Zukunft Bau

SHORT REPORT to the research project

Title

Resource-efficient reduction of reinforcement in reinforced concrete slabs

Occasion / Initial position

In real world construction projects reinforced concrete slabs are often subjected to vertical loads and restraint forces at the same time. At present it is necessary to conduct non-linear Finite Element simulations in order to obtain realistic results of the effects of such combined actions of loads and restraint forces. A separate assessment of both actions often leads to unnecessary large amounts of reinforcement which are additionally often placed in wrong positions of the slabs.

Subject of research project

For longitudinally restrained reinforced concrete slabs, the amount of necessary reinforcement is often given by the necessity to limit the crack widths of the slabs to allowable values.
A prediction of realistic values of the crack widths however is only possible if the internal forces and bending moments of the slab can be calculated as accurately as possible. In such a calculation it has to be taken into account that some parts of the structure may exhibit cracks while others remain uncracked and therefore have larger stiffnesses.
As part of a research project, supported by the federal initiative "Zukunft Bau" of BBSR (Federal Institute for Construction, Urban Affairs and Spatial Research), the question whether a resource-efficient reduction of the reinforcement in reinforced concrete slabs subjected to vertical loads and restraint forces at the same time is possible was followed up by experimental tests and Finite Element simulations.
39 large scale tests (short-term and long-term tests) with one-way slabs subjected to vertical loads and restraint forces were conducted. The results of post-test Finite Element calculations corresponded very well with the results of the tests confirming the suitability of the chosen Finite Element model for an extensive parametric study.
In this parametric study the influence of the reinforcement, the concrete strength and the structural system on the restraint forces due to shrinkage of the concrete were thoroughly investigated. It could also be shown that the influence of creep and the influence of the diameter of the provided reinforcement bars on the restraint forces could be neglected for cracked slabs.
It had been shown before that by using the values of the internal forces divided by the dimensions of the cross section and the value of the concrete strength it was possible to obtain the restraint forces for single span slabs as a function of the support conditions and the vertical loading. However most real world structures are multi-span systems and it is obvious that for such systems it is not sufficient to just account for one span in order to obtain realistic values for the restraint forces. In this project an approach was elaborated which allows the calculation of the increase of the restraint forces resulting from those spans of a multi-span slab which remain uncracked under the applied vertical loading. Based on the results of the experimental tests and the parametric study it was possible to derive diagrams which can assist design practitioners in obtaining realistic values for the restraint forces in one-way reinforced concrete slabs.

Conclusion

The new approach which has been developed in this research project uses a similar concept as the governing standards [(DIN EN 1992-1-1), (DIN EN 1992-1-1 / NA) and (DIN EN 1992-1-1 / NA / A1)] do and therefore lends

itself perfectly to an application within the same framework. It can be applied to multi-span one-way reinforced concrete slabs with arbitrary values of the span lengths.
The restraint forces of such systems can be determined accurately allowing a precise calculation of the amount of reinforcement that is necessary to limit the crack widths to the allowable values and preventing the use of unnecessary large amounts of reinforcement.

KEY DATA

Short title: Resource-efficient reinforced concrete slabs

Researcher/ Project manager:
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Total cost: 269.000,00€

Federal grant: 167.830,00€

Project duration: 24 Months

FIGURES / ILLUSTRATIONS:

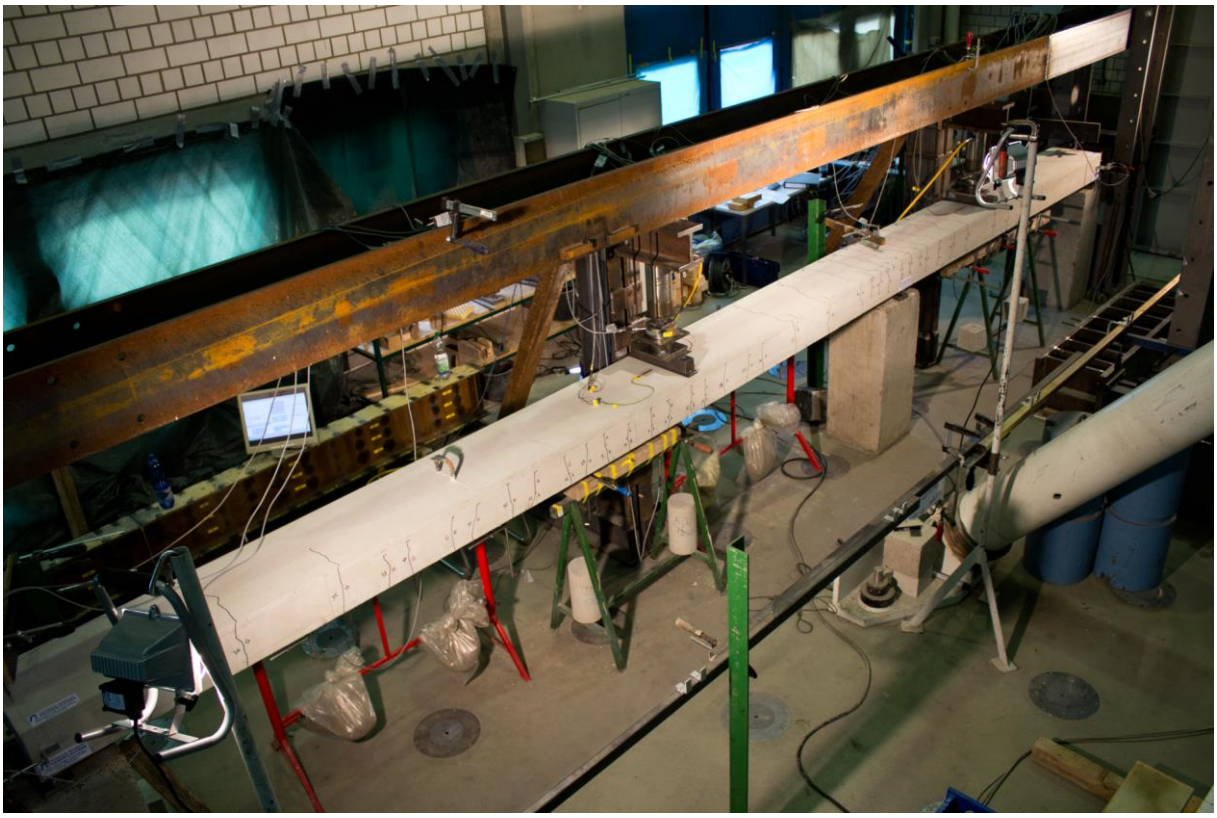

Figure 1: Kurzzeitversuch.bmp
Overview of the short-term test

Figure 2: Dauerstandversuch.bmp
Setup for the measurement of the restraint forces

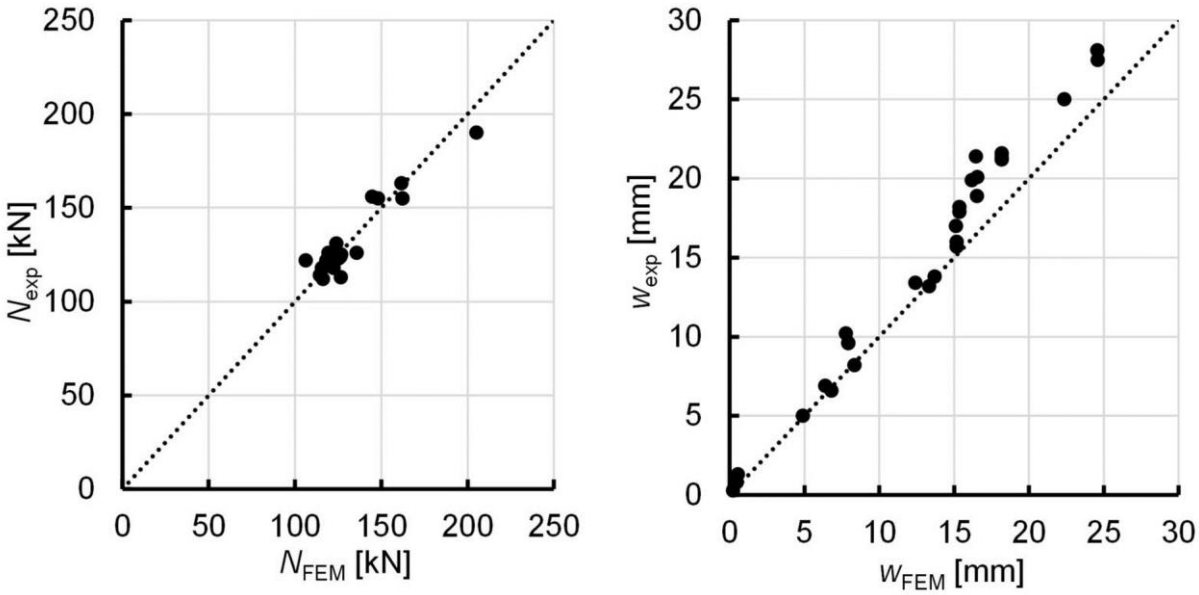

Figure 3: Nachrechnung der Kurzzeitversuche.bmp
Comparison of the resulting tensile forces (left) and of the mid-span deflection of the span with the largest length (right) obtained from the Finite Element calculations and from the experimental tests subjected to a combination of vertical loads and restraint forces ($\varepsilon_L = 0{,}485$ ‰ bzw. $0{,}437$ ‰)

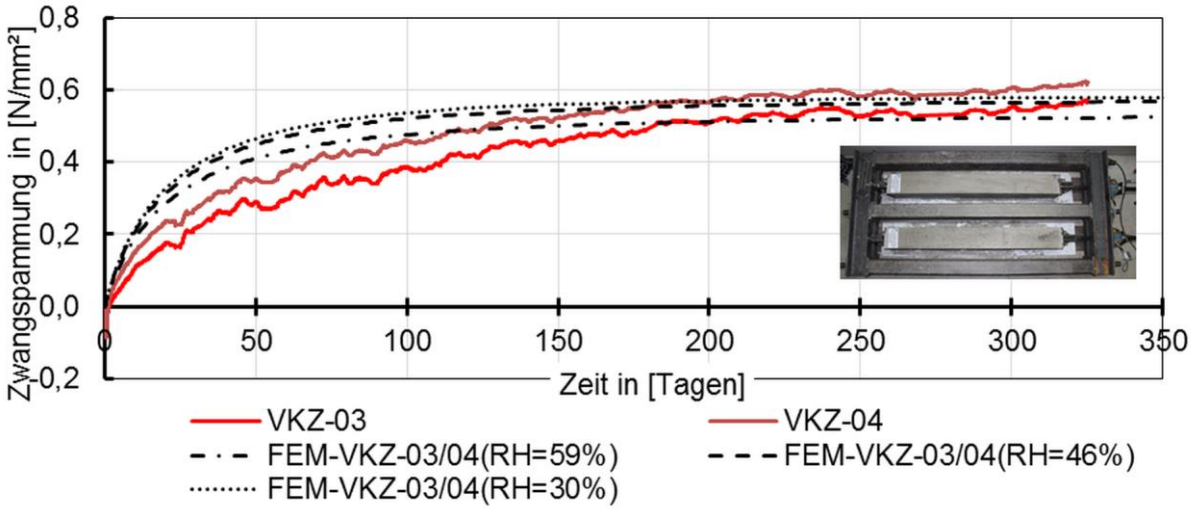

Figure 4: Nachrechnung des Dauerstandversuches.bmp
Restraint force obtained from experimental tests and from post-test Finite Element simulations

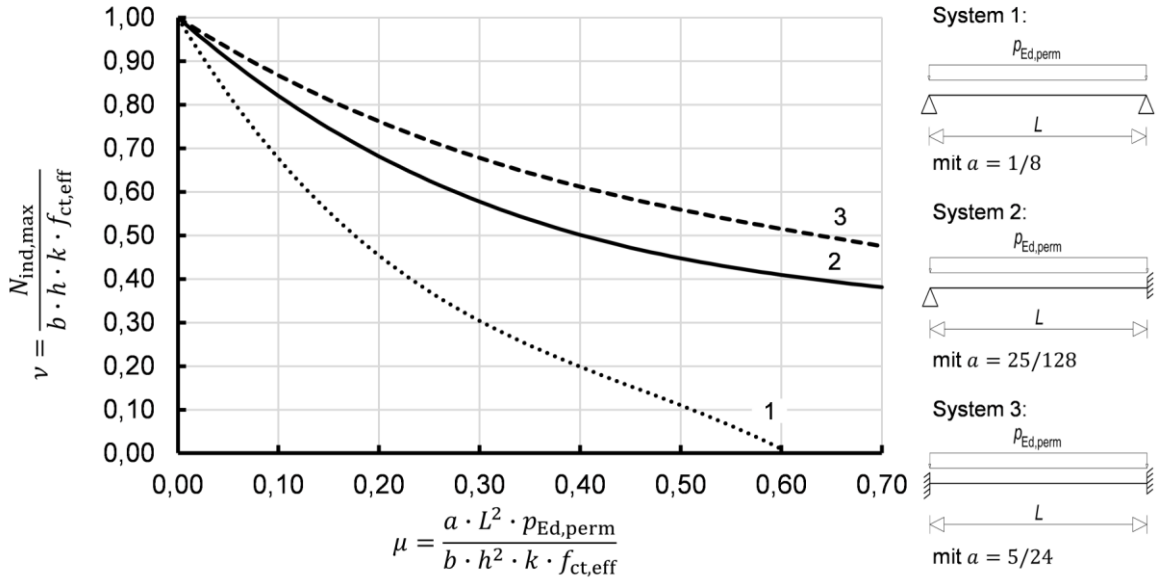

Figure 5: Interaktionsdiagramm.bmp
Diagram for determination of the restraint force resulting from shrinkage in an single span slab