Dam behaviour prediction

Suggested theme for the 16th ICOLD BW

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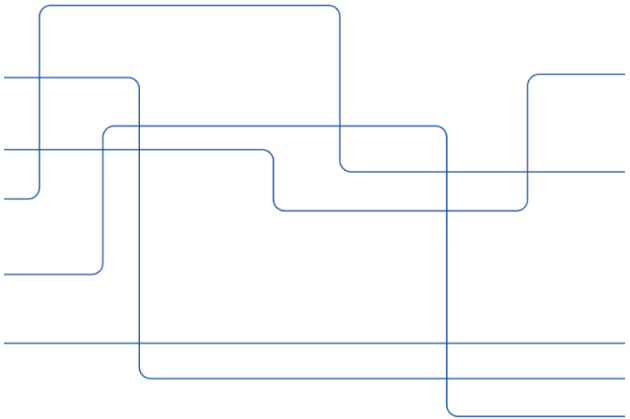

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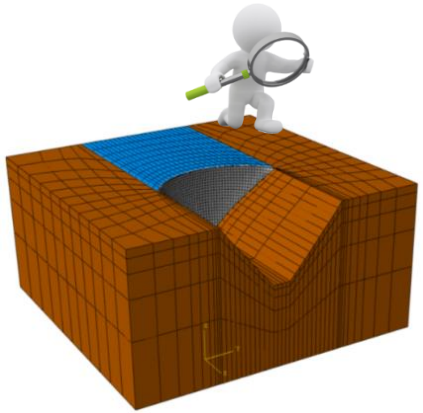
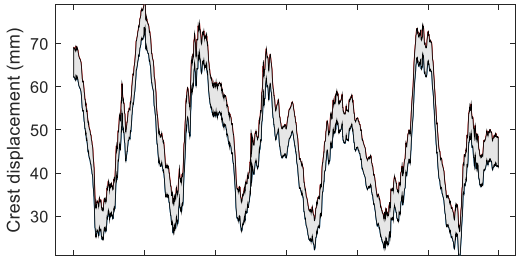


- Monitoring is a vital tool to detect anomalies in the dam behaviour and thereby minimize the risk of catastrophic failures.

- To assess the measured behaviour and classify it as normal or unexpected, a prediction model is required. For this purpose, different types of models are available, based on finite element methods or data-based mathematical approaches.
  - Measurement prediction is becoming more and more common today and is something that all dam engineers are encountered with.

- Vast developments have occurred in the field of prediction models over the recent years, especially regarding machine learning and numerical modelling.



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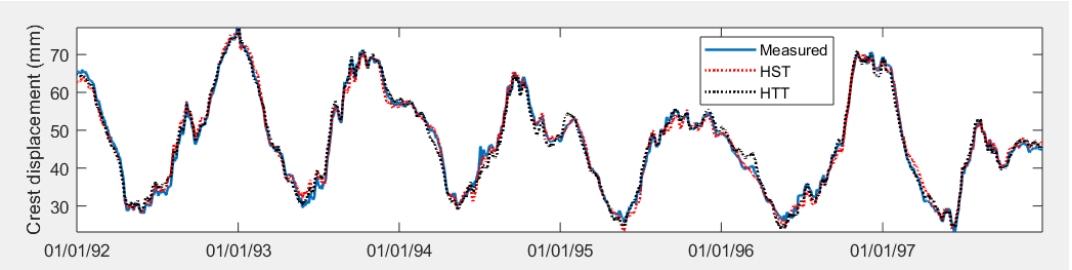
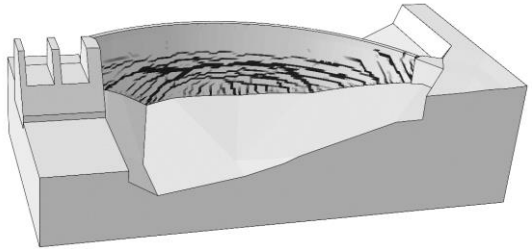


- 20 years ago, prediction of the measured behaviour of the Schlegeis dam was a theme in the 6th ICOLD BW.

- In the 14th ICOLD BW 2017, a theme was focused on predicting the dam behaviour, including cracking, caused by seasonal temperature variations.



- For the 2021 ICOLD Benchmark Workshop, we want to build from these experiences and see how modern tools can help in the prediction of dams

It is time to analyse the capabilities of the prediction models

Formulating team

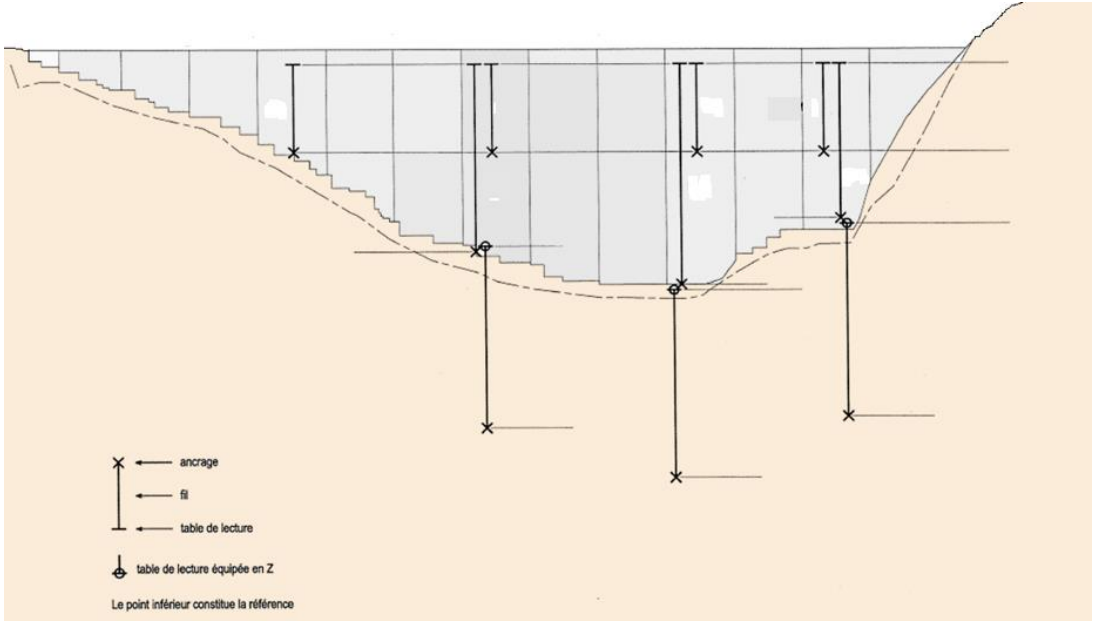
- Collaboration between two ICOLD Committees
  - Com. A (COMPUTATIONAL ASPECTS OF ANALYSIS AND DESIGN OF DAMS)
  - Com. Q (DAM SURVEILLANCE)

- The formulating team has experience in working with prediction models from different roles in the dam engineering field (universities, research institutes, dam owners, consultants, etc.)



Theme; Concrete arch dam

- As the case study, a concrete arch dam has been selected which has been extensively monitored for more than 30 years.
  - 40 m high
  - 150 m crest length
- Monitoring
  - Displacements
    - > Along the crest
    - > Half dam height
    - > In the foundation
  - Uplift pressure
    - > Several points near the concrete rock interface
  - Leakage
  - Temperature
  - Water level



Theme formulation

- Contributors will be given
  - Measured data for 20 years (air temperature, water level, displacements, uplift pressure and leakage)
  - Measured input data for the prediction period (temperature, water level)
  - CAD geometry model and FE mesh
  - Material properties

- All types of models are welcome to use (statistical, hybrid, deterministic, machine learning, finite element modelling) from the simplest to the most complex ones.

- For all cases, the formulators will provide excel templates that the contributors should use for submittal of their results

Cases

- The theme consists of three subcases

- **Case A – Model calibration**
  - Develop a calibrated model that accurately can capture the provided measurement period (training period)

- **Case B – Short term prediction**
  - Short term predictions (3 months) to predict the dam behaviour without influence of time dependent effects

- **Case C – Long term prediction**
  - Long term predictions (5 years) to predict the dam behaviour including influence of time dependent effects

Tasks

- For each case, the contributors should perform
  - Predictions
  - Define warning levels
  - Interpret the influence of external parameters (water level, air temperature, time dependent effects)
- For the different output variables
  - Displacements
  - Uplift pressures
  - Leakage
- Six tasks are mandatory while the remaining are optional

Mandatory *Optional*

		Case A: Calibration	Case B: Short term	Case C: Long term
Predictions	Displacements	Mandatory	Mandatory	Mandatory
	Uplift pressure			
	Leakage			
Warning levels	Displacements		Mandatory	Mandatory
	Uplift pressure			
	Leakage			
Interpretation	Displacements	Mandatory		
	Pore pressure			
	Leakage			

Overall view of the theme

- The theme has been developed to be a realistic case study similar to what the analysts normally encounters when predicting the measured dam behaviour.
  - The results of the contributors will be assessed regarding the accuracy of their predictions.
  - The contributors defined of warning levels will be assessed in terms of classification accuracy (precision, recall)

- Several different type of models are expected to be used in this theme
  - The contributors can chose their level of engagement, depending on the number of tasks that they perform and also depending on which type of model/models they use.
  - The required effort will be quite low for those contributors using regression models and hence making the theme accessible for many contributors.

- This theme is expected to attract both data analysists (such as surveillance experts) and FE analysists (numerical experts) to participate

Expected outcomes

- Improve our understanding of dam behaviour and the applicability of theoretical methods and models compared to the real response of a dam.
- Highlight the development that has undergone within the industry especially in data-based models over the last 20 years (since Schlegeis, 2001)
- Evaluate the pros and cons of different type of models for dam behavioural analyses.
- Make the link between the FEA and data-based models. In dam prediction models both types of methods are vital for evaluation of dams.
- Discuss and evaluate methods to define warning thresholds from predictions.

Thank you for your attention!

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