

SEISMIC MODELLING OF A MASONRY CHIMNEY

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Key words: material modelling, masonry, industrial chimney, seismic loading, Drucker-Prager, Willam-Warnke.

Summary. Different plastic/failure are applied to a masonry structure showing the difficulties to deal with masonry material and the results obtained for a masonry chimney under earthquake loading when two different criteria are used.

1 INTRODUCTION

Modelling masonry structures demands a deep knowledge of the distinctive features that masonry exhibits as a construction material and its behaviour in the structure where it is used.

Many different strategies can be adopted to model masonry, from micro-modelizations to macro-modelizations, through homogenization techniques¹.

Sometimes half-way approaches using continuum models representing the bricks and interface models for mortar are used to analyze masonry.

The influence of bed joint orientation on the strength developed by masonry in biaxial stress states is a matter of concern that can be considered through the orthotropic behaviour. But problems arise performing macromodelling approaches when the anisotropic or orthotropic behaviour are included and joined to any type of homogenization. There is a great complexity in formulating anisotropic inelastic models for masonry².

Many modern material models have been considered to reproduce unreinforced masonry behaviour, based on or combining both plasticity theory and damage theory.

Regarding to the failure criterion, many different criteria are being used in masonry depending on the goal of the investigation. For example, sometimes plastic criteria as the Drucker-Prager criterion are used in static analysis, failing to predict some results in dynamic analysis.

Failure criteria including cracking or damage in some sense seem more appropriate for this type of analysis. The softening behaviour that masonry can exhibit in seismic analysis due to crack propagation on head, bed joints and bricks is another problem to solve. If we add a damage scalar variable to this, one can get an idea of the problem that is being treated.

Furthermore, the solution dependency on the mesh size is a fact to take into account³.

Usually mortar in joints are considered the weakest part of the assemble brick-mortar and many are the possible kinematic modes that can lead to failure in this part as sliding, opening or closing of cracks, dilatancy. Furthermore, fracture on masonry can occur in different ways in mortar: bed joints, head joints, stepped along diagonal through bed and head joints. But bricks can also undergo splitting or cracks.

All these facts must be taken into account when performing non linear analysis on masonry structures.

In the present paper an experimental study on masonry chimneys is presented and the numerical approximation to fit structure parameters. Main arising problems are presented when the numerical model is used to reproduce a seismic calculation.

These problems are mostly related to the failure criterion and to the anisotropic behaviour that masonry exhibits, all involved in a non linear analysis.

When dealing with structures like the masonry chimney presented here, computer limitations can recommend the use of a macro-modelization for numerical analysis.

2 THE STRUCTURE AND THE MATERIAL

The structure considered in this work is a masonry chimney from the XIX century (see figure 1).

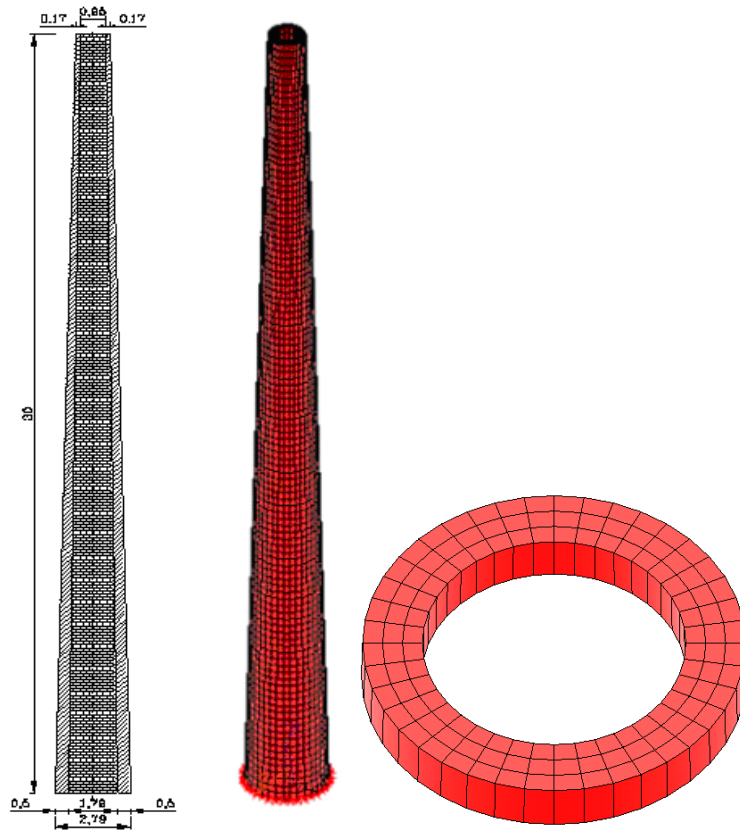


Figure 1. Geometric dimensions and finite element discretization.

A macro-model with an homogeneous material is used to show the results for the two approximations presented here. The following main characteristics are obtained based on the strength properties of the materials used in the construction of the industrial chimneys of that period³:

uniaxial compressive strength: $f_c = 637.500 \text{ N/m}^2$
 uniaxial tensile strength: $f_t = 196.200 \text{ N/m}^2$
 elastic modulus: $E = 5.886 \times 10^9 \text{ N/m}^2$
 Poisson coefficient $\nu = 0.2$
 density: $\rho = 1600 \text{ kg/m}^3$

3 THE ANALYSIS AND THE RESULTS

The two approximations presented are a plastic model using the Drucker-Prager criterion, and a smeared crack model using the Willam-Warnke criterion.

Both cases lead to a non-linear analysis.

A seismic loading has been introduced to the structure using both criteria.

Some of the results can be observed in the next figure (Figure 2):

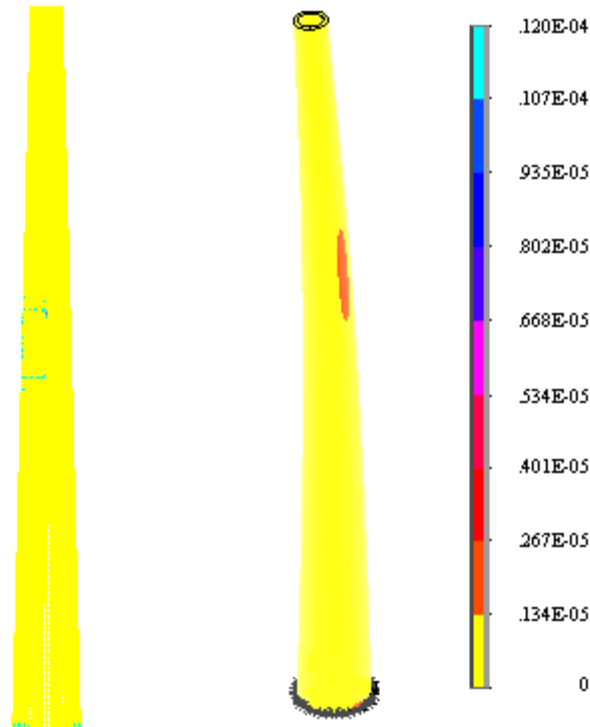


Figure 2. Results from the cracking (left) and plastic (right) criteria.

4 CONCLUSIONS

Modelling masonry structures is a difficult task that requires a deep understanding on the behaviour involved. In this work different types of approximations to the material modelling are presented and an example is shown for a particular structure when an earthquake occurs.

The structure is an industrial masonry chimney where two different plastic/failure criteria are applied and different results are obtained.

Special care must be taken when adopting certain kind of behaviour or criteria to model the material in masonry structures.

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