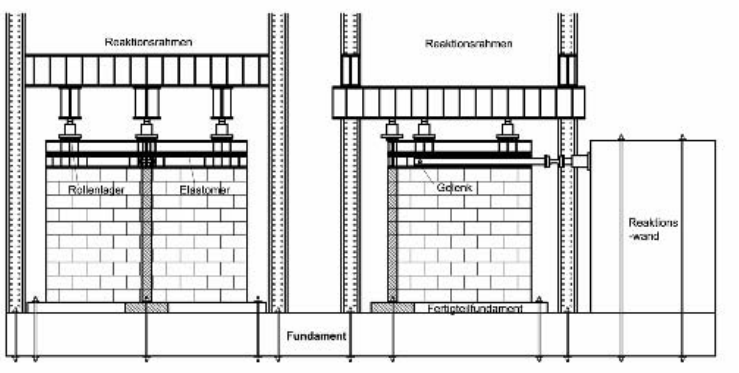
Experimental investigations of the non-linear load bearing behaviour of compounded shear walls made of unreinforced masonry under seismic loading

Introduction

Unreinforced masonry has been used for load bearing structures of residential houses in Germany since many decades. As a matter of the new national and international Codes for the actions on structures, especially regarding wind or seismic actions (e.g. DIN 4149 (2005), resp. EN 1998-1 (2006)), the commonly used design approaches for masonry can no longer satisfy the structural analysis. Nevertheless there have been no relevant damages reportet in masonry buildings in the German seismic areas in the past. One reason of this divergency results from the very conservative design approaches of unreinforced masonry in the existing codes. In particular, the influence of cross walls on the main shear wall at compounded wall sections is not yet considered adequate in the actual codes (DIN 1053-1 resp. EN 1996-1). At the Laboratory of the Lehrstuhl für Massivbau at the Technische Universität München, extensive experimental investigations had been performed, to get further acknowledge of the behaviour of compounded wall sections under combined vertical and horizontal loadings.

Experimental Investigations

The experimental part of this research projekt, which was funded by the Bundesamt für Bauwesen and Raumordnung, contains wall tests on full scale compounded masonry walls. The test were carried out using different kind of masonry materials (clay and calcium silicate), different unit sizes and varying geometric properties of the test specimen. Furthermore two different test methods, the static-cyclic testing method and the pseudodynamic testing method had been used.



Experimental test-setup

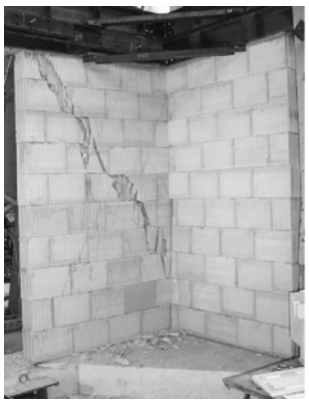
To examine the behaviour of a masonry structure under seismic loadings more realistic, the pseudodynamic test method with sub-structure technique was used. This test method contains two different parts: the experimental part and a numerical model of the rest of the structure (Sub-structure). The model described a typical german three storey terrace house (ground view: 10.5 x 6.0 meters), with RC slabs and load bearing masonry walls. Within the tests, only the main shear

wall in the ground floor of this building was tested experimentally, the rest of the structure was modeled numerically by the use of a 3-D finite element analysis program. The seismic loading for the tests consists of an artificial generated (according to DIN 4149 (2005)) ground acceleration time history with a duration of 10 seconds.

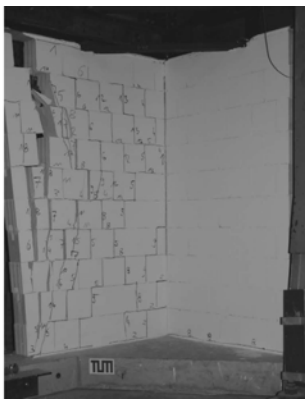
Conclusion

The results of the performed experimetal tests can be summarized as follows:

- Regarding the bending deformation of the cross wall, a deformation along the whole width of the cross wall was found.
- The used testing method (static-cyclic vs. pseudodynamic) showed an evident influence on the behaviour of the specimen (e.g. load-displacement hysteresis).
- The shape of the hysteresis curve (horizontal load vs. horizontal displacement at the top of the specimen) and the load bearing behaviour of the whole specimen are significantly influencend by the cross wall . The two different execution techniques connecting the two walls (a: shear wall and cross wall are built with interlocking bricks, b: shear wall and cross wall are build separately, only connected trough special perforated stainless-steel strips, which are bonded in the mortar of the horizontal joint) has a considerabel influence on the stiffness of the specimen under shear loading. Because of the wide variation of parameters within the test programme, a generally statement about the influence of the execution technique in respect to the horizontal load bearing capacity, the ductility and the energydissipation of a compounded wall could not be derived from the results.
- A decoupling of the two walls (shear wall and cross wall) at the junction, was only observed at specimens, where no interlocking was used.
- The crack pattern, failure mechanism, the ductility and the load bearing capacity of the specimen depended on the the type of masonry, the unit size, the vertical loading and the slenderness of the wall (ratio between length and height of the wall). Further tests should be carried out, to achieve provable statements about the influence of each parameter.



Specimen V0a after the final test



Specimen V09 after the final test