Abstract

The purpose of this research project was to proof the application of the stiffening criterion α of DIN 1045 for the specific properties of common masonry construction. In this connection the influence of a realistic definition of the flexural stiffness EI'' of bracing masonry shear walls should be determined. Finally, a suggestion for the modification of the stiffening criterion to the specific properties of common masonry construction method should be developed.

The proof of the three-dimensional stiffness and stability in masonry design and reinforced concrete design is based on the check of DIN 1045 (1988-07). If the α criterion is maintained, the check against buckling of the bracing components can be neglected. The α−criterion can be found in original form in DIN 1045-1, as well as in DIN 1053-1 and DIN 1053-100. If the criterion is not maintained, a detailed analysis of the axial force and shear strain must be carried out. A proof is required for vertical structures, when the second order bending moments exceed 110% of the first order moments.

The theoretical background and the derivation of the stiffening criterion are analysed in a detailed way within this report to point out how the global safety factor and the reduction of stiffness influence the α−criterion.

To determine a realistic flexural stiffness EI'' in the cracked state, different wall models with typical application load cases are examined. Shear walls are modelled as cantilevers and then are examined with concentrated loads or with linearly distributed loads in horizontal and vertical direction. Based on a significant reduction of stiffness due to gaping, an analytical model is developed taking into account the compressed length of the cross section. It can be stated that the wall rotates around the lower corner if there is a deflection of the upper end of the wall. The compressed area becomes smaller and the stiffness of the wall decreases correspondingly. A relation between the reduction of stiffness and the respective slenderness could be determined, including different dimensions and loading cases. Beside the analytical solution the different wall models were checked with a Finite Elements analysis based on first order theory and second order theory with non-linear stress-strain relationship, in which a very good correspondence could be found between the models.

This relation between can be shown in a diagram covering all application cases of straight bracing walls (I-shaped cross-section) with linearly distributed loads spread on the height.

With the inclusion of the decrease factor α_{EI} a modified stiffness criterion can be suggested considering the specific properties of masonry construction. The new stiffening criterion does not contain a global reduction factor for the stiffness. The reduction is calculated in every particular system. So reserves in bearing capacity can be activated which make a more precise calculation unnecessary. Another important fact is the covering of safety risks that were provided by the current model for certain load and geometry combinations. It can be summarized that in common masonry construction a calculation according to second order theory mostly does not become decisive, so a security gap is existent only in very special cases (e.g. very slender structural components with smaller superimposed load).

The currently available stiffness criterion leads to sufficiently exact results, so that it is recommended to keep this criterion in the codes due to the simple application.