On the question whether the volume of glulam bending members changes their reliability

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According to Eurocode 5 rules [1], the characteristic bending strength of glulam may be increased for member depths h less than 0.6 m to benefit from the volume effect. For depths greater than 0.6 m, the bending strength is assumed as constant value, although it seems logical that the volume effect should also be considered, at least to a certain extent. For this purpose, the depth factor k_h given in Eq. (1) was proposed [2].

$$k_{\mathrm{h}} = (0.6 / h)^{0.12} \qquad 0.3 \text{ m} \le h \le 3.0 \text{ m} \tag{1}$$

However, the question whether the application of this depth factor actually changes the reliability or not was still open and caused critical discussions [3]. Therefore, it is the aim of this contribution to examine the influence of the depth factor on the reliability index β. Bending strength data, obtained from computer simulations [3], for two glulam strength levels A and B (Table 1) were processed in reliability analyses using the Monte Carlo approach. Corresponding details of the numerical method are quoted in [4, 5]. In doing so, the limit state functions g_1 and g_2 given in Eq. (2) were evaluated based on millions of single realisations. In g_1, the bending strength denoted as R was divided by k_h in order to show its effect. The normally distributed bending stress denoted as E was calibrated so that the index β is 3.8 on average across the depth range of 0.3 - 3.0 m in case of g_1. That is fulfilled for glulam A with a mean stress of 15 N/mm² and for glulam B with 24.5 N/mm² and a COV of 10 % each.

Table 1: Mean (in N/mm²) and COV (in %) of the modelled bending strength values depending on depth (in m)

Depth	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
Glulam A	37.9/17.3	32.6/14.8	30.6/12.5	29.1/11.9	28.0/11.7	27.5/10.6	26.9/9.84	26.1/10.1	25.7/9.09	25.4/8.80
Glulam B	56.6/16.4	48.6/13.3	45.6/11.2	43.2/11.4	41.9/10.7	40.8/9.72	39.7/9.59	38.9/9.03	38.4/8.31	37.7/8.17

$$g_1 = R / k_{\mathrm{h}} - E \qquad g_2 = R - E \tag{2}$$

Fig. 1 shows the impact of the depth factor on β. In case of g_1, the course of β oscillates around 3.8, and in case of g_2, β oscillates too, but decreases with increasing depth. The oscillation is due to limited amount of simulated data points per depth. The proposed depth factor (Eq. (1)) is suitable to modify the glulam bending strength of members with depths greater than 0.6 m in order to reflect a more balanced reliability within the Eurocode 5 format. However, simplifications regarding the modelled bending stress in the reliability analyses, i.e. omitting variable loads, limit impact of the results. Hence, this contribution aims at triggering and facilitating discussions on further steps such as size depending load or stress models and the inclusion of appropriate model uncertainties.

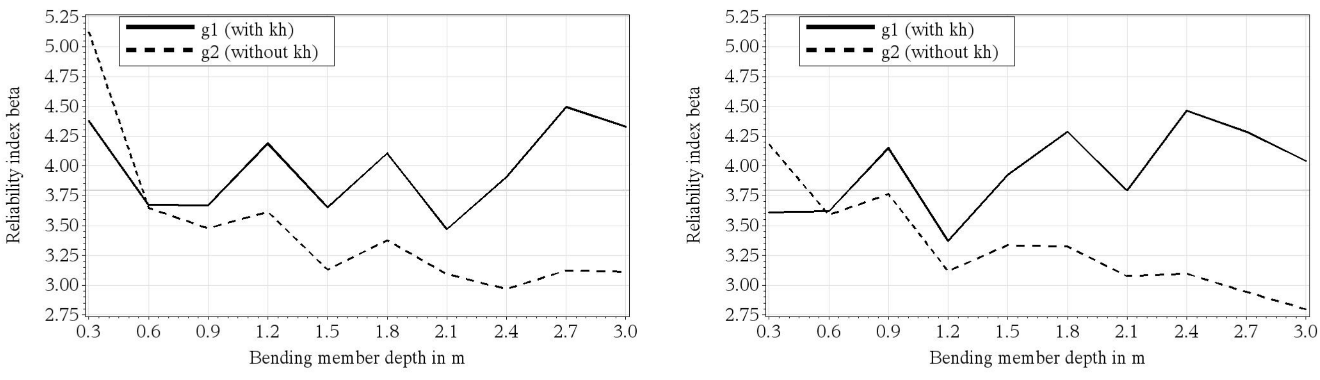

Figure 1: β depending on member depth and application of depth factor k_h, glulam A (left) and B (right)

References

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