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Determination of foundation settlements trought analysis of cracks in old masonry buildings.

Détermination du tassement à travers l'analyse des fessures dans un vieux bâtiment en maçonnerie.

In order to design structural reinforcements in old masonry buildings an appropriate knowledge of the actual state of stress, mainly due to dead weight and to foundation settlements, is required. As settlements are sometimes difficult to identify properly even by means of accurate in situ and laboratory tests, and complete historical reconstruction is seldom possible, an auxiliary procedure can be proposed. It is based on the simulation of the crack pattern present on the masonry walls, using a numerical model of the whole building.

This procedure was firstly proposed in Jurina et al. (1980) for the stability analysis of Palazzo della Ragione, a 13th Century building in Milan (Fig.1). The main steps are here described.

An accurate survey of the existing cracks and their openings was previously prepared while complete information about geometry, loads and constitutive laws of the materials was introduced in a finite element model of the structure (Fig.1).

As a first approximation, masonry was considered as orthotropic elastic and the main cracks were introduced simply disconnecting the nodal points.

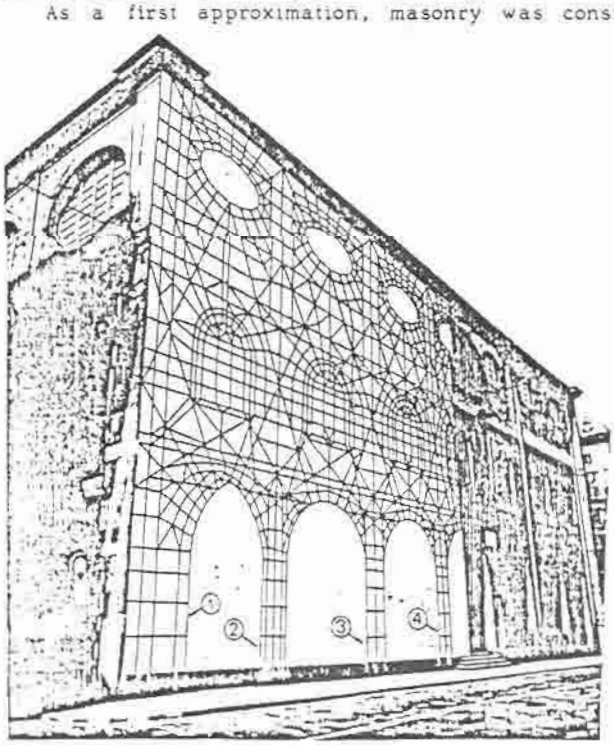

FIG.1 - Palazzo della Ragione in Milan (Italy) and adopted Finite Element model.

Unit distortions imposed to the basis of each column cause relative displacements of the opposite sides of all the cracks, which can be calculated and recorded. This was done for every column and for three different types of distortions, i.e. vertical settlements, horizontal settlements and rotations. If we amplify properly the effects of each unit settlement, it is possible to obtain, by addition, a distribution of openings in the cracks as similar as possible to the actual one.

COLUMNS	1	2	3	4
VERTICAL SETTLEMENTS [CM]	3.60	.14	0.	.38
HORIZONTAL SETTLEMENTS [CM]	.10	0.	0.	0.
ROTATIONS [DEGREES]	0.	.49	0.	0.

FIG.2 - Computed settlements in the identification process.

A simple procedure, based on the least square method, allows to find the amplification coefficients which minimize the discrepancy between calculated and observed response of the structure. In fig.2 the obtained settlements distribution is reported. The calculated crack pattern reproduces the actual one in quite an accurate way. It can be observed that the main damages are principally due to an anomalous settlement of column 1 and to a remarkable rotation of column 2 caused by the horizontal thrust of the no-constrained masonry arches. Repeating the same procedure for the adjacent masonry wall the identified settlement of the common corner column (column 1) is practically the same. The calculated out of perpendicularity displacements of the walls are in good agreement with the measured ones in both cases. Geotechnical in situ tests have also confirmed that the nature of the underlying soil is particularly poor expecially under the corner zone.

Jurina L., Bonaldi P., Rossi P.P., (1980). Experimental and numerical investigations on the damages of Palazzo della Ragione in Milan. (in italian). Proc. Nat. Cong. Geotech., Firenze.