FINAL REPORT - ABSTRACT

DIBt Research Project:
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LONG-TERM CREEP BEHAVIOR OF XPS INSULATION MATERIAL UNDER COMPRESSIVE STESS ACCORDING TO DIN EN 1606 - ROUND ROBIN TEST

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Initial Background

There are only very few publications about long term creep behavior of insulation material in Germany and abroad.

The substantive work about creep behavior has been published by Findley [1] in 1944.The test standard DIN EN 1606:2013-05 [2] and the extrapolation of measured values on Factor 30 is based on this publication.

Some measured values about creep behavior of EPS-, XPS and PUR rigid-foam insulation have been published by N. Krollmann in 1989 [3]. More measured values about creep behavior of foam glass and XPS have been published in the final report of the building research project "Erdberührte Wärmedämmung" of the University of Karlsruhe [4] in 1992.

Literature, dealing with influential factors, scattering and modifications of XPS- insulation material is practically non-existent nor are there publications about analysis, measurement uncertainty and interpretation of measured values, concerning long term creep behavior. This status hasn´t been changed during the term of the research project.

Implementation

To remedy this lack and make fundamentals and assessment criteria available for DIBt and expert committees, the following test series have been carried out:

- Preliminary tests of influential factors on long term creep behavior of XPS insulation material
- Round robin test of long term creep behavior of XPS insulation material under compressive strain according to DIN EN 1606

In the preliminary tests the influential factors of

- Thickness on behavior during compression
- Apparent density on behavior during compression
- Behavior during compression over the width
- flatness/foamed skin (on behavior during compression and on the E-modulus)
- Change of behavior during compression over the time

are being analyzed.

The preliminary tests have been described in detail in the report FO-5-09, preliminary report XPS long term creep behavior.

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From the previous outline of the results some conclusions concerning XPS can be drawn:

- Recording of production date.
- Preparation of test specimens according to measurements of Norm DIN EN 1606 nominal thickness 50 mm x 50 mm², 100 mm x 100 mm² or cubes with thickness as edge length. Subsequent storage at laboratory climate for 45 days as defined in DIN EN 13164.
- The gas exchange for thicknesses > 40 mm has not been completed!
- Testing of compressive strength through width profile according to DIN EN 826
- Selection of test specimen with medium compressive strength through width
- Removal of test specimens for the creep test in the line under the selected specimen with medium compressive strength in the same panel. Only in this line approximately equal production ratios can be assumed.
- Grinding of the wavy foam skin as thin as possible, depending on the ripple max. 1 mm – 3mm.
- With thicknesses >50 mm measurement the compressive strength measurement in width profile should be repeated towards the test end to better classify the results of the test.

To meet the wide range of influential factors, the short-term pressure behavior has been tested on samples from one production plant with thicknesses 80 mm, 120 mm und 160 mm. The behavior under compressive strain has been measured scheduled according to thickness on three instants of time (after 45, 90 and 180 days) and has been plotted versus time (results see FIW test report: Nr. L1-10-130).

A round robin test, lasting 10,000, hours has been executed after this. Extra long deposited panels (3.5 years) with a thickness of 100 mm have been chosen. The skins have been grinded by FIW. The reason for studying extra long deposited material is that temporal alteration is of no more importance (see above conclusions).

The following laboratories took part, in alphabetical order:

Test Institutes:

- FIW München (leading institute)
- IFBP Institut für Bauphysik der Universität Hannover
- MPA NRW Dortmund (tests have been terminated beforehand)
- MPA Stuttgart

Industrial laboratories from XPS-Manufacturers:

- AUSTROTHERM, Purbach, Austria
- BASF, Ludwigshafen
- DOW, R & D Labor, Rheinmünster
- URSA Insulation, El Pla de Santa Maria, Spain

FIW has worked out and send off a consistent measurement report.

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RESULT

At the beginning of 2013, there have been measuring protocols of 7 laboratories.

MPA NRW had to stop the tests due to big influence factors caused by renovation work.

The specified ranges of values recorded are the average value and the maximum deviation of the measured value. This means it´s neither a standard deviation nor a statistically significant probability.

- Initial deformation: The measured values of the initial deformation with an average value of 0,77 ± 0,10 mm (without the measured value of IL 3) the values are very close together. The minor differences in values of measurand IL 3 (deviation 0,13 mm ≙ 0,13 %), are probably due to mechanical differences of devices.

- Compressive creep deformation:
  The measured values of creep deformation with an average value of 0,49 ± 0,06 mm are closer round factor 0.6 than when tested in a round robin test with EPS.

- Total deformation:
  These values of 1,24 ± 0,17 mm are very close together. The slightly higher divergence results from the influence of the difference in the initial deformation.

- Extrapolated deformation after 30 years:
  The values extrapolated for 30 years from the 7 laboratories concerned and agree very well with an averaged value of 2,0 ± 0,2 %. They correspond with the result of the round robin test.

CONCLUSION

The selection and preparation of the samples is crucial for the informational value of the creep tests. This is impressively demonstrated in chapters 1, 2 and in the results of chapters 3, 4.

Evaluating the measured values of the 7 laboratories show that the measured values disperse in the range ± 0,17 mm with a thickness of 98 mm. This corresponds to relative deformations 0.1% to 0,2%.

These small deviations of the measured values are to be regarded as excellent, considering the tolerances you normally have in the construction industry. Also in relationship to permissible deformations in the approvals for insulation materials under foundation slabs from 2% bis 5%, the measured scattering of extrapolated deformations of 0,1% - 0,2 % can be rated as small.

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With this result, the proof could successfully be provided that this test method, according to DIN EN 1606 for thickness 100 mm, can also generate well comparable, reproducible measured values with sufficient care concerning selection and preparation of samples and stable indoor climate.

The user of the measured values, working for building authorities and manufacturers, can be sure that this measuring method can provide measurement precision as well as reproducibility.

Material scatter and possible errors which might occur during the taking of and preparing of samples, are not covered.

From the different measurement protocols and evaluations some conclusions can be drawn. These should be integrated into a revised version of DIN EN 1606 for an easier manageability and more meaningful test results.

The individual observations lead to the following recommendations:

- Application of the load and determination of first measurement value after one minute should be described more detailed.
- Technical notes to follow the number of measured values and intervals should be paid regard to more thoroughly, thus to avoid diverging results for extrapolation.
- The start of extrapolation should be defined more precisely, for example 24 hours after application of the load.
- Selection and grinding of samples should be described more detailed because this could have a huge influence on the test result.
- The influence of temperature fluctuation, thermal length expansion and the necessity of climate control has to be integrated into the testing standard.

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