3D-PARAMETRIZATION OF BRICKS IN FASTENING TECHNOLOGY

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SUMMARY

The testing of newly developed fasteners can become very expensive. Numerical simulations can help to significantly reduce the testing costs. The huge variety of different brick stones requires an adequate modeling tool. This paper presents such a modeling tool.

Keywords: Masonry structures, fastening technology, 3D modelling, Numerical Analysis Structural analysis, Masonry, timber and composites

1. INTRODUCTION

In fastening technology, the behaviour of a fastener and its foundation are a very crucial point. Before introducing new fasteners, a manufacturer has to show that his product meets certain criteria. This is done by extensive testing both during the research phase and for the certificate of approval. Unfortunately, testing methods are very expensive and consume a lot of personnel and material resources. As in many other engineering areas, numerical analyses could support the manufacturer because they are easier to perform and cost less than lab testing. Unfortunately, accurate modelling of masonry structures is an almost unsolved task yet. This is due to the complex, almost infinite variety of brick models. This thesis is an ongoing research project whose aim is to establish a modelling tool for bricks and masonry structures, primarily for the research engineer. The computer program should allow for free parametrization of brick holes' position, cross section, application of grids, etc. A three-dimensional model is generated which can be transferred to meshing programs and can be used in FE-programs in consequence. This last step enables the research engineer to analyse the behaviour of a brick assembly or even a complete masonry structure. Besides FE-calculations, first studies at the Institute of Structural Engineering at the University of Applied Sciences, Vienna, have shown that a plate-approach for bricks is feasible for certain 2D applications. The 2D and 3D parametrization will make it possible to perform accurate numerical analyses which will then be compared and verified against formerly done tests.

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2. REQUIREMENTS

The software to be developed shall allow for parametrization of arbitrary vertically or horizontally perforated bricks, place a fastener on any place and create a three-dimensional computer model of this. The 3D model can then be used to perform FE analyses.

Further, the software shall use a plate-approach for bricks as has been shown in (Wobornik, 1997). This implies an idealization of the geometric structure to a static model.

The primary concern in this project is the development of an easy and flexible research tool for the design of fasteners in masonry structures.

The following points summarize the main functionality:

- parametrize bricks with an arbitrary layout;
- set a fastener on any point both within bricks and joints;
- automatically derive the static model for a plate-approach;
- determinate the failure load;
- export the three-dimensional model to some common formats (e.g. SAT, STL, DXF, ...) for use in mesh generators and FE–programs;
- store the different brick layouts in a database for easy access.

3. BRICK PARAMETRIZATION

Due to the overwhelming quantity of different brick layouts, brick parametrization can become a complex task, depending on the individual brick type. Here are a few considerations concerning this issue:

- **Brick shape**
  In many cases, the brick sides are not smooth surfaces but they have furrows and convexities of different shape and depth. One must distinguish if they could be ignored for the calculation of the failure load or not.
- **Holes**
  Brick holes can have completely different shapes and dimensions. Even in relatively simple bricks there can already be several different holes.
- **Hole arrangement**
  Bricks have an enormous amount of different but mostly regular two-dimensional arrangements.

The important thing in this project now is that it follows a *hole-oriented* approach, instead of trying to model the solid parts of a brick. The hole-oriented method simplifies brick parametrization by a great deal since the holes are often arranged in regular patterns.

In order to establish modeling parameters, it is necessary to identify the important parameters that make up a brick. Starting from these parameters, it is possible to create a complete computer model. Thus, we derive a few basic parameters for a simple brick (fig. 1):

- **Brick shape**
  The absolutely predominant brick shape is a box–like shape. Thus we only need three basic parameters for the brick shape: length, width and height.
- **Holes**
  Brick holes have either rectangular, elliptical or an arbitrary polygonal cross section. The parameters are length and width; the two elliptical axes, and the x/y-coordinates, respectively.
- **Hole arrangement**
  Holes are organized in vertical and horizontal rows with a certain offset to each other. The offsets are regular most of the times and complete hole-rows can be generated simply by giving the number and offset.

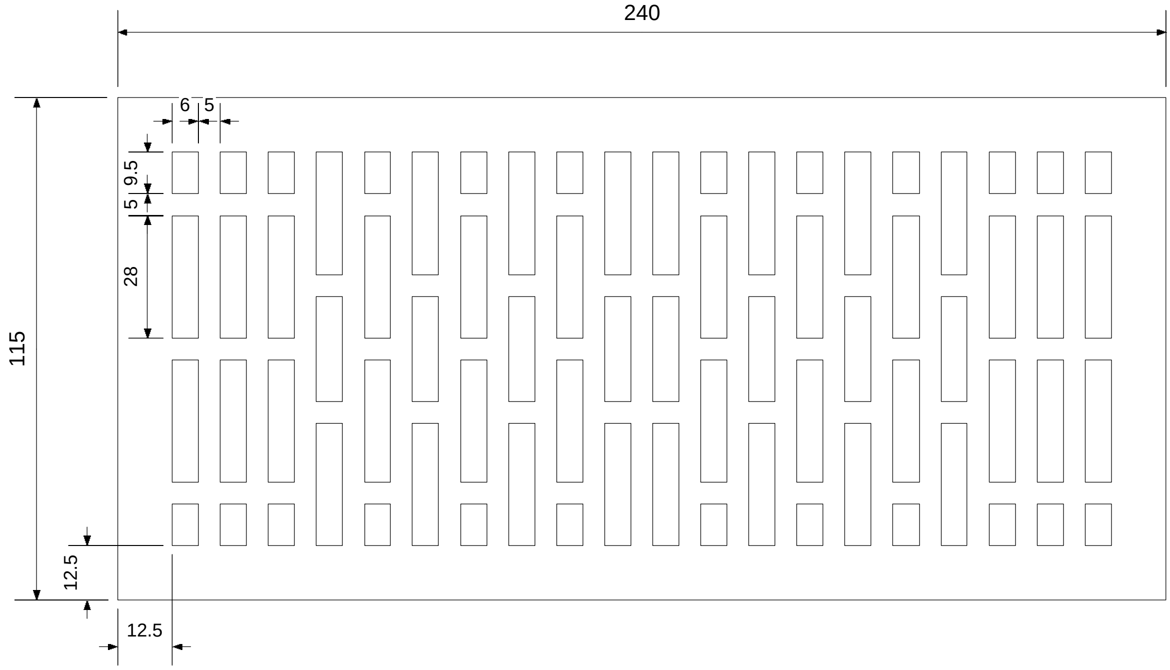

Fig. 1 A simple brick.

3.1 An example

To show the approach, we may now parametrize a (relatively simple) brick shown in fig. 1.

Brick dimensions

L	240 mm
W	115 mm
H	113 mm

Margins

top	12.5 mm
left	12.5 mm
right	12.5 mm
bottom	12.5 mm

Holes

hole	*l*	*h*
A	9.5	6
B	28	6
C	24	6

Hole rows

row	hole–offset
1	A–5–B–5–B–5–A
2	B–5–C–5–B

Complete brick

Having defined the above components, we may now define the complete brick, subsequently giving the complete row sequence (fig. 2). Fig. 3 shows a screen shot of the program's corresponding dialog.

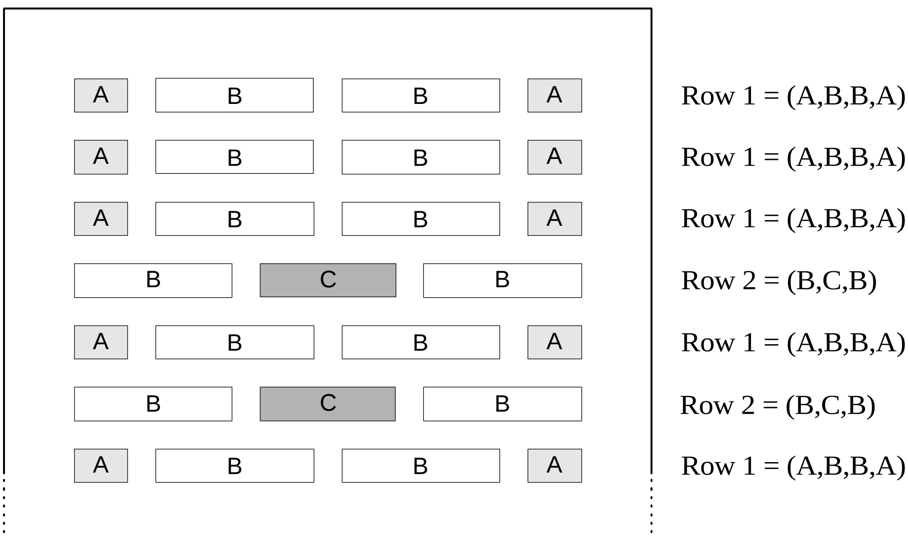

Fig. 2 The brick model

From the brick's cross section it is then easily possible to create a full three-dimensional model suited for external finite element programs.

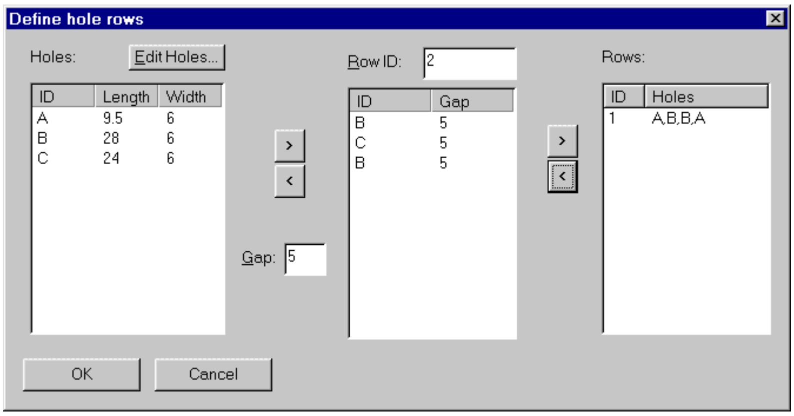

Fig. 3 Definition of the holes and rows in the software.

4. ANCHOR PLACEMENT

The brick definition is only the first step in a numerical simulation process. The user should then place an anchor at some point in the brick and let the computer calculate the failure load. To achieve this, the software must offer:

- **Easy geometrical handling**
  When placing the anchor, the cursor should 'snap' into important spots on the brick (e.g., middle of the hole, middle inbetween the holes, etc.). A WYSIWYG-interface („What You See Is What You Get") assists the user in this task and avoids clumsy number fiddling.

- **Derive the static model**
  (Wobornik, 1997) has shown that brick failure can be modelled through a plate-approach. The static model used is a fixed plate with a circular aperture (fig. 4). The software should automatically derive the static model, based on the hole and anchor parameters.

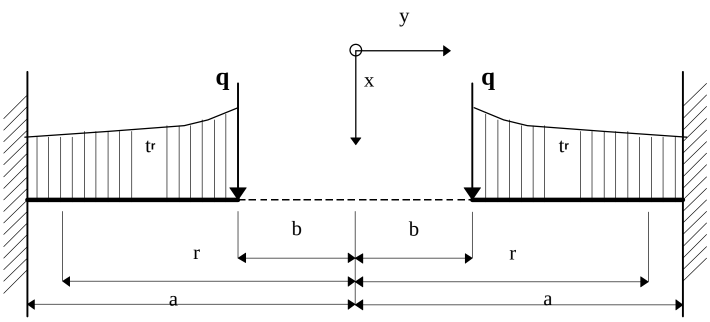

Fig. 4 Static model (Wobornik, 1997; Bares, 1971)

- **Handle calculation parameters**
  Of course, only *geometrical* data is not enough to perform a computation. We also need material parameters, control parameters, etc.

5. CONCLUSIONS

The software to be developed in this paper assists the research engineer in his investigations during the design of fasteners for masonry structures. Of course it must still be the engineer himself performing experiments carefully and control the numerical simulation accordingly. But the easy definition of an arbitrary brick geometry, combined with both implizit calculations and an interface to external FE-computations relieve him from elaborate tasks and let him concentrate on the actual problems.

6. REFERENCES

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