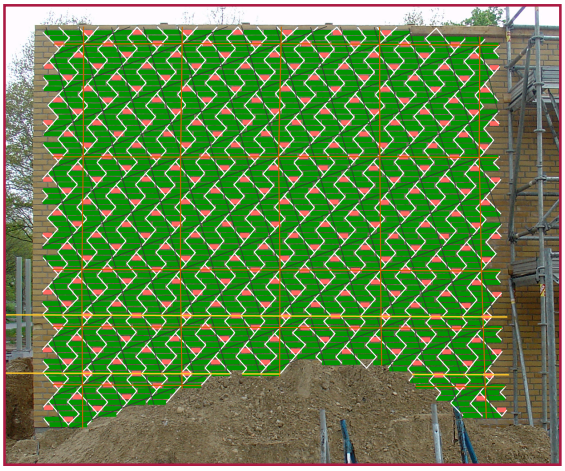
CEN Building Brick Pattern - Plane Symmetry Under Constraints

Center for Electron Nanoscopy in the Technical University of Denmark

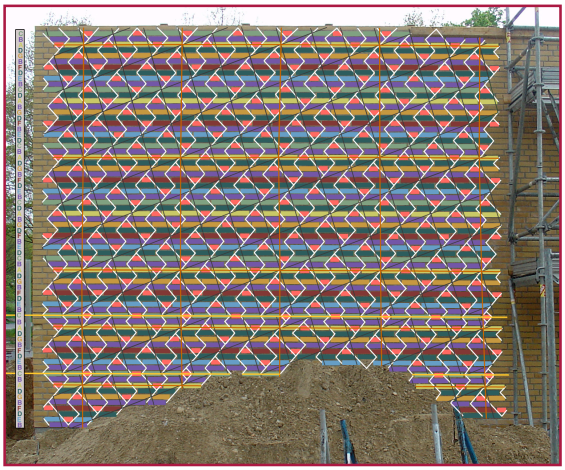
Under construction - photograph taken in April 2007

East wall

Symmetry of the brick pattern



Stacking fault



Stacking fault

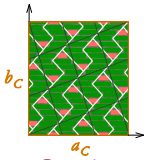
Unit cell

The CEN brick pattern (a type of Monk bond, or munkeforbandt - there are two stretchers between headers in alternate rows) consists of 7 distinct layers and a 20 layer repeat. The unit cell contains 2 small and 9 large bricks. The Cartesian unit cell contains 20 small and 90 large bricks.

Positions of diad symmetry elements

Of the 17 possible plane symmetry (or wallpaper) groups, the CEN brick pattern has plane symmetry $p2$ (arbifold notation 2222) and contains four diad symmetry elements in each unit cell. p refers to a primitive unit cell, while 2 refers to the highest order of rotation. There are no reflections or glide reflections.

The white lines show a motif formed by joining adjacent vertical lines of mortar. A stacking fault is marked using horizontal yellow lines. It can be described as a (0.5, 0.5) translation of the conventional unit cell or a (0, 0.5) translation of the Cartesian cell.



Cartesian unit cell

Alternative motif

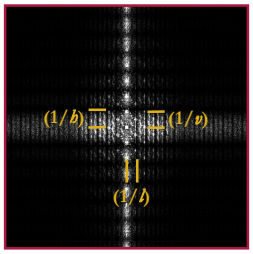
Layers A, C, E, F and G each repeat every 10 layers.
Layers B and D each repeat every 4 layers.

In the stacking fault, layers B and D are interchanged - all other layers remain in registry.

The bricks have length $l = 225$ mm , height $b = 55$ mm and depth $d = 105$ mm, and are rotated by 90° to generate the two sizes. They are separated by 11.5 mm vertically and 15 mm horizontally, resulting in an effective vertical brick height v of 66.5 mm and horizontal brick dimensions of $u = 240$ and $(u/2) = 120$ mm.

The conventional unit cell has parameters:
$a = \sqrt{(36v^2+u^2/4)} = 417$ mm; $b = \sqrt{(4v^2+9u^2/4)} = 384$ mm; $\gamma = 93.6°$.
The Cartesian unit cell has parameters:
$a_C = 5u = 1200$ mm; $b_C = 20v = 1330$ mm ; $\gamma_C = 90°$.

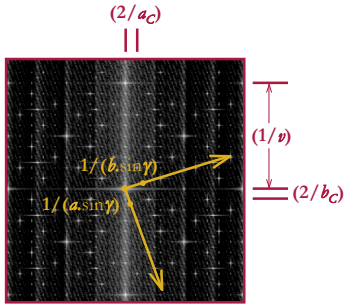
Fourier transform of the brick pattern



Fourier transform of the arrangement of bricks

The dark vertical and horizontal bands are associated with the sizes of the bricks l and b, respectively.

The white dots along the vertical axis are associated with the height of each layer of bricks v.



Center of the Fourier transform

The central part of the Fourier transform contains a complicated pattern of systematic absences, and features that are characteristic of the Fourier transform of a shear wave .

Poster by:
Rafal Dunin-Borkowski May 2007.
Discussions with Kevin Knowles, Andy Horsewell and Mihály Pósfai are acknowledged.

Further reading:
C.J. Stolze Møller: Murstensforbandter: 40 kodede og 2 ukodede, Erhvervsskolernes Forlag: Odense 1996.