Creep – Transfer of complex rheological behaviour into timber engineering

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Following the basic principles of the timber design code EC5 [1], not only displacements due to short term loading, but also additional displacements, such as according to creep, due to quasi permanent loading have to be taken into account for both serviceability limit state (SLS) and ultimate limit state (ULS) design. Although scientific research on this topic is challenging and still work in progress, its implementation in everyday timber engineering might be much less complicated, if it is well organised. Before presenting and discussing the aspects of an appropriate implementation of creep in both design codes and engineering software, a few basic considerations are made first.

In general, the **evolution of creep strains is a time dependent** phenomena and only related to stress components from permanent loading [2]. Such time dependent relationships could already be successfully derived for different building materials like concrete. It is well known from testing standards [3,4], that the **structural stiffness is only slightly reduced by creep** (maximum 10 % reduction of the initial stiffness). That is why assessment of dynamic behaviour - even at time infinity – is still to be performed with the initial stiffness. Typical for the anisotropy of wood, the evolution of **creep strains is dependent on the type of loading** [2]. Creep strains due to permanent shear stress is about three times higher than creep strains due to tensile stress parallel to the fibre. Therefore, it is obvious, that for a single span solid wood beam, the contribution of shear forces to the global displacements in comparison to the contribution of bending moments will be much more significant at time infinity than at time zero. The evolution of **creep strains also depends on the height of the corresponding stress component** from permanent loading. For the case of linear elastic distribution of bending stress over the beam height, it might happen, that creep strains are growing faster at the outer fibres than in the interior of the beam. Consequently, a redistribution of bending stress and reduction of the corresponding effective internal lever arm of the resultants of stress components might be the reason for a fictitious reduction of the nominal bending strength only valid for short-term loading conditions. Since the evolution of **creep is also significantly affected by the moisture content**, the knowledge about the distribution of moisture content across the cross section of a beam should be helpful for a more accurate estimation of the extent of creep strain evolution.

Following these basic mechanical observations, it seems natural to follow this track also within the domain of structural modelling and approval. Nearly every structural engineering software is capable to handle induced strains originated from loading by temperature. Therefore, a proposal [5] for **modelling of creep strains** could consist of a) calculating elastic strains from only one load combination dedicated to permanent loading, b) scaling these elastic strains or curvatures possibly by individual values of k_{def} and c) final application as separate load case to all load combinations at time infinity. For the case of heterogeneous cross sections with different creep behaviour of the subsections, the **consequence of eigenstress** and related curvature should be processed as well according to best practice with temperature, shrinkage or swelling. This procedure has also to be repeated for connections in terms of relative displacements, which again are well known from influence lines for internal forces of beam elements and only have to be reused this time as external loading for sake of creep. The good news are, that a) **structural stiffness is constant across all load cases** and b) at least for 1D and 2D structural elements, these procedures have already been activated in the software from Dlubal [6].

Concluding, the case sensitivity with respect to stages of approval, distributions of creep factors, order of analysis and stiffness parameters, as actually implemented in EC5, could easily be substituted by correct mechanics and complemented even within existing structural engineering software due to the fact of the already existing and working basic computational features. Therefore, EC5 could become slimmer with better interoperability to other design standards and partial safety factors could even be reduced due to more transparency of mechanics and realistic structural modelling.

References

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