Zukunft Bau

ABSTRACT to the research Project

TITLE

Optimized lapped joints with reinforcing steel of different grades in building on existing structures

SITUATION / INITIAL POSITION

During design and construction of existing buildings new reinforced concrete components often are connected force-fit to existing support structures. (Figure 1). Frequently, historical smooth BSt I steel with hooks and actual ribbed B500 steel should be lapped. Because rules for such combined lapped joints are missing, this should be developed by analogy to the rules of EC2 for lapped joints of equal steel grade.

SUBJECT OF RESEARCH PROJECT

To avoid the often improvised „on-site solutions“ in construction practice in future, reinforcement rules were worked out on the basis of a newly developed engineering model, allowing scientifically and simultanously economical solutions for combined lapped joints.

Initially the base was the historical evolution, the structural behavior and the design and construction rules of equal lap reinforcement in the context of different composite mechanisms, material properties and anchorage of smooth and ribbed reinforcement.

Afterwards experimental investigations were carried out. After initial reference and trial tests (Figure 2) to study the structural behavior, followed systematic test series (Figure 3) for empirical determination of the required lap lengths for selected combined lap joints of smooth and ribbed concrete reinforcement. A distinction was made at combined joints of the type I, consisting of a smooth steel BSt I with hook and a ribbed steel B500 with straight bar-end, and combined joints of the type II (Figure 4), that each had a smooth steel BSt I and a ribbed steel B500 both with hook. Combinations were tested with practical orientation, primarily with bars of different diameters, whose cross-sectional areas were chosen in proportion to the yield strengths of the steels B500 respectively BSt I, for utilizing the maximum stresses.

While the trial tests and the systematic test series were performed as four-point bending tests on beams or slabs, with applied DMS at or on the reinforcement bars for recording the stress progress on tension members (Figure 5), there could additionally been obtained a basic understanding in the structural behavior of combined lapped joints of type I and been transferred to a load transfer model.

The engineering model, which reliably describes the supporting effect of combined lap joints of the type I on the basis of the test results and allows the calculation of the required lap length with an generally valid design equation taking into account of the variation and member securities, is ultimately derived using the analytical relationships between the significant influence parameters.

For this purpose, the geometric parameters were specified in the test series on their maximum influence quantity, in the same bond conditions and lack of transverse reinforcement, by complying with extreme constraints for bar and lap spacing and concrete cover. Also, the other variable parameters – lap length $l_{0,com}$, concrete tensile strength f_{ct}, steel stresses σ_s and bar diameter ϕ – determined or identified in the tests and then with the exception of the bar diameter bundled by introducing the related combined lap length α_{com} and mapped as a function taking into account their interdependencies. Since α_{com} and $l_{0,\,com}$ are dependent on the bar diameter ϕ, using the test results, the related combined lap length α_{com} could empirical be derived as function of the bar diameter ϕ. On this basis the function of the average lap length $l_{0,\,com,\,m}$ for the investigated lap type I was declared by calculating the corresponding regression line.

After statistical review and additional exposure to the component securities, the equation for the design value of the combined lap length $l_{0,\,com}$ revealed, which finally for further study (e.g. combined lap type II, reduced edge distances etc.) was examined and transferred and stored with design rules.

The by use of a comparative finite element model (Figure 6) confirmed engineering model and it's referring design equations apply under compliance of the described boundary conditions for combined laps each with a smooth bar BSt I $\phi_{BStI} \leq 26$ mm with hook and a ribbed bar B500 $\phi_{B500} \leq 16$ mm with straight bar end or hook in usual building construction (Figure 7).

CONCLUSION

On the basis of an engineering model and design equations derived of this, design and construction rules for combined lapped joints consisting of smooth reinforcement steel BSt I ($\phi_{BStI} \leq 26$ mm) with hooks and ribbed reinforcement steel B500 ($\phi_{B500} \leq 16$ mm) with

straight bar end or hook for building on existing structures were stated, which can be applied equivalent to the rules of Eurocode 2 for new construction (figure 7).

Furthermore not regulated remain lapped joints of historical reinforcing mesh with modern mesh and multilayered or two-level-lapped joints. Likewise combined laps of modern reinforcement steel B500 with higher quality steel (i. a. St 48, 52 und BSt II) or with profiled mold steel remain unexplored.

KEY DATA

Short title: Kombi-Stöße (combined lapped joints)

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FIGURES / ILLUSTRATIONS

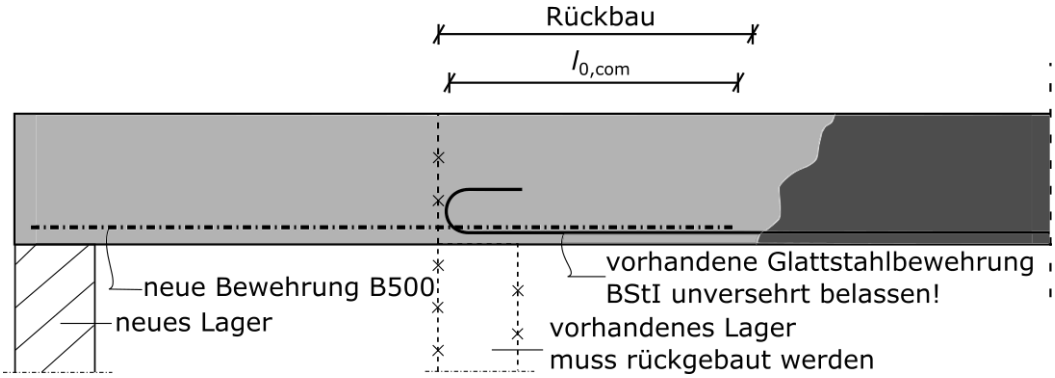

Figure 1: typical connection situation in building on existing structures

Figure 2: Experimental setup for reference and trial tests with test bodies after trying

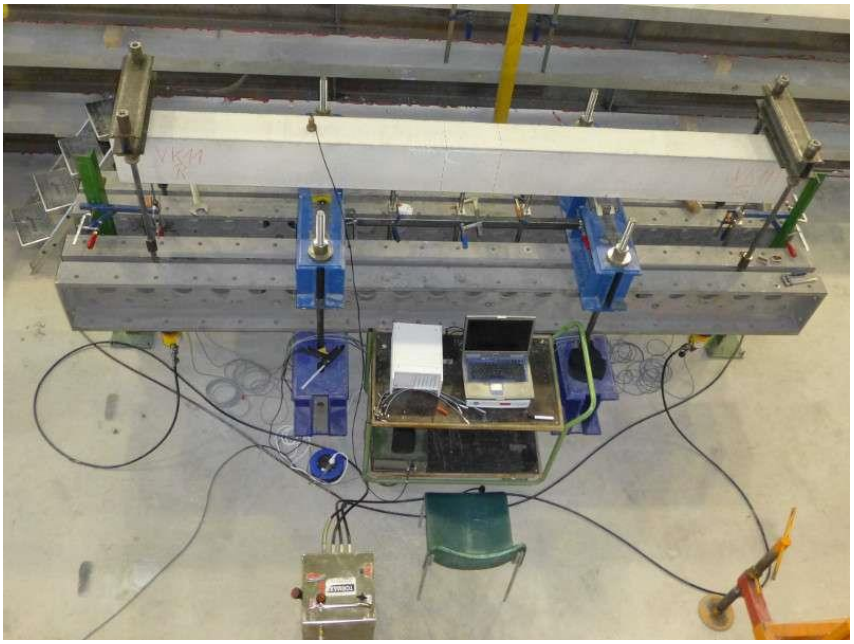

Figure 3: Experimental setup for systematic test series with test body

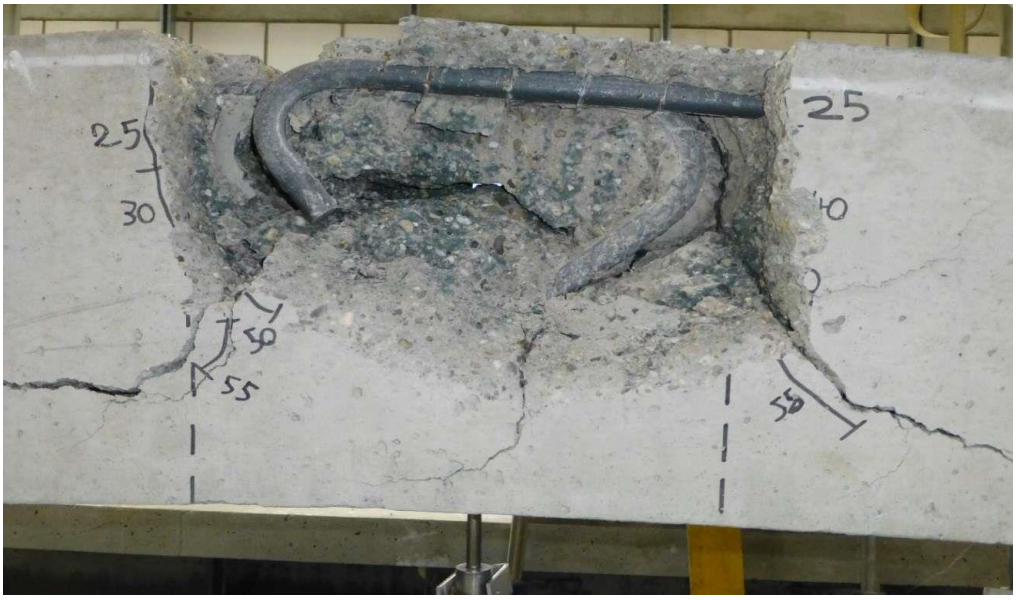

Figure 4: side view bar with combined lapped joints of type II after trying

Figure 5: Experimental setup for tension member tests

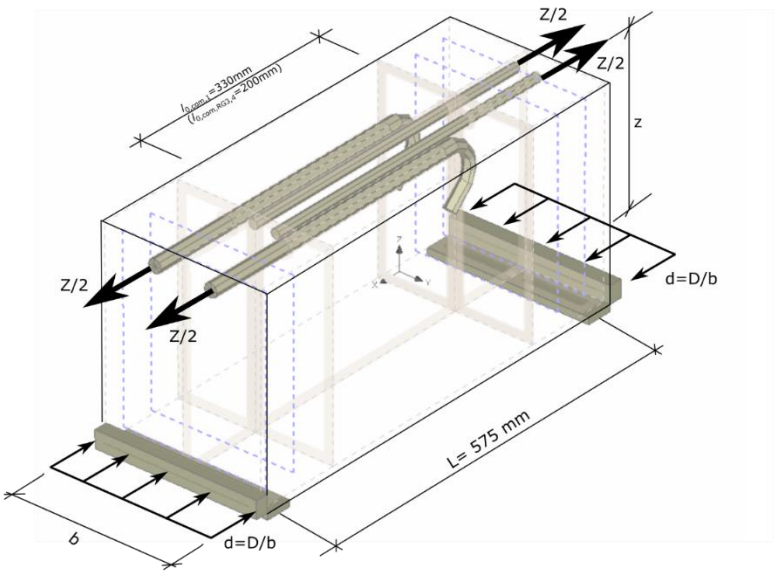

Figure 6: Structural System of FE-Models

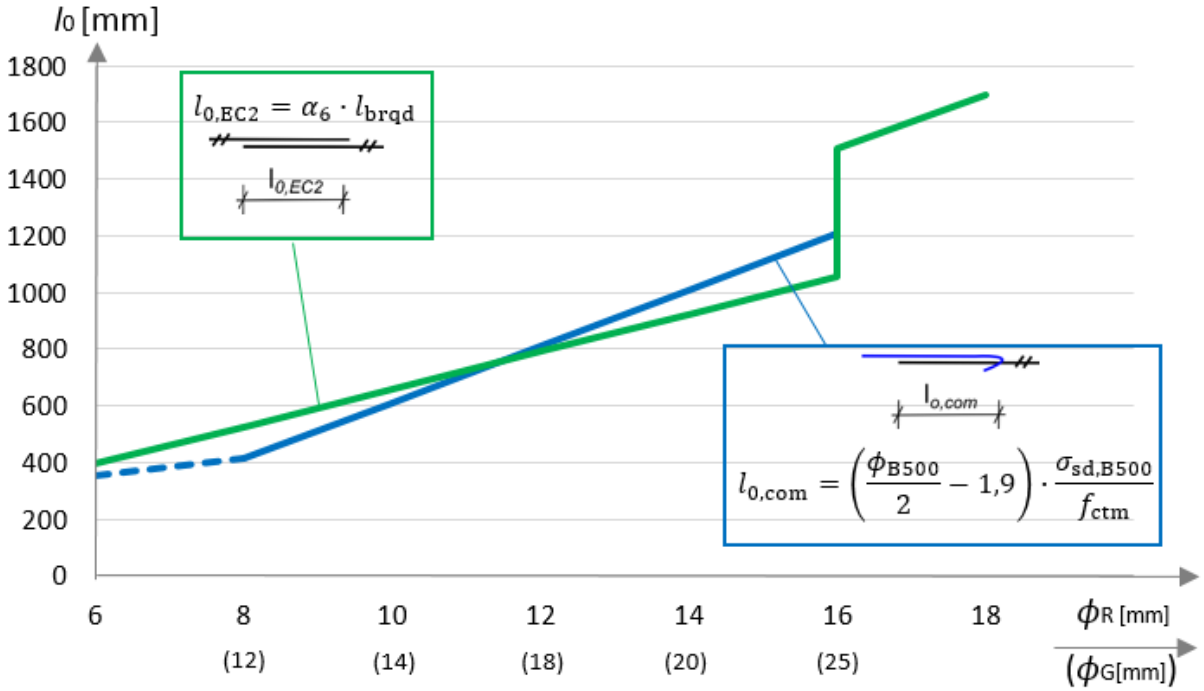

Figure 7: Rated values of the lap lengths for combined lapped joints type I and lapped joints according to EC2 with reinforcing bars B500 and straight ends