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Reconstruction of elastic stress fields in adjacent tectonic plates from discrete data on stress orientations

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Development of mathematical background for modelling elastic stress fields in regions separated by major faults or tectonic plates margins is the main aim of this work. Only data on modern stress orientations (available through the World Stress Map Project www.world-stress-map.org)) are used as input and no data on stress magnitudes are employed. The following assumptions are accepted:

- Adjacent regions are elastic isotropic plane domains (curvature is neglected)

- One of three principal stresses is assumed to be vertical and normal to the domains

- Stress vector is continuous across the regional boundaries

Data on stress orientations are mostly available in relatively narrow zones associated with the regional boundaries although orientations can also be known within the regions. This necessitates combining two approaches developed earlier for solving elastic problems with known stress orientations but unknown stress magnitudes. First approach deals with the boundary value problem (BVP) formulated in terms of principal directions. This type of BVP has no unique solution in general case, however, the number of independent solutions is identified by analysing the distribution of stress orientations along the entire boundary (Galybin & Mukhamediev, 1999, *JMPS*). Then the total solution of the BVP is constructed as a linear combination of independent solutions and hence it contains several arbitrary real constants. Second approach is applied when principal directions are known at discrete points located within the considered domain. In this case the problem does not belong to any type of BVPs and its

solution is sough by a Trefftz-type method applied for complex potentials (Galybin & Mukhamediev, 2004, *IJ Solids & Structures*).

Two boundary conditions, BC, are used in mathematical formulation. The following BC determines the number of independent solutions $(T_{22}-T_{11})\sin 2\varphi_k+2T_{12}\cos 2\varphi_k=0$, k=1…$N$. Here T_{ij} are in-plane stress components in a reference frame Ox_1x_2 and angles φgrepresent principal directions (the angle that the major principal stress constitutes with the x_1-axes), N is the number of domains. Another BC provides continuity of the normal and shear stresses components across the boundaries, which does not introduce additional solutions.

As an example, the analysis of stresses in the region near Sumatra has been performed. Sunda trench represents the only boundary taken in consideration; other boundaries (between Australian, Indian, Sunda and Burma plates) are neglected due to continuity of the stress tensor evident from the data. The analysis has shown that in each of two domains (representing adjacent parts of Indo-Australian plate and the union of Sunda and Burma plates)

- Stress trajectories are unique

- Maximum shear stress (acting in-plane) depends on an unknown multiplicative constant

- Solution for stress components includes two arbitrary real constants

The arbitrary constants cannot be identified from stress orientations alone but they can be determined if stress magnitudes are known at some locations.

Computations have been performed to plot the fields of stress trajectories, maximum in-plane shear stresses and mean horizontal stresses. In particular, the results for the Sumatra region reveal that the epicentre of the 26/12/2004 earthquake is associated with the low level of maximum shear stress, which provides an insight on the generation of devastating tsunami.

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