Discrete Modelling of Blockwork Structures
Application on Admiralty Breakwater Alderney

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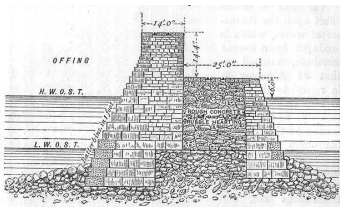
Motivation

During the 19th and the early 20th Century, many coastal structures (breakwaters or sea wall) were built from blockwork (dry-stacked masonry) made up of either natural stone or cast concrete blocks.

One example for blockwork structures which is still in use is the Admiralty Breakwater Alderney (Channel Islands). This blockwork coastal structure suffers recurrent damages, whereby it is assumed that wave impact pressure enter water filled cracks and generate pressures acting inside of the structure, causing the removal of single blocks seawards.



Structural influences

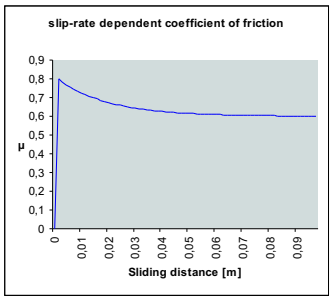
The forces preventing the blocks from being moved seawards by this big horizontal forces are the frictional forces between the blocks, resulting from the vertical stresses on the surfaces of the blocks and the friction between the surfaces. The inclination of the sea front of the structure was increased during construction, also was a parapet installed on top of the structure; possibly to increase the vertical stresses and therefore reduce the effect of wave impacts.

Modelling techniques for masonry

The common techniques to model masonry (either with mortar-filled or mortar-less joints) can be differed in homogenized models and discrete models. While the constitutive laws of homogenized models smear the behaviour of joints and units of a composite structure, discrete models allow to model the joints and the units separately with their original geometry and behaviour and therefore to investigate the stresses on the surfaces of single units.

The discrete model of the breakwater

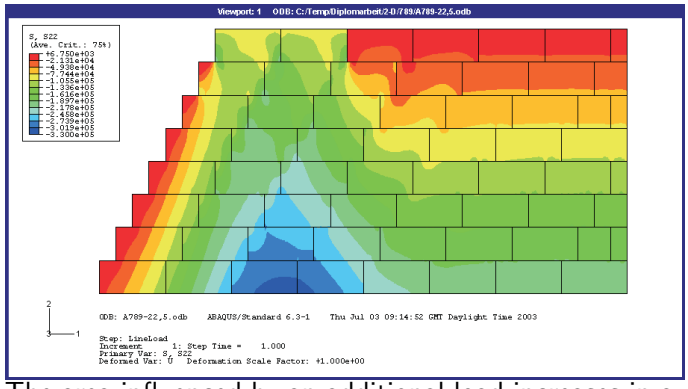
For the discrete model of the structure the finite element package ABAQUS is used. The blocks are modelled as elastic units with the material properties of granite and their original geometry. To model the interactions between the blocks the frictional properties of a brittle material like granite are included in the numerical model. The interaction properties normal to the surfaces are modelled as a so called hard-contact (any compressive stresses but no tensional stresses can be transmitted) for all joints.



The vertical joints are modelled to be frictionless, while the horizontal joints are modelled with a slip-rate dependency for the coefficients of friction, including an initial elastic slip.

Vertical stresses within the structure

It is shown that the parapet does not serve its purpose to increase the holding forces on the surfaces of the blocks on the seaside face of the breakwater.



The area influenced by an additional load increases in a blockwork structure with the load. This effect is caused by a combination of block deformation and frictional forces transmitted between single blocks.

Adjustment of the numerical model

The need to proof the used numerical model is caused by the complex combination of block deformation and surface interactions. As the results can not be verified with analytical calculations, experiments with photoelastic material are made. The experiments also show that small irregularities in the block size have a big influence on the stress distribution, what could not be included in the numerical model without unreasonable expense.