Short Term Scientific Mission

COST action: FP1004: Enhance mechanical properties of timber, engineered wood products and timber structures

STSM title: Prefabricated timber concrete composite floor

STSM period: 23.04.2012-14.05.2012

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Budget request:
- Travel: 400€
- Subsistence: 1800€

Background:

Timber-concrete composite structural systems and floors have been investigated for nearly 80 years and used successfully in bridges, buildings and platforms. Most research on wood-concrete composite structures has been performed on various types of shear connectors, used together with standard concrete and glulam beams or wooden decks. No previous research has focused on timber-concrete systems where “dry-dry” shear connectors are embedded in the concrete so the slab and the timber beams can be connected off-site. The purpose of this research project is to explore the mechanical performance of “dry-dry” shear connectors. At the beginning pure shear tests on the connectors used were performed ad SP research center in Boras. Two full scale floor were then tested at the laboratory of the University of Lund. A really good result was achieved both in terms of strength and stiffness. In the last months other three floor was built. Two of them was already tested at the laboratory on the University of Lund. The third one was loaded by dead load and now is monitored. The goal of this mission is to elaborate the data obtained from the two test already done and to follow the acquisition of the data for the third specimens already placed in the laboratory of the Lund University.

Objectives of the STSM:

The objectives of this Short scientific mission are:

- Collect and validate the data obtained from the experimental campaign carried out at the Lunds Tekniska Hogskola (Department of Structural Engineering) on fully prefabricated timber concrete composite structures. The work was already started by Moar in his master thesis. My objectives is to elaborate all the data and validate the first elaborations that he has done.

- Collect all the data on long term bending test that is still running on one timber concrete composite floors.

- Perform dynamic tests on the floor in order to understand the natural frequency and the eigen modes.

-Write an article with prof. Roberto Crocetti concerning the previous experimental campaign on semi-prefabricated timber concrete composite structure carried out in February 2011 at the Lunds Tekniska Hogskola, Department of Structural Engineering.

Contents of the STSM:

I have spent the first days to collect the data obtained from the short term bending tests done on two timber concrete composite floors. The geometry of the two specimens are reported in Figure 1.

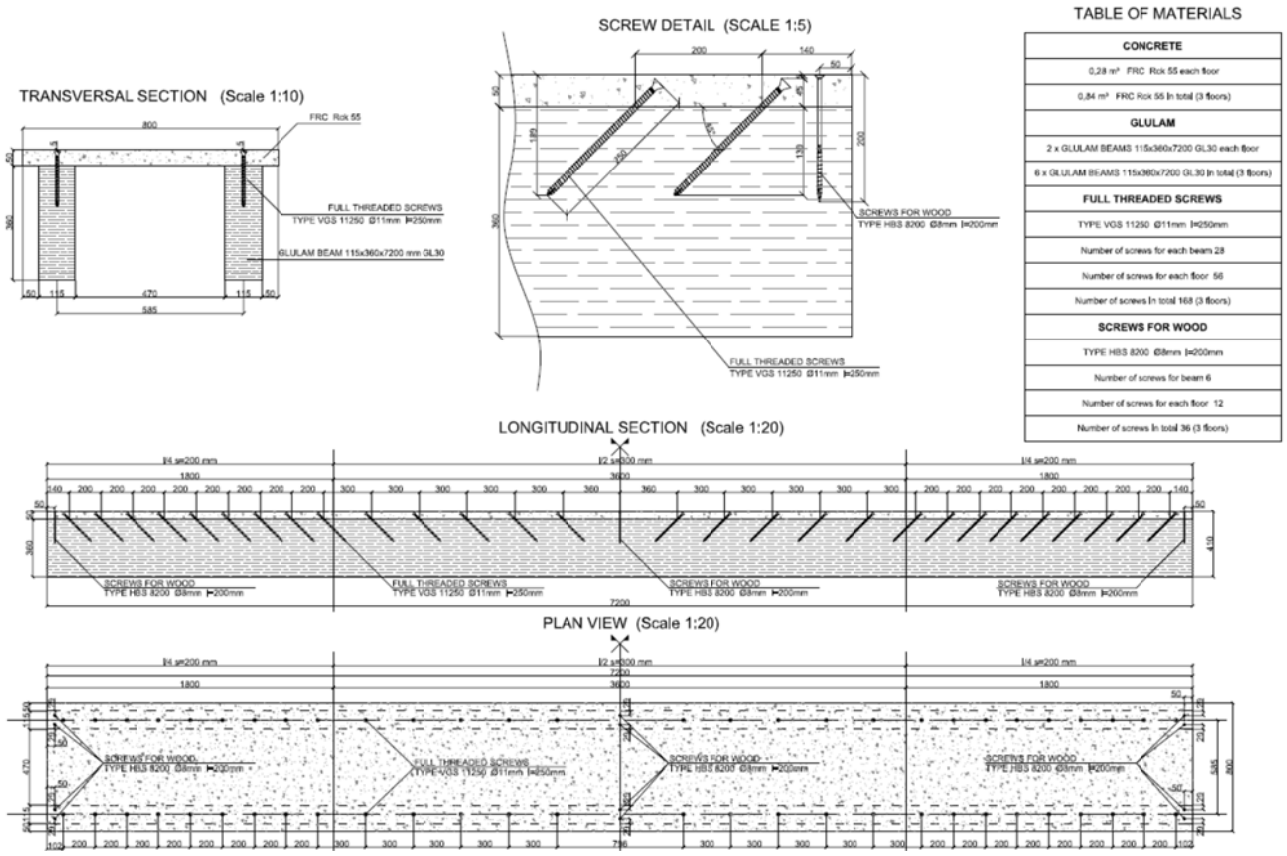


Figure 1: geometry of specimens

The full-scale specimens are both made by two glulam GL30c beams with dimensions 115 x 360 x 7200 mm, joined to a steel fiber reinforced concrete slab with 50 mm thickness, 800 mm depth and 7200 mm length, through the inclined screws. The bending tests have been performed with the machinery and equipment shown in Figure 2.

The load has been applied on four lines through steel partitioning beams; number and position of these lines have been determinate in order to induce in the slab effects (bending moment, maximum shear stress and mid-span deflection) similar to those induced by a uniformly distributed load with same resultant. The force has been applied through an hydraulic jack jointed to a reply beam constrained to the laboratory floor, located on axis to the midpoint of the testing beams, and to the partitioning main beam.

The four loads, amounting to P=4 (where P is the load applied through the hydraulic jack), have to be positioned at the specific distance from one of the two supports.

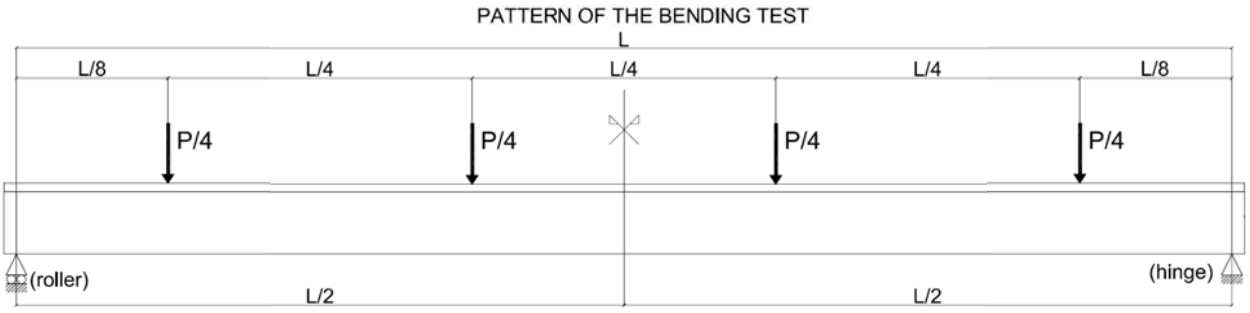
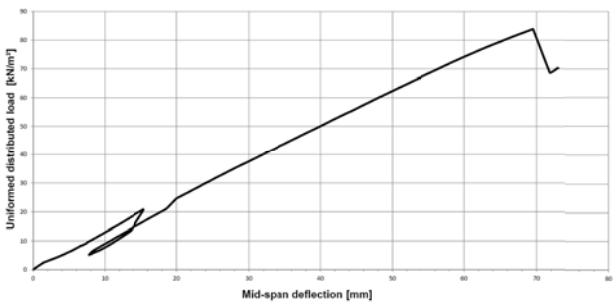


Figure 2: test set-up

The composite beams have been placed on four supports which consist in four steel plates 145 mm wide. The supports have been realized through two rollers on one side (one for each beam) and on the other side through two hinges (one for each beam). It has been chosen to reinforce the timber (compression perpendicular to the grain) at the supports with screws, in order to avoid a premature rupture of the glulam beam at the supports. Experimental tests have been performed according to standard reference UNI EN 26891:1991.



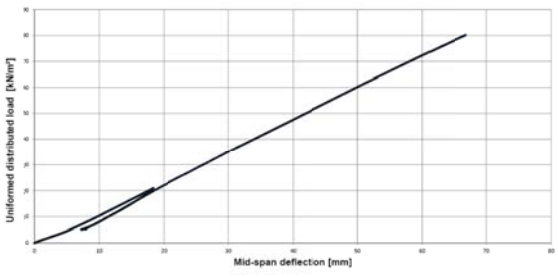


Figure 7.31: Load - mid-span deflection curve.

Figure 3: test results

Figure 3 shows that the behavior of the full-scale specimens are really linear up to the failure and even if the good design requires a ductile failure, here the failure are brittle, but it is far from the usual service conditions so it may be considered highly unlikely to occur. Eventually, the maximum mid-span deflection corresponding to an instant just before the failure of the finger joint was close to 70mm.

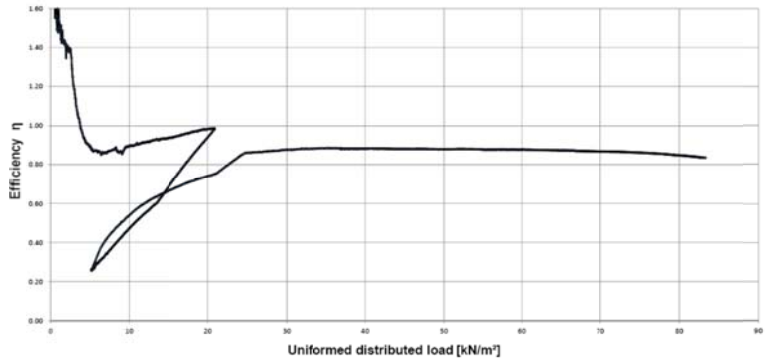


Figure 4: efficiency of the system

The efficiency assumes a constant value equal to 0; 88 of the full-composite action after the setting phase of the test up to almost the failure. As conclusion I can say that it was found that both floors behave really good both in term of stiffness and resistance.

After these elaborations I have focused my activity on the long term bending test. The floor was loaded at the beginning of February (3th) with 1 kN\m^2 of dead load (Figure 5).

Figure 5: long term bending test

The displacement at the center of beams was registered. I have collected the data. The chart is presented in Figure 6.

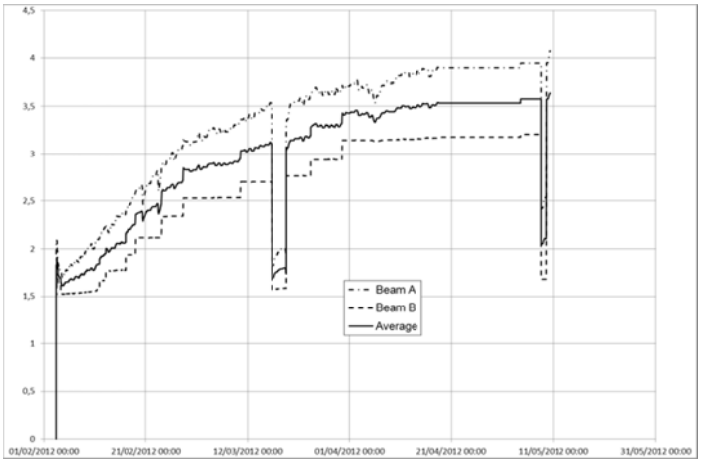


Figure 6: load displacement of long term bending test.

As it can be seen in Figure 6 the mid span deflection is more or less doubled after three months. In March the floor has been downloaded by Edurne Bona Gallego, a master student from Spain. The floor than it was reloaded and it achieved the same level of deflection than before. This operation was redone by me and it was found the same result.

The floor was then tested in dynamic way. Three accelerometers were placed on the top of the deck in three different position (Figure 7). A hammer was then use to excite the specimen. Different tests were done to well understand the dynamic behavior. Tests with load applied on the deck and tests with downloaded specimens.

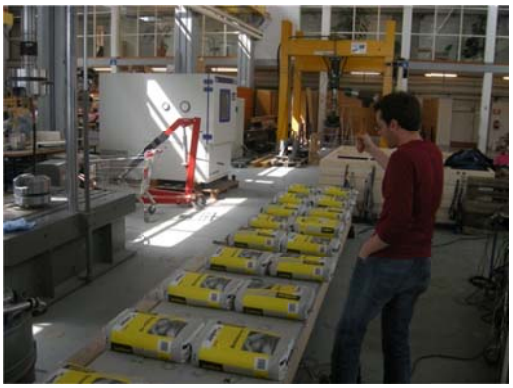


Figure 7: dynamic tests

The eigen frequencies and the eigen modes were then derived by the Matlab program.

In Figure 8 are reported the frequencies obtained from the tests.

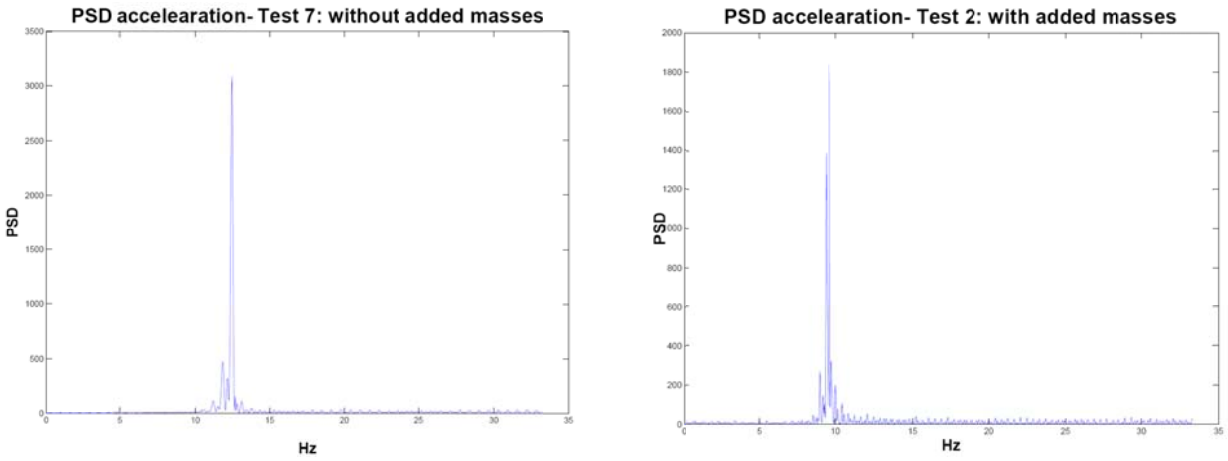


Figure 8: result of dynamic tests

The first frequency of the downloaded specimens is around 12.6 Hz. This values decrease since 9.57 Hz when a load of 1 kN\m^2 is placed on the floors. This is in agreement with the theoretical values.

After these laboratory activities I have written with Roberto Crocetti a scientific paper that resume the first experimental campaign done on shear connectors and of semi-prefabricated floors. This paper , titled "TIMBER-CONCRETE COMPOSITE STRUCTURES WITH PREFABRICATED FRC SLAB", will be send soon to an international journal.

Conclusion and further step of the STSM:

This STSM between the University of Trento and the University of Lund is part of a collaboration that will be stronger and hopefully fruitful in the next years. Master thesis students have followed all the experimental campaigns on timber concrete composite structures carried out at Lund University by the supervision of me and prof. Roberto Crocetti. My STSM is fundamental part of this activity. The data collect in the test were reordered and re elaborated and dynamic tests were done. The objective of the next months is to write another paper related to the test here presented and monitor the long term behaviour of the floor.

Trento, 29-05-2012

Tiziano Sartori