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DAMDAMAGE1.0: A MATLAB 3DFE PROGRAM FOR NON-LINEAR ANALYSIS OF ARCH DAMS

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ABSTRACT

In this work it is presented a 3D finite element program (*DamDamage1.0*), developed using MATLAB, for the non-linear analysis of concrete arch dams under static loads, aiming to assess the structural safety. The non-linear calculations are performed based on an iterative numerical method using a stress-transfer technique (considering the redistribution of unbalanced stresses), and simulating the concrete's behaviour up to failure with a constitutive damage model using 2 independent damage variables: d^+ for tension and d^- for compression.

Keywords: 3DFE program, non-linear analysis, arch dams, damage model.

INTRODUCTION

The safety control of large structures, such as dams, is of the utmost importance during their whole life cycle, since the design phase until the end of the useful life. Large dams are civil engineering structures of high potential risk, given the personal and material damages that may result from a situation of structural collapse, as referred in the Portuguese Dam Safety Regulation (RSB, 2007). Furthermore, the specific case of arch dams is of high complexity, given their particular geometry and the specific nature of the dam-reservoir-foundation system's behaviour. Thus, it is essential to develop reliable numerical models to simulate the structural behaviour of dams and to support safety control studies. In the scope of this work, it is relevant to highlight: i) the Finite Element Method (FEM) (Zienkiewicz, Taylor and Zu, 2005), commonly used in developing dam-reservoir-foundation models; and ii) isotropic constitutive damage models (Oliveira and Faria, 2006) to simulate the material non-linear behaviour.

The safety assessment studies of large dams are generally carried out for scenarios concerning the stability of the foundation and the structural safety of the dam body (Pina, 1988), namely considering failure scenarios as the concrete strength decrease scenario, which has been studied in the CDD of LNEC for several decades, based on experimental tests with physical models and based on numerical models. The main goal of this scenario is to compute a global safety factor λ_S, which represents the maximum material strength decrease that can occur without causing the dam's collapse. This is equivalently calculated as the maximum multiplying factor (λ) of the applied loads.

This scenario is studied for the case of Cabril dam, a 132 m high double curvature arch dam with a crest length of 290 m between its abutments. The central cantilever has a maximum width of 19 m at the base and a minimum width of 4.5 m in the upper part, which is widened at the crest to allow the dam to be crossed by a road.

RESULTS AND CONCLUSIONS

The non-linear analyses were performed using the *DamDamage1.0* program and a numerical model of Cabril dam (Figure 1). The main results for the concrete strength decrease scenario are presented, considering the load combination with the self-weigth (SW) and the hydrostatic pressure (HP) at the upstream face (full reservoir situation).

The referred failure scenario is studied for a concrete with $f_t^+ = 3$ MPa and $f_c^- = -30$ MPa as strength properties, and considering different constitutive laws to assess the influence of the softening phenomenon in the dam's global resistant capacity.

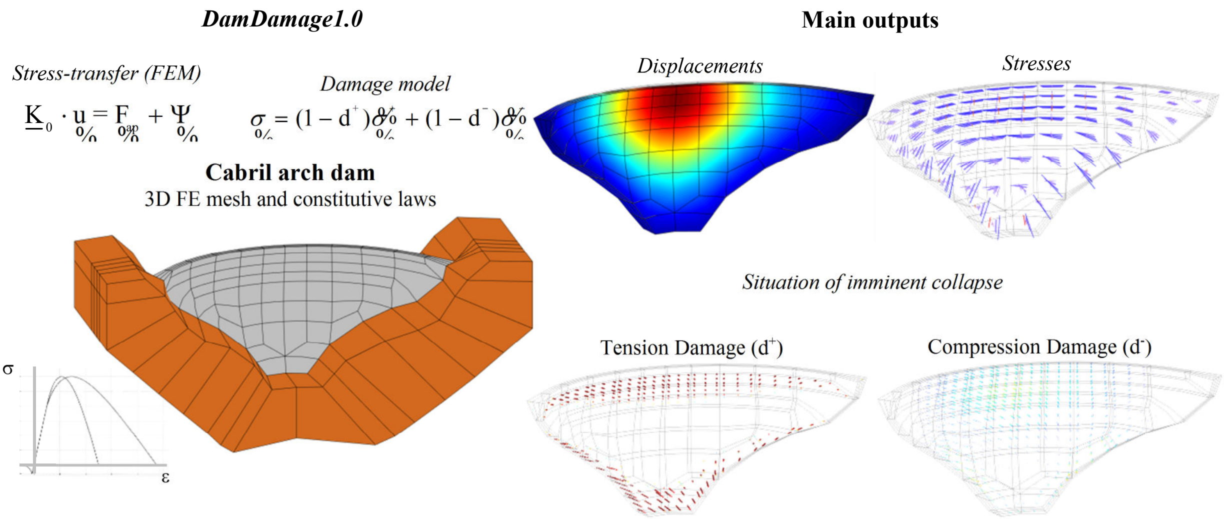

Fig. 1 - Schematic summary of the developed work

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