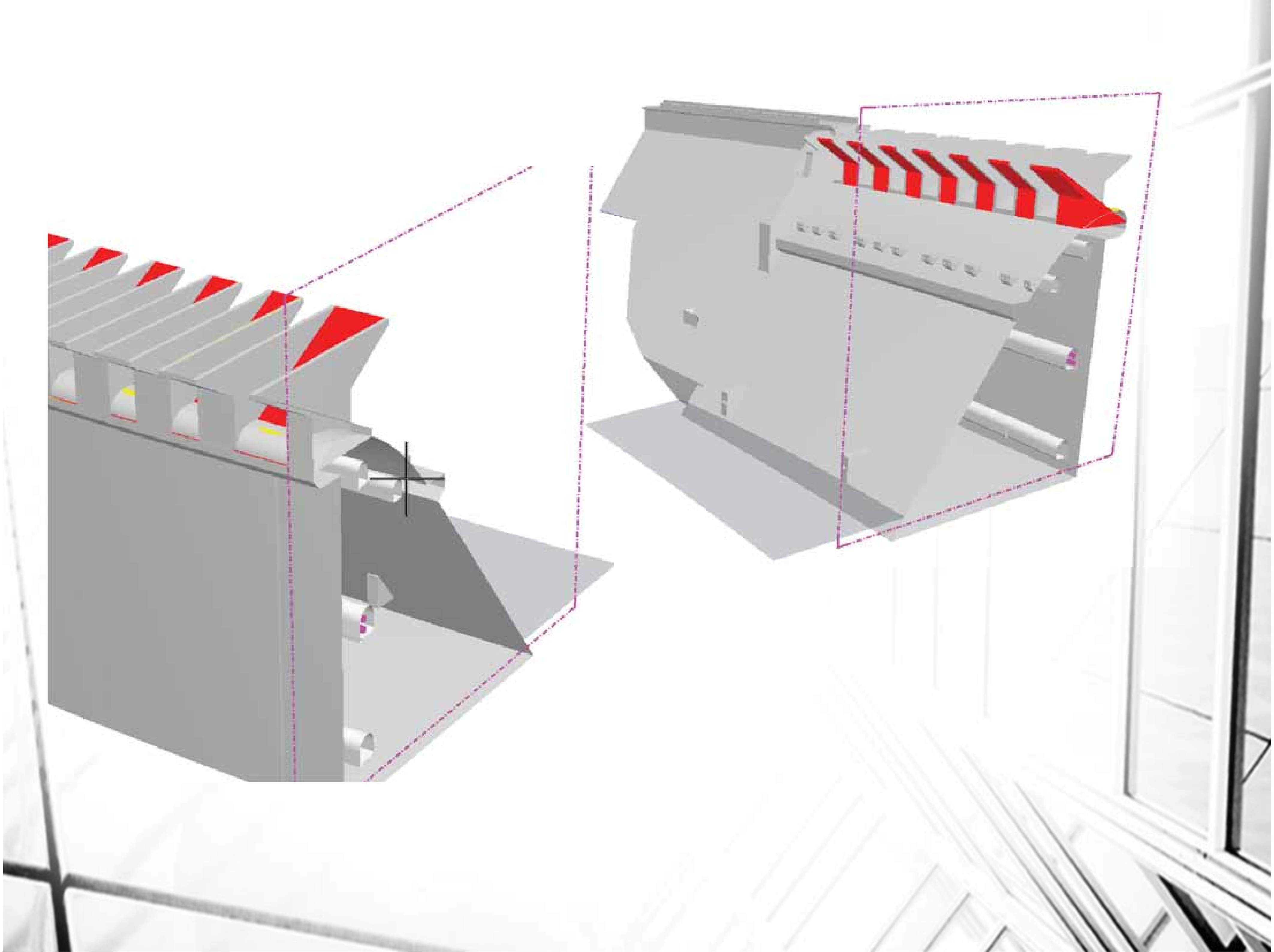


Discharge rating curve



3D MODEL OF PKW AND DAM WALL





CHALLENGES

- The main design considerations were to:
  - ❑ Configure a modified PKW to conform with the geometry of the existing ogee structure.
  - ❑ To position the PKW structure such as to ensure efficient contribution to the stability of the raised structure on top of the existing ogee.
  - ❑ To provide sufficient anchorage to the existing concrete. The mass concrete ogee structure was designed with a strength of 18 MPa, but concrete core tests indicated a strength of more than 34 MPa.
- By carefully reviewing design criteria, it was possible to obtain an optimised design

SUMMARY OF KEY POINTS

- The FSL of an existing dam can be raised using this type of structure creating additional storage capacity and yield from the dam
- Furthermore, additional spillway capacity can be obtained by constructing a structure like a PKW that does not require human intervention to operate it.

Thank You