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VARIATION OF INTERNAL FORCES USING ARTIFICIAL NEURONAL NETWORK

BY

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Abstract. Color maps for normal and tangential tensions, for a masonry wall under a dynamic action, are used as input dates into artificial neuronal network (ANN). The advanced modeling software with finite element used for this model is ANSYS. The mansory wall has been discretized with the steps:10 cm, 7.5 cm, 5 cm, 2.5 cm, 1.25 cm and 1 cm. The numerical value of internal are used to obtained the way how they varies.

Keywords: FEM; meshing step; internal forces; artificial neuronal network; back-propagation algorithm.

1. Introduction

In the last years, the numerical modeling has become an area highly studied for researchers with the development of modern computing technology, that allow programs using parameters and networks of mesh as fine to get results closer to reality .

Mathematical modeling of a structure subjected to dynamic actions requires a description of the system in relation to a small number of parameters.

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By reducing the real system using differential equations in time and space and by applying contour conditions a mathematical model is obtained. Although the model has an infinite number of degrees of freedom, imposing that the number of degrees of freedom to be finite, a numerical simulation is obtained.

This process of reducing the number of degrees of freedom is called discretization. The meshing elements used are proportionate, internal angles have values less than 180 degrees and are very low in the vicinity of singular points (holes, cracks, corners, etc.), the solution being continuously changing.

SAP, ALGOR, ANSYS, RDM are computing programs based on finite element method that allow the modeling of masonry structure. Finite element method implementation includes two stages: preprocessing and postprocessing. Between the two stages there is a process of assembling and solving the system of equations. In the preprocessing stage a geometrical finite element model is constructed, the loads and bearing conditions are declared. Post-processing stage involves sorting and displaying the results.

2. Case Study

Spatial tension and strain has been studied for a masonry wall under a dynamic action (Fig. 1), using the advanced modeling software with finite element, ANSYS.

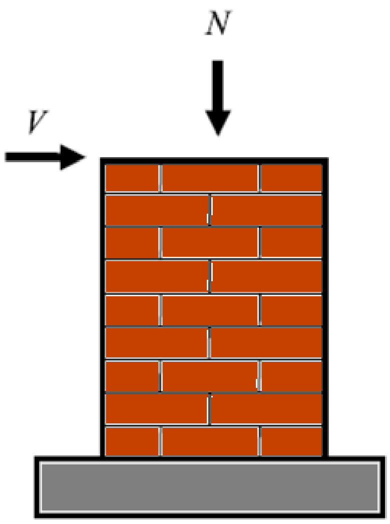

Fig.1 – Masonry wall under a dynamic action.

Geometric characteristics of the masonry wall are: length, L = 1 m, height, H = 3 m and thickness, b = 0.375 m. Mechanical characteristics of the masonry wall are: elasticity module, E = 3,000,000 kN/m^2, Poisson's ratio, ν = = 0.2 and brick density, ρ = 22 kN/m^2.

The masonry wall is geometrically symmetric. By applying the loads, vertically, N = 1,000 KN and horizontally, V = 100 KN, the model can no longer be regarded symmetrically (Fig. 2).

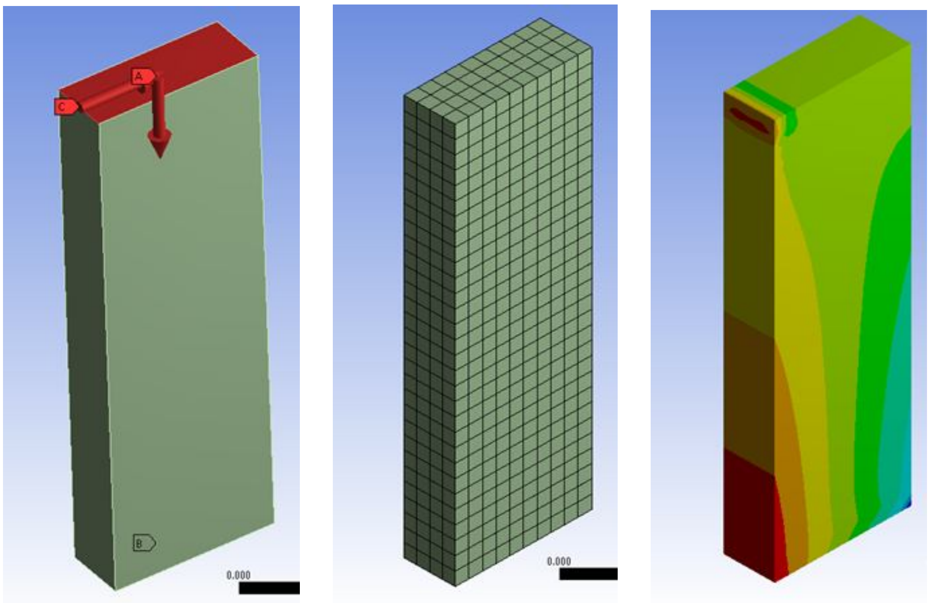

Fig. 2 – The masonry wall model in ANSYS.

The structure can be represented as a multitude of finite elements. The analysis accuracy depends on the number of used items and the type of motion. Thus, this model has been discretized with the steps: 10 cm, 7.5 cm, 5 cm, 2.5 cm, 1.25 cm and 1 cm.

Both in modeling and getting solutions, a number of approximations appears, which involves deviations from the exact solution. Among the most important sources of error include: conceptual errors, approximations in the geometry of real structure, loads, bearing conditions, finite element approximations, FE distortioned form, truncation errors in the calculation process.

Also, the efforts and tensions determination introduce additional errors due to approximations. Nodal displacements are the first unknown values obtained after finite element analysis. The rest unknown values involve more computing mathematical operations, and therefore more rounding errors. For each item, in some points and certain directions, the tensions are determined in nodes by applying arithmetic average of nodal tensions for all elements connected to each node.

3. Artificial Neural Network

The artificial neural network used for this type of problem has the following features:

a) the training algorithm is back-propagation;

b) the transfer function used for this type of problem is the sigmoidal function;

c) the rate of learning is located in the [0÷1] interval;

d(the error is recommended to have the value under 0.1;

e) the separation of the images into regions requires the use of the Levenberg-Marqmardt's algorithm.

The article *Determination of internal forces using artificial neural networks*, Pandelea A.E. *et al*. shows very detailed how to use the program *ISANNIF* (intelligent system artificial neural network internal forces).

Color map for normal tension (Fig. 3 *a*) and that for tangential tension (Fig. 3 *b*), from ANSYS program are used as input into artificial neuronal network (ANN).

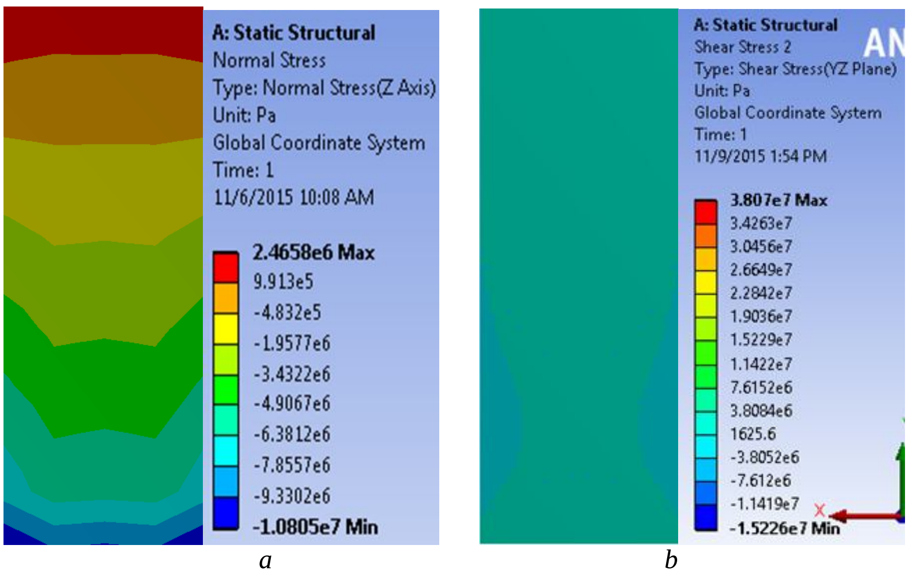

Fig.3 – Color maps and tension numerical values: axial force (*a*) and shear force (*b*) for meshing step of 10 cm.

After training the network (Fig. 4), results the numeric values of axial force and bending moment, for meshing step of 10 cm, $N = -1{,}015.47$ kN and $M = 295.86$ kNm. Proceeding likewise, results the numeric values for shear force, for meshing step 10 cm, $V = -100.3547$ kN.

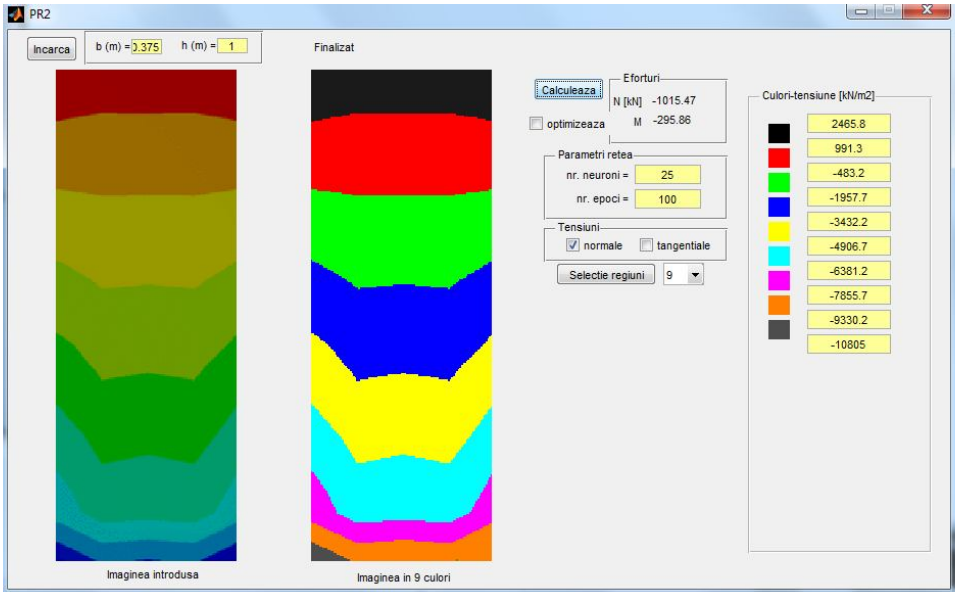

Fig. 4 – Determination of axial force and bending moment using *ISANNIF*.

Table 1
Numerical Values of Sectional Effort for Several Meshing Steps

Meshing step, [cm]	σ_{max} kN/m^2	σ_{min} kN/m^2	τ_{max} kN/m^2	τ_{min} kN/m^2	*N* kN	*V* kN	*M* kNm
10	2,465.8	–10,805	3,807.0	–1,530.2	–1,015.9	–93.15	–290.12
7.5	3,110.3	–11,639	5,142.5	–2,041.6	–1,019.3	–95.98	–294.54
5.0	5,786.2	–13,019	4,520.0	–8,954.0	–1,021.6	–98.97	–299.02
2.5	14,239	–15,655	15,240	–10,037	–1,023.5	–99.80	–300.12
1.25	31,139	–19,330	30,453	–12,176	–1,024.5	–100.35	–300.94
1.0	39,582	–20,679	38,070	–15,226	–1,025.3	–101.65	–301.07

Internal forces are also determined for other meshing steps, thus the numerical values are centralized in Table 1.

Using the numerical value of internal forces meshing with passes made at this model they were obtained graphic. For all three graphs the internal forces variation is curvilinear (Figs. 5,...,7).

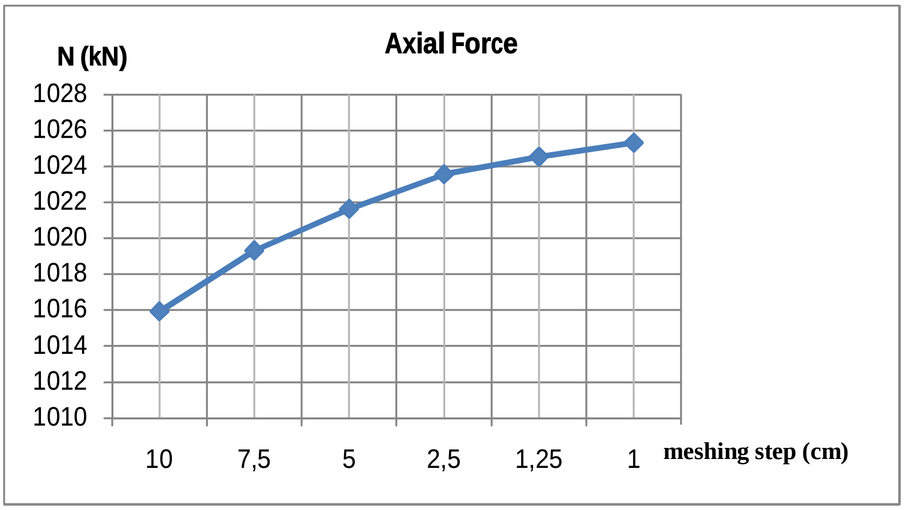

Fig. 5 – Curvilinear variation of axial force.

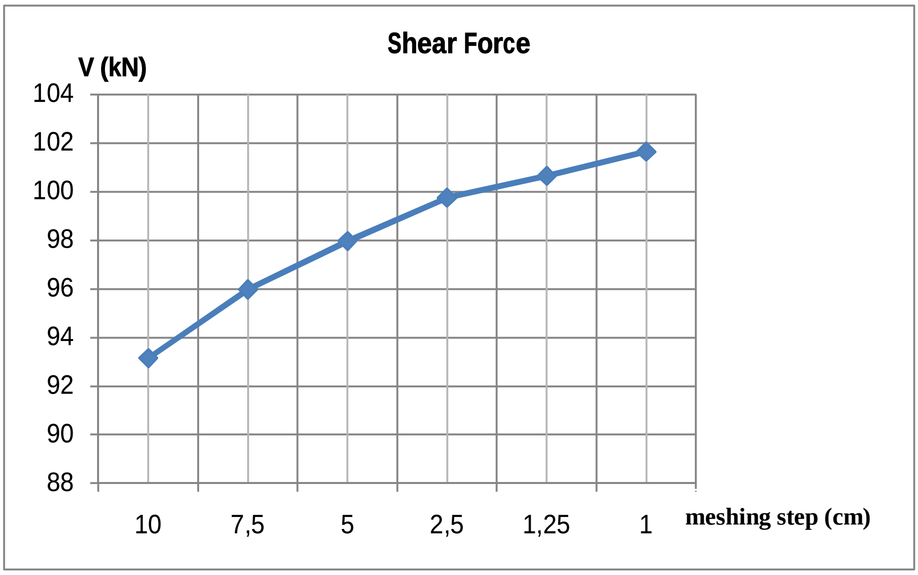

Fig. 6 – Curvilinear variation of shear force.

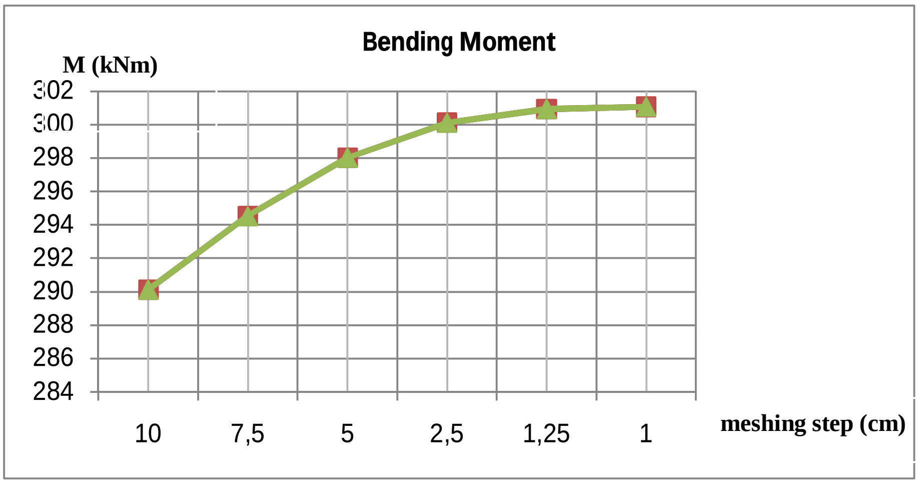

Fig.7 – Curvilinear variation of bending moment.

4. Conclusions

After modeling the masonry wall with the finite element analysis program *ANSYS*, the resulted maps of tension for a number of meshing steps are used to train the program *ISANNIF*, which determines the numerical values of axial force, the shear force and the bending moment.

Due to rounding errors that occur by determining the tension, the numerical values of the internal forces for different meshing steps are not the same. Comparing the numerical values of the internal forces for the biggest meshing step used and the lowest step, has registered a difference 9.39% for axial force, 8.50% for the shear and 10.95% for bending moment.

Reducing the effect of approximation errors, there aren't indications of general applicability, so far, every user of the program, knowing the source of the error and how they influence the final results of the analysis with finite elements, adopt certain principles in order to obtain an acceptable solutions.

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VARIAȚIA EFORTURILOR SECȚIONALE FOLOSIND REȚEAUA NEURONALĂ ARTIFICIALĂ

(Rezumat)

Hărțile cromatice ale tensiunilor normale şi tangențiale pentru un şpalet de zidărie supus acțiunii dinamice, sunt folosite ca date de intrare în rețeaua neuronală artificială (ANN). Programul de modelare avansată cu element finit folosit pentru acest model este ANSYS. Şpaletul de zidărie este discretizat cu pasurile:10 cm, 7,5 cm, 5 cm, 2,5 cm, 1,25 cm şi 1 cm. Valorile numerice ale eforturilor sectionale sunt folosite pentru a determina modul cum acestea variază.