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A 2-D NUMERICAL MODEL TO ANALYZE STRESS DISTRIBUTION IN A SOIL MASS DUE TO APPLIED LOADS

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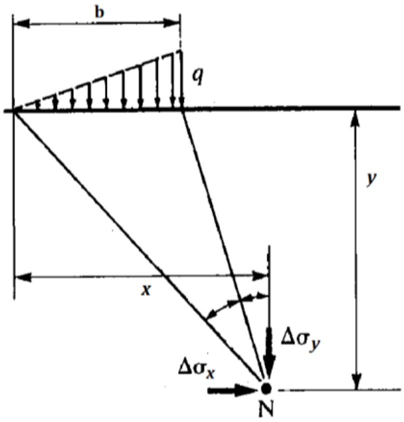
Interrelationships dependency of stresses and strains [1] have been of great potential value to civil engineers when settling the continuous stress redistribution within the soil caused by externally applied loads [2]. For the elastic theory to be applied in soils there must be constant ratios between stresses and the corresponding strains, a requirement that goes beyond the scope of the lineal elasticity. Stress distribution depends on the thickness and homogeneity of the soil mass, the size and shape of the area to be loaded and the mechanical properties of the soil. Stress arrangement in depth determines the magnitude of the settlements; this have to be numerically determined, except in few cases in which it can be analytically solved from the works of Boussinesq [3].

For any kind of 2-D distributed loads, this communication presents a numerical model capable to provide accurate and fast computationally, steady state solution of stresses and strains in a finite and semi-infinite mass of soils. The model is based on network simulation method, a powerful numerical tool that has already been successfully applied in other engineering problems; heat transport, electrochemical reactions and transport through membranes [4]. In the model, the addends of each one of the spatially discretized governing equations, derived from the PDEs, are assumed as electric currents. These are balanced in a common node of the elementary cell. To implement the electric components of the circuit, constitutive equations of resistors and capacitors are used. On-lineal or coupled addends, as well as complex boundary conditions, are implemented by software using controlled current source. In this way, very few components are used and, as a consequence, very few programming rules are required for the implementation of the model. Once this is designed, it is run by the code. Post-processing data is made with Matlab.

The 2-D mathematical model is formed by Navier-Stokes equations plus the equations that define the boundary conditions in terms of forces and/or displacements. The full communication will contain the governing equation as well as a detailed description of the network model. To check the powerful and reliability of the proposed model, applications to uniform and triangular pressure distribution on an infinite strip are studied. Stress iso-lines along sections of the domain are presented and compared with the analytical solutions derived from Boussinesq. Deviations and errors caused for the mesh size as well as for the geometry limits of the domain are also reported in order to give reasonable and approximated numerical solutions of the model.

For the case of the triangular pressure distribution given in Figure 1a, using the finite equivalent domain whose geometry is shown in Figure 1b, Figure 2 shows the numerical and analytical solutions of vertical stresses. Elastic parameters of the soil are: E (modulus of elasticity) = 3500 kN/m^2, ν (Poisson´s ratio) = 0.3.

a)



b)

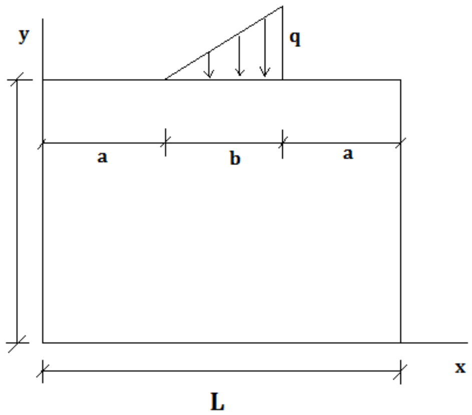


Figure 1. Left (a): triangular pressure distribution; right (b): equivalent finite domain

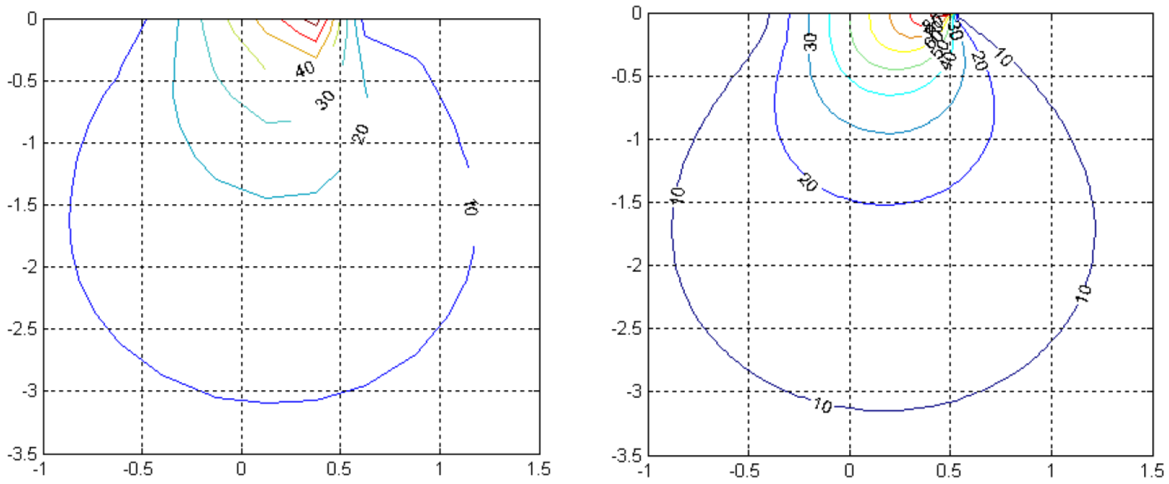


Figure 2. Distribution of stress iso-lines for a mesh grid of 20×20 volume elements.
L = H = 5 m, q = 100 kN/m, b= 1m

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