CCT_{10}: A method for determine creep properties of fluting in high humidity

Introduction

Creep is defined as the slow continuous deformation of a material subjected to constant load during a long time period.

Corrugated containers are frequently subjected to long time compressive forces during shipment and storage. Often, the contents such as fruit and vegetables require high relative humidity. Therefore, it is important to evaluate the long time performance of the components of the board in humid climate.

Here a method for evaluating the creep properties of fluting in high relative humidity is presented. The CCT_{10} value is defined as the corresponding CCT load the material can carry for 10 days (240 hours) in 20°C and 90 % r.h. The method is based on standard CCT testing supplemented with a compressive tester able to hold constant load and record the deformation of the sample and a climate chamber.

Results are presented as integers with unit kilograms per meter.

Apparatus

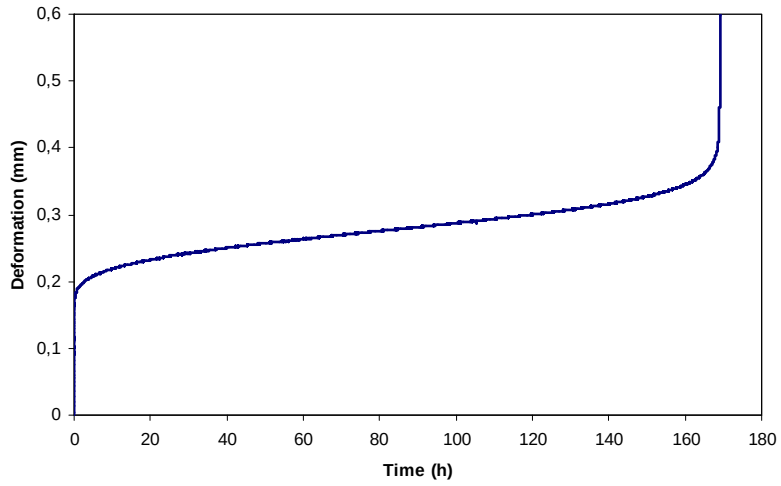
Test apparatus used are cutting device, laboratory corrugator and holder defined in the SCAN-P 42 standard for CCT value and CCT index. Additionally, a compressive tester with parallel platens able to hold a constant load with an accuracy of ± 0.5 N, continuously recording the deformation of the sample and a climate chamber holding a constant climate of 20°C ± 1°C and 90 % ± 2 % relative humidity are needed.

Holder placed between the platens in a compressive tester

Test procedure

Test stripes are prepared in accordance with SCAN-P 42 standard. The samples are conditioned in 20°C, 90 % r.h. until moisture equilibrium is reached and then mounted in the holder and placed between the platens in the compression tester. The platens are set to move at a speed of 10 mm/min up to a preload of 10 N. Immediately after the preload is reached, the compression force is increased with 100 N/s until decided load is attained. The load is held constant until collapse of the sample can be detected.

The figure below shows a typical creep response of a test piece of semi-chemical fluting subjected to a load of about 20-25 % of the ordinary CCT value measured in standard climate (23°C, 50 % r.h.).



For each quality tested at least ten stripes are tested. The highest load included in the evaluation is to give a time to collapse of approximately 1 hour. The compression load is then gradually reduced to find the load the test piece could carry for at least 10 days (240 h). The chosen loads shall be evenly distributed. Decreases in steps of 2-2.5 N from the highest load are suitable.

Evaluation

The times to collapse for all test stripes are plotted against the applied loads. An exponential function is fitted to the data using the method of least squares. From the attained function, the load the test piece can carry for ten days is interpolated.

Calculations and presentation

The CCT_{10} value is presented in kilograms per meter and calculated using following equation:

$$CCT_{10} = \frac{F}{g \cdot l}$$

where *F* is the load obtained from the fitted curve in Newton, *g* the standard gravity (9.81 N/kg) and *l* the length of the test strip (0.152 m).

The exponential function fitted to the data will be of the type $y = Ae^{-Bx}$ were *y* is time to collapse in hours and *x* is applied load in Newton. The load *F* which the test strip can be expected to hold for 240 h will be

$$F = \ln\left(\frac{A}{240}\right) / B$$

Example

In the example below, the equation $y = 6.20 \cdot 10^{12} e^{-0.251x}$ is fitted to the dataset. Using the equations, a CCT_{10} value of 64 kg/m will be obtained.

$$F = \ln\left(\frac{6.20 \cdot 10^{12}}{240}\right) / 0.251 \approx 95.5N \qquad CCT_{10} = \frac{95.5}{9.81 \cdot 0.152} \approx 64kg/m$$