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TEST REPORT

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# FFU SLEEPERS BENDING TESTS AT LOW TEMPERATURE

## Static centre load tests

Tampere University tested Sekisui FFU sleepers at low temperatures that may occur in Finland. Initial temperature target was minimum -40 Celsius degrees, but the cooling arrangement led to even lower temperatures. All loading tests were load-controlled and performed according to European standard EN 13230-2, that describes load test for concrete sleepers. A static load was applied on center of sleeper. The distance between supports was 1600 mm and the supports were 100 mm wide. Between supports and sleeper were installed 15 mm thick resilient pads. Two vertical displacement transducers were installed directly above the support points, and two displacement transducers were installed directly below the loading point. The test arrangement is shown in Figure 1.

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*Figure 1 Test arrangement.*

The initial load was set to 30 kN (first load step 0 to 30 kN). After initial load phase the load was increased in steps of 5 kN. Time between the load steps was 15 seconds. The load was increased at speed of 50 kN/min. The principle of the loading curve is shown in the Figure 2. The recording frequency of the measurement results was 1 Hz.

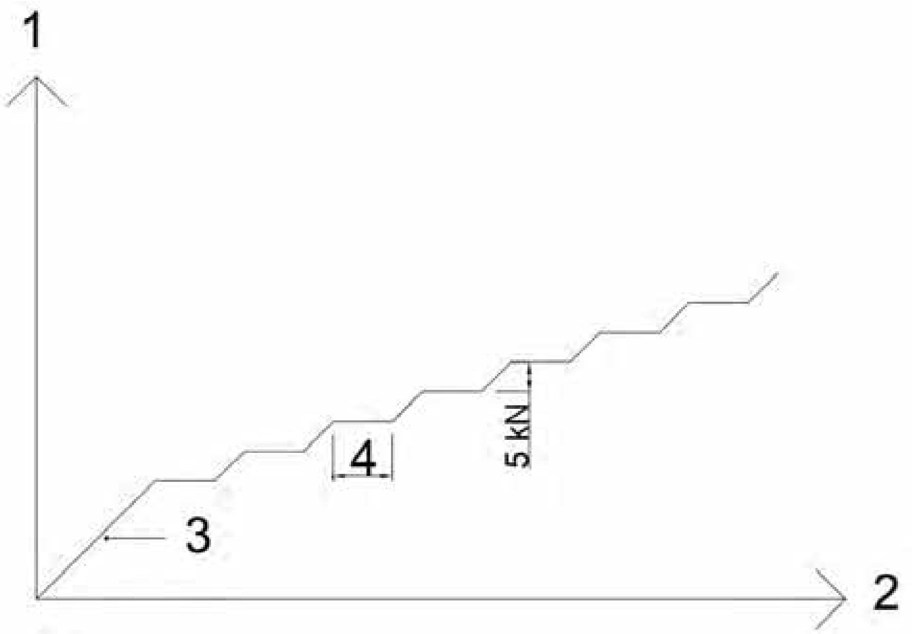


*Figure 2 Principle of loading steps in the load tests. In figure: 1 = load, 2 = time, 3 = 50 kN/min and 4 = 15 s.*

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The temperature of the sleeper was measured at three points during the loading tests. One of the points (point 1) was installed approximately 80 mm deep inside the sleeper. The second point (point 2) was installed approximately 30 mm deep inside the sleeper and the third temperature sensor measured the temperature of the sleeper surface (point 3).

## Tested sleepers

In total five FFU sleepers were delivered to tests. The dimensions of the sleepers were 260 x 160 x 2600 mm. One of the sleepers was loaded at room temperature (≈20 °C) and four sleepers were loaded at cooled. The measured temperatures during the test are shown in Table 1. The sleepers were cooled with dry ice in an insulated box that was manufactured for this purpose (Figure 3). FFU sleepers were in storage with dry ice for at least 24 hours, while sleepers cooled in temperatures of -65 – -70 °C. During the tests, the sleepers were not cooled, so the sleepers warmed from the surface during the test. Significant increase of temperature during the tests was only observed on the surface of the sleepers as shown in Table 1.

*Figure 3 Cooling box. FFU sleeper on the bottom and dry ice in baskets on top of the sleeper.*

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*Table 1 Temperatures of sleepers during tests.*

| | | Temperature [ºC] | | |
|---|---|---|---|---|
| | **Temperature measuring point** | **Beginning of the test** | **Middle of the test (Force ≈ 120 kN)** | **End of the test** |
| **Sleeper 1** | 1 | 20 | 20 | 20 |
| | 2 | 20 | 20 | 20 |
| | 3 | 20 | 20 | 20 |
| **Sleeper 2** | 1 | -68.6 | -68.3 | -67.7 |
| | 2 | -66 | -64.7 | -61.8 |
| | 3 | -61 | -52.3 | -43.7 |
| **Sleeper 3** | 1 | -70 | -70 | -69.9 |
| | 2 | -67.6 | -62 | -57.3 |
| | 3 | -51.3 | -41.7 | -31.1 |
| **Sleeper 4** | 1 | -70.4 | -70.4 | -70.2 |
| | 2 | -68.1 | -64.2 | -57,4 |
| | 3 | -60 | -50.6 | -42 |
| **Sleeper 5** | 1 | -65.3 | -65.2 | -65.2 |
| | 2 | -63.8 | -60 | -54.8 |
| | 3 | -55 | -45 | -36 |

* *Measuring points:*
- o *1: ≈ 80 mm below the sleeper surface*
- o *2: ≈ 30 mm below the sleeper surface*
- o *3: surface*

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## Force-Deflection

All force-deflection –diagrams of FFU sleepers are presented in figure 4. Bending test results showed a very high bending tensile strength. In two tests (sleeper 2 and sleeper 3) the maximum load was 230 kN and in three tests (sleeper 1, sleeper 4 and sleeper 5) 250 kN. The stiffness of the material increased slightly at low temperature. The variation between tests was negligible.


*Figure 4 Force-deflection –diagrams of sleepers.*

After the tests all the FFU sleepers were visually inspected. No cracks were detected within the bending tensile area or anywhere else on the surface of the sleeper.

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## Modulus of elasticity

Based on the measured deflection and force, the Modulus of elasticity was determined using the following equation:

$$E = \frac{FL^3}{48Iv}$$

| | |
|---|---|
| E = Modulus of elasticity | [MPa] |
| F = Loading force | [N] |
| L = Bearings clearance | [1600 mm] |
| I = Area moment of inertia | [mm4] |
| v = Deflection | [mm] |

The modulus of elasticity of each sleeper was determined from the average of the results of the entire load test.

Average Modulus of elasticity:
- Sleeper 1 : 8237 MPa [temperature ≈ 20 ℃ ]
- Sleeper 2 : 8947 MPa [cooled]
- Sleeper 3 : 8942 MPa [cooled]
- Sleeper 4 : 8973 MPa [cooled]
- Sleeper 5 : 8869 MPa [cooled]
- Average of cooled sleepers (2,3,4,5): **8933** MPa

As we can see the FFU sleepers are only a little stiffer in cold conditions compared FFU sleeper in temperature +20 °C. The Modulus of elasticity increases about 8 % higher between the temperature from +20 °C to ~ -65 °C.

## Comparison to wooden sleepers

In Finland, wooden sleepers are made of pine (dimensions: 240 mm x 160 mm x 2700 mm). Average failure load of a new wooden sleeper is about 80-100 kN in similar static test (temperature +20 ° C) which have been made to FFU-sleepers. Modulus of elasticity of the new wooden sleeper is about 7300 MPa.

## Conclusions

The tests showed that FFU composite sleepers are very strong and flexible at same time. FFU sleepers will carry the loadings coming from rolling stock operating on Finnish railways. Very cold temperature makes the sleeper slightly stiffer. Low temperature did not affect the strength of the sleeper. The testing was halted before failure because the load was considered high enough for any railway application and because the deflection of the sleeper was relatively high.

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*Sleeper 1, load 250 kN.*

*Sleeper 3, load 120 kN.*

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*Sleeper 5, load 250 kN.*

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