Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 999 (1997)

Artikel: Long term performance of timber concrete composite structural elements

Autor: Meierhofer, Ulrich A.

DOI: https://doi.org/10.5169/seals-1123

Long Term Performance of Timber Concrete Composite Structural Elements

Ulrich A. MEIERHOFER
Dipl.-Ing. ETH
EMPA
Dübendorf, Switzerland

Summary
Little information was available on the long term performance of timber concrete composite structural elements (TCCs) up to now. Recently finished long term shear and bending tests suggest design creep values.

1. General remarks

Composite construction originally meant the combination of structural steel and concrete. For many decades the combination of timber and concrete has not been considered as feasible for various reasons, one important being the distinctively different properties of the two materials. Together with a changing attitude of the engineers in combining various materials, the combination of concrete and timber - especially used as floors - also offered various advantages and became more acceptable. A vital point is the development of an efficient connection to transfer the shear forces between timber and concrete. A considerable amount of theoretical and practical research and development in this field resulted in a rapidly increasing knowledge and an in implementation in many building rehabilitations and new projects.

Newly acquired knowledge and experience on concrete composite structural elements (TCCs) are not restricted to structural properties such as strength and stiffness, but also encompass fire safety, acoustics, working condition during erection, economics and even aesthetics.

2. Long term deformation as governing criterion

The analysis of built up structural elements with semi-rigid connections requires the solution of differential equations and doesn't belong therefore to the everyday's problems of the structural engineer. Solutions have been developed, however, and designs aids are available. For the modelling of the structural behaviour various simplifying assumption must be made including behaviour and properties of materials and connections. To calibrate and verify this assumptions and to establish system behaviour not so far accessible by theoretical means, experimental work is indispensable. This refers particularly to the deformation behaviour of the connectors within the wood.

As had already been shown by early investigations, of all the factors necessary for a satisfactory performance of TCCs, the bending stiffness, particularly the long term bending stiffness or the long term deflection proved to be of special importance. The susceptibility of TCCs to long term deformations is a consequence of creep phenomena as well as relaxation of residual stresses caused mainly by the differential thermal and hygroscopic behaviour of concrete and timber. For a theoretical analysis of this complex phenomena the basics are still lacking and the experimental work - especially on long term deformation - is so far very limited.

3. Research and development at EMPA

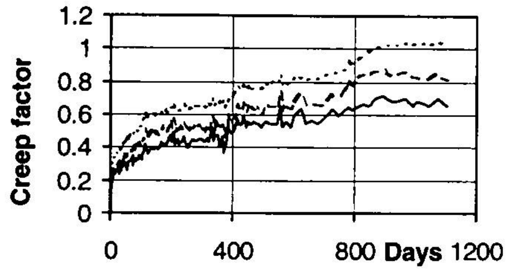
The Wood Department of the Swiss Federal Laboratories for Materials Testing and Research (EMPA) has undertaken extensive research in this field with a special screw like connector developed by SFS Stadler, Heerbrugg, Switzerland. This connector is characterised by its high slenderness which allows a very efficient installation without predrilling. The lack of bending stiffness of this connector is compensated by a mounting under an angle of ±45° which allows transfer of the shear forces between the concrete and the timber by tension and compression within the connectors (instead of the more common bending and bearing).

The tests performed encompassed basically withdrawal tests from timber and concrete, shear tests with symmetrical timber/concrete/timber specimens and bending tests with TCCs having spans of nearly 4 m. This work has been performed mainly in the years 1990 to 1993 and was reported in [1,2,3]. Within this period appropriate long term shear and bending tests were started too. Test parameters were the (geometrical) arrangement of the contors, load level and climatic conditions. The maximum load level was fixed in such a way that it superseded to some extent which was considered a reasonable operational level deducted from the results of the short term tests. The shear creep tests were run under constant climatic conditions (23°/50% r. h.) whereas the bending creep specimens were installed outside under roof, i. e. they were subjected to the natural variation of temperature and humiditiy. Even though the investigated TCCs had been developed and earmarked for interior use, this severe test configuration was selected to obtain conservative results.

After an extended period of creep (about 5 years for the bending tests and about 3 years for the shear tests) the specimens were unloaded, creep relieve recorded and then tested to failure in a short term test. The results are reported in [4] and some brief information follows.

4. Long term shear tests

Fig.1 Development of creep factor of shear tests with different connection stiffnesses



The main interest was the long time deformations which are shown in *Fig. 1* as the development of the creep factors over a period of about three years.The recovery behaviour after unloading (not shown here) proved to be satisfatory and indicated that the long term high loads did not cause any damage to the structure, resp. connection system. The creep curves may be fitted particularly well by potential curves of the type y = a * x exp b (correlation factors between 0.966 and 0.981), where 'a' variied between 0.10 and 0.16 and the exponent between 0.243 and 0.276. Extrapolated to a period of about 20 years, this implies creep factors between 1 and 1.7.

5. Long term bending tests

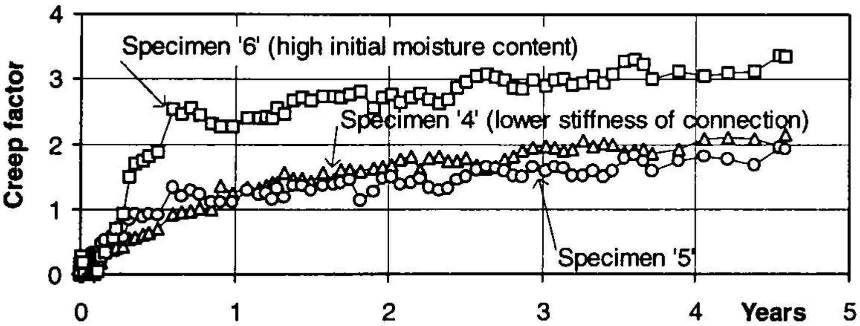


Fig. 2. Creep of three different TCC-specimens

The bending specimens, composed of a timber beam 12 cm x 18 cm and a concrete slab 8 cm x 75 cm cross-section were equipped with dial gauges to measure the sag at mid span and the end slip between timber and concrete. Strain at various points at mid span were recorded also by deformeter. One of the main results is the increase of sag shown in *Fig. 2* as creep factor. Due to the strong influence of climatic residual stresses (changes of humidity and temperature), the sag creep factors are considerably higher than those of the shear tests. Extrapolations of the fitted potential curves suggest a twenty years creep factor between 2.5 for normal and 4.5 for especially unfavourable conditions.

5. Conclusion

Long term deflections of TCCs under higher loads can't be neglected even in indoor climatic conditions. A creep factor of at least 2.5 should be applied until further research results suggest more differenciated values.

References

[1] Timmermann K., Meierhofer U. A. 1993. Timber Concrete Composite Structural Elements; Tests, Research and Development. Forsch. u. Arb.-Ber. der EMPA Abt. Holz. Rep. 115/30. English abstract.
[2] Meierhofer U. A. 1993. A Timber/Concrete Composite System. Struc. Eng. Int. 1993(2), p.104...107
[3] Meierhofer U. A. 1994. Untersuchungen und Entwicklungen zum mechanischen Verbund von Holz und Beton. Schweiz. Ing. u. Arch. 1994(37).
[4] Kenel A., Meierhofer U. A.1997. Long Term Performance of Timber Concrete Composite Structural Elements. Forsch. u. Arb.-Ber. der EMPA Abt. Holz. Rep. 115/35. English abstract. To be published in 1997.