

Design of steel lined pressure tunnels and shafts (2009)

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Objectives

- The physical scaled model tests are needed to correlate the change of wave speeds produced by the different propagating modes during water-hammer phenomenon with the local change of stiffness of the test conduit.
- The prototype monitoring aims to propose a non-intrusive monitoring & control methods for detecting the presence, locations and evolution of possible "hot spots". These spots are characterized by a local and relative stiffness deterioration of the composite structure (steel-concrete-rock) of the shaft compared to its initial state at the beginning of the measurement campaign.
- The ultimate objective is to suggest new design guidelines for steel lined pressure shafts and tunnels through the validation of a theoretical model that considers the Fluid-Structure Interaction phenomenon.

Physical scaled model

Different configurations will be examined by changing systematically the position of the steel conduit flanges and by exchanging the steel pieces of the test conduit with other type of materials (PVC and Aluminium).

Prototype measurements

Two measurement locations have been defined on the high-pressure side of Grimsel II shaft. These measurement sections will be equipped with sensors to measure the transient phenomena during the daily operations of the pump/turbine groups.

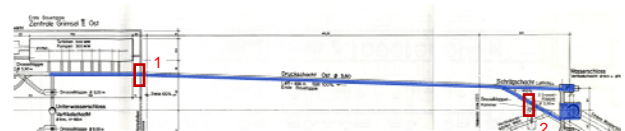
Theoretical model

A Fluid-Structure Interaction (FSI) model with axis-symmetrical behaviour and longitudinal displacement will be prepared. This model can detect the compressional water mode in water and the radial and axial propagation modes in the steel liner and in the far field rock zone. The time-dependent stress diagrams, resulting from the FSI problem, will be used as input for the deterministic and probabilistic fracture mechanics models for steel liners. The final results will be used to adapt some existing design procedures as in aeronautical field, nuclear power plants and long span steel bridges to steel liners design.

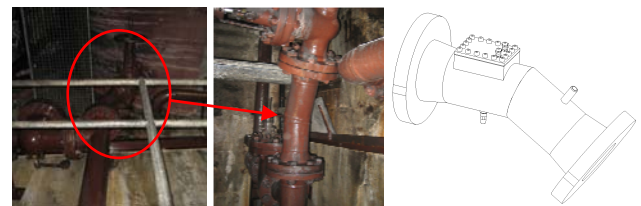


View from the upstream end View from the downstream end

Physical scaled model (test conduit)



Plan view of Grimsel II shaft

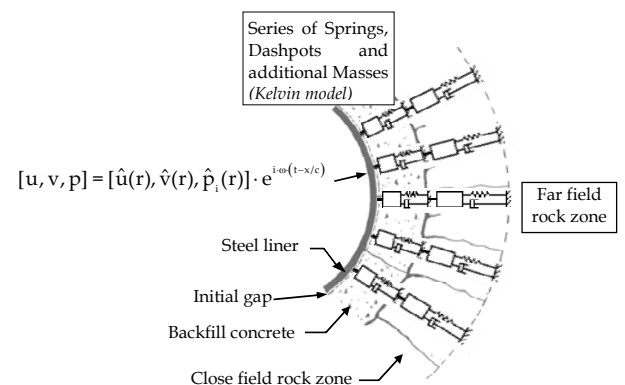


1) Downstream measurement section



2) Upstream measurement section

Prototype measurements (Grimsel II)



Theoretical model