

**Univ.-Prof. Dr.-Ing. Carl-Alexander Graubner, Dipl.-Ing. Eric Brehm**

***Determination of the Governing Load Combinations for the Design of Unreinforced Members in Common Construction***

This research project was funded by the German Federal Office for Building and Regional Planning (BBR).

(project. Z 6 - 10.07.03-07.06/II 2 - 20 01 07 - 06)

The author is responsible for the content.

**Introduction**

Safety plays a major role in structural engineering. Safety concepts are subject to research and development in the same manner as construction and design methods and materials. The current German masonry design code DIN 1053-1 is still based on the global safety concept which is not state of the art. In this concept, the space between action and resistance is controlled by only one (global) safety factor. Every other current design code, e.g. the German concrete design code DIN 1045-1, have been changed to the partial safety concept according to DIN 1055-100. This concept uses partial safety factors and therefore different loads and material properties can be multiplied by different safety factors to account for different scatter of every variable. This leads to a more constant level of safety and reliability.

The fact that DIN 1053-1 is based on a different safety concept leads to various problems because in common construction usually several materials are used parallel (e.g. masonry walls and reinforced concrete slabs). Therefore, a conversion of the forces and moments from one member to the other is necessary.

DIN 1053-100 now introduced the partial safety concept to masonry design. This means a significant change to the previous design of masonry structures. While the simplified design method according to DIN 1053-100, section 8 gives simplified load combinations for the design, the design engineer has to face a large number of possible load combinations for the exact design method according to DIN 1053-100, section 9. A simple determination of the governing load combination based on engineering judgment is not possible due to the large number of possible load combinations and the interaction of action and resistance. Therefore, many load combinations have to be investigated; this leads to higher design costs.

In this project, the possible load combinations will be investigated and assessed aiming at reduction of amount of load combinations. It has to be noted, that these investigations only cover the check against compression failure and buckling, shear failure is not part of this study.

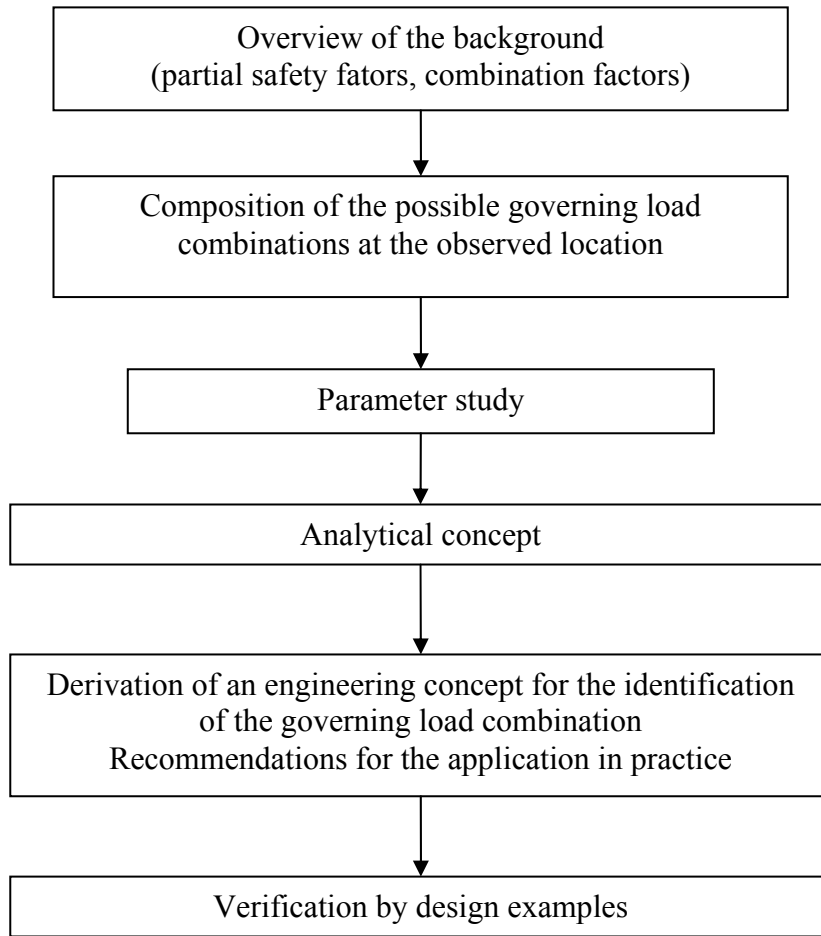
## **Procedure**

The code background is explained and the partial safety factors and corresponding combination factors according to DIN 1055-100 are provided. Subsequently, a comprehensive parameter study on the check against flexural and compression failure according to DIN 1053-100s conducted. Inner and outer walls and the different locations of the check are analysed.

It could be found that the number of possible load combinations that govern the check against compression failure is limited. This fact is used for the derivation of the analytical concept for the determination of the governing load combination which is derived in the next step. In this concept, the boundaries between the governing load combinations are determined. This concept makes it possible to identify the governing load combination using the results of the parameter study. Simplified rules for the identification of the governing load combination are formulated.

The application of this concept is shown by two examples. The overall procedure of this project is summarized in Figure 1.

An easy applicable concept for the determination of the governing load combination could be derived. The overall number of possible governing load combination could be limited for every location of the check. Therefore, a valuable contribution to the simplification of the design of masonry walls subjected to flexure could be found. Last but not least, it could be shown that only a small number of load combinations can govern the design if typical side conditions of masonry construction and code regulations ( $e/d \leq 1/3$ ) are maintained.



**Figure 1** Overall procedure of the project