

Fuzzy probabilistic safety assessment of a T-beam floor construction with textile strengthening

The safety level for the limit state defined by system failure of the unstrengthened T-beam floor construction should be assessed with the aid of the fuzzy probabilistic safety concept considering uncertainty of the physical parameters appropriately. This safety level supports the decision about structural strengthening. An increase of the loadability and safety level respectively is possibly adding a textile reinforced finegrade concrete layer. The expected increase of the safety level is to be demonstrated by a further investigation.

The T-beam floor construction (s. Fig. 1) is a part of an existing building. The load history consists of the dead weight and an only uncertain known live load p_1 . The safety level concerning system failure is assessed with the aid of an incremental increase of the live load p_2 which is anticipated in the future. Exemplarily the live load p_2 is modeled by means of a fuzzy random variable. The live load p_1 and the concrete compressive strength are real random values. Fig. 2 shows the fuzzy probability density function $\tilde{f}(p_2)$. The bunch parameters of this function (expected value \tilde{m} and standard deviation $\tilde{\sigma}$) are fuzzy triangular numbers (s. Fig. 2). The parameters of the GUMBEL distribution of live load p_1 are $a = 2.565$ and $u = 5.699$. The normal distribution of the concrete compressive strength is specified by the mean value $m = 30 \text{ N/mm}^2$ and the variation coefficient $v = 0.1$.

The physical nonlinear deterministic fundamental solution is represented by the FE program FALT-FEM for the calculation of reinforced concrete folded plate structures. In this program the newly developed algorithms of subproject D2 (SFB 528) are included concerning the nonlinear determination of structures with strengthening of preloaded systems. The supplementary addition of textile reinforced strengthening under consideration of the current stress and deformation state equals a modification of the cross section. The post-strengthening is modeled in this case by rigid bond between the added layer and the old concrete.

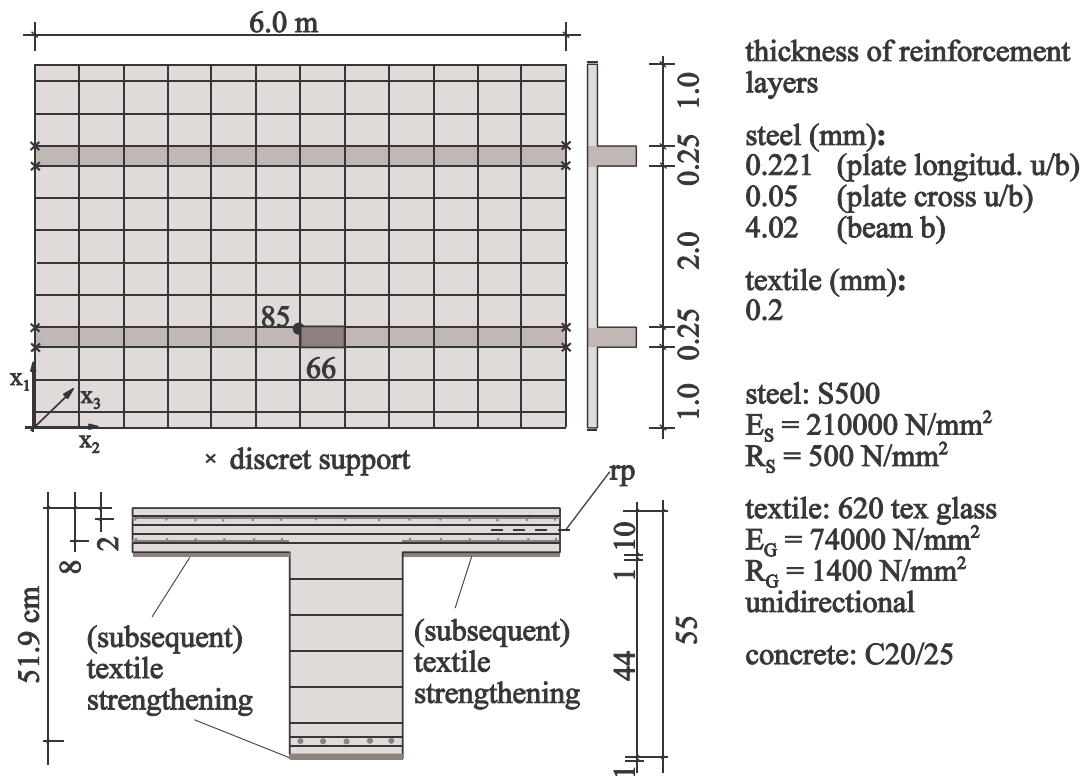


Figure 1: T-beam floor construction: geometry, FE mesh and material parameters

The Fuzzy First Order Reliability Method (FFORM) is used for fuzzy probabilistic safety assessment. The calculation results in the fuzzy reliability index $\tilde{\beta}$ shown in Fig. 3. The increase of the safety level due to strengthening is clearly observable.

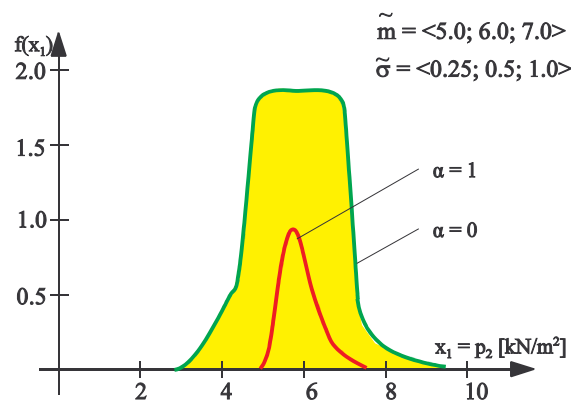


Figure 2: Live load p_2 - GUMBEL distribution

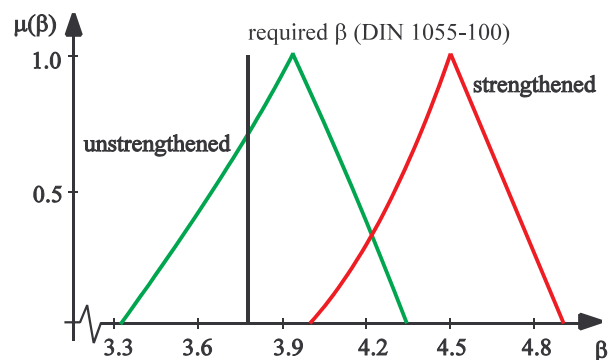


Figure 3: Fuzzy reliability index $\tilde{\beta}$

The safety assessment without appropriate consideration of uncertainty of the input variables pretends a higher safety level ($\beta = 4.5$).

Exemplarily the load displacement dependencies of the unstrengthened and the strengthened structure are plotted and compared in Fig. 4 for certain parameters ($\mu = \alpha = 1$). Fig. 5 shows the stress development of the lower beam reinforcement of the finite element 66 during the load process. When the reinforcement steel attained its yield stress the textile stress began to arise strongly. The loadability and the structural safety of the T-beam floor construction may be increased because of the post-strengthening.

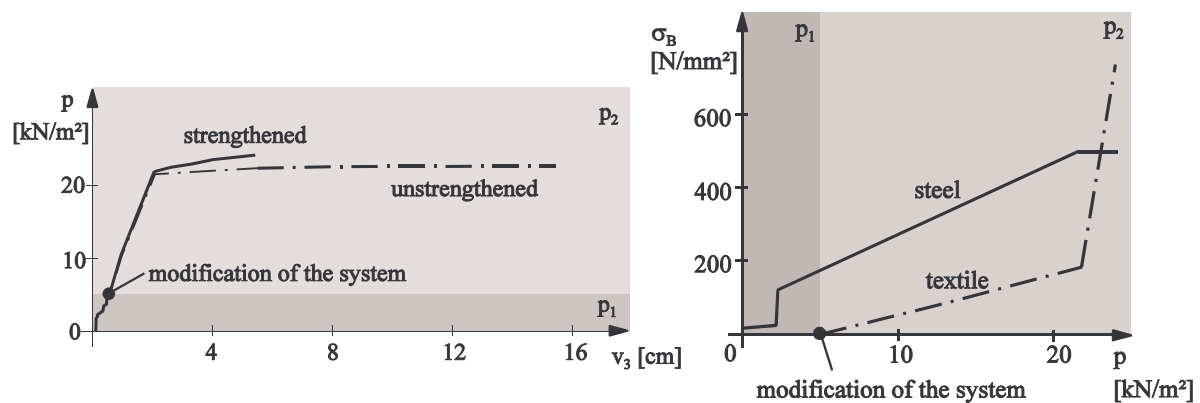


Figure 4: Load displacement dependency node 85

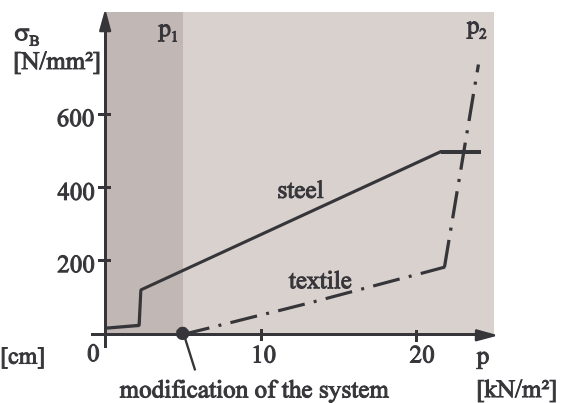


Figure 5: stress in the reinforcement element 66