TESTING THE TIMBER – LIGHTWEIGHT CONCRETE COMPOSITE GIRDER SAMPLES

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1. Introduction

Samples of timber – lightweight concrete composite girders were tested at the Laboratory for Testing of Structures, Department of Technical Mechanics of the Faculty of Civil Engineering University of Zagreb. The composite girder consisted of a glulam web GL28 of 22/40 cm cross section and a lightweight aggregate concrete board LC 25/28 of 60/10 cm cross section. Three sample types were tested, differing by the type of connector. In Type 1 sample, connectors were 180 mm long sleeper screws installed into the predrilled holes at longitudinal distance of 20 cm, two in each section. Type 2 connectors were 180 mm long steel dowels Ø 22 mm installed into the predrilled holes filled with epoxy-based adhesive, at the same distance as the screws. Type 3 was tested as an example close to ideal composite, where the connector was epoxy-based adhesive on which fresh concrete was poured. The numerical analysis of the tested samples was conducted by finite element method by use of ABAQUS software.

The aim of the testing was to analyse the behaviour of lightweight aggregate concrete and timber when the two materials are joined by means of the foregoing connectors.

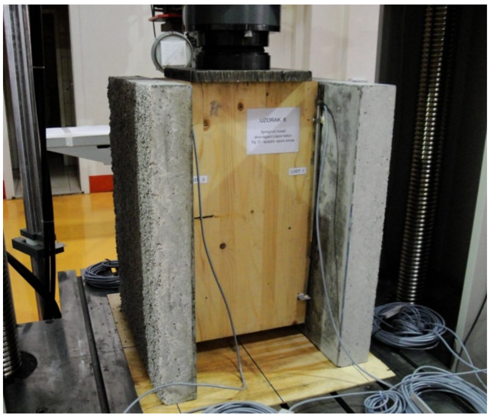

Fig. 1: Push-out test on a sample

2. Experimental Analysis

The girder samples were subject to a push-out test in a Zwick Roell 600 kN testing machine, as shown in Fig. 1. The load was increased up to 40% of the bearing capacity, after which the sample was relieved to 10% bearing capacity and then burdened (tested) until failure, i.e. slip of 15 mm. This method of increasing the load was defined in standard EN 26891 [1]. Relative displacements between timber and concrete were measured by inductive sensors (LVDT) of 10^{-3} mm precision, placed on four points, as in Fig. 2.

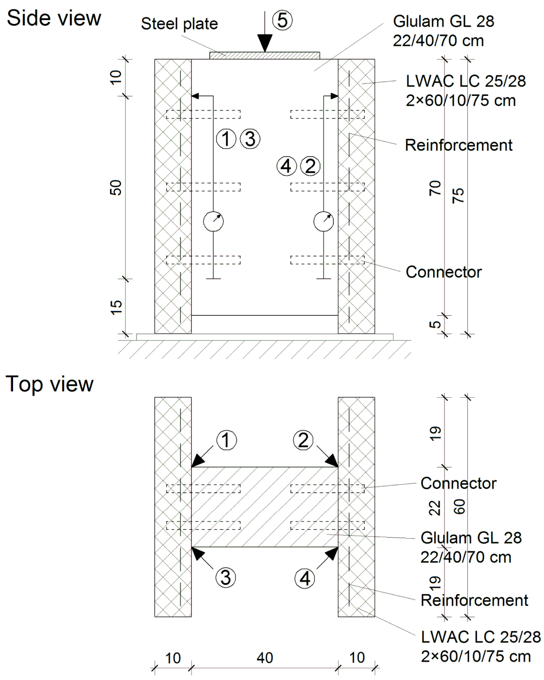

Fig. 2: Sample testing scheme with measurement points

Epoxy-based adhesive *wet* joint (timber-fresh concrete joint) has shown unexpectedly bad behaviour. The reason is significant shrinkage of lightweight concrete in early stage which was not prevented by adequate reinforcement. It caused the local separation of timber and concrete and cutting of the joint, while epoxy-based adhesive did not reach the sufficient strength yet. For comparison, another sample was tested subsequently, namely a *dry* joint of hardened concrete boards and a timber beam by means of epoxy-based adhesive.

3. Numerical Analysis

The analysis was conducted by the use of ABAQUS software. For cost-efficient and easier calculation, only a segment of the girder was modelled by the use of symmetry conditions. Three separate parts were modelled; the concrete part, the timber part and the fastener. The interaction of the contact surfaces between the timber and the concrete was modelled as *frictionless* while the interaction with the fastener was modelled as *hard contact*. The *hard contact* interaction of the contact surfaces enables their separation when not in pressure. SOLID elements C3D8R were used for the model. The finite element grid was adjusted to the size of the modelled segment and made additionally dense in the contact area of the fastener with the timber and concrete, in the maximum stress zone. Materials forming the model were modelled with the appertaining physical and mechanical properties obtained by earlier testing.

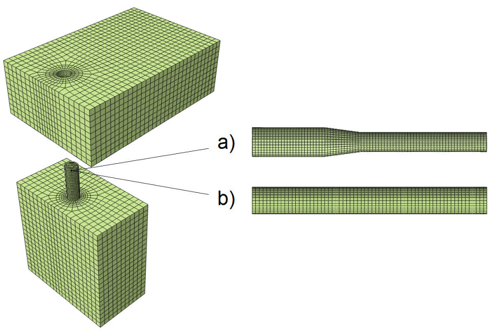

Fig. 3: FEA numerical model of a segment of timber-concrete composite structure with a) sleepers screw and b) steel dowel as connector

4. Analysis of Results

The results of experiments have shown that timber and lightweight aggregate concrete may be joined in high quality manner by the use of mechanical fasteners, as additionally confirmed by numerical analysis (Fig. 4). Type 2 with steel dowels as fasteners assumed much higher force than Type 1 with sleeper screws as fasteners. The reason is primarily the difference in the quality of steel used for the production of the dowels and sleeper screws, as well as the fact that the dowels were installed into the holes prefilled with epoxy-based adhesive, which penetrated into the timber and increased its perimeter strength. As a result of installation of the dowels into the epoxy-based adhesive, the experiment in the yield point area shows better behaviour than the numerical model. The test results and the comparison with the numerical analysis results are presented in Fig. 4 and Table 1.

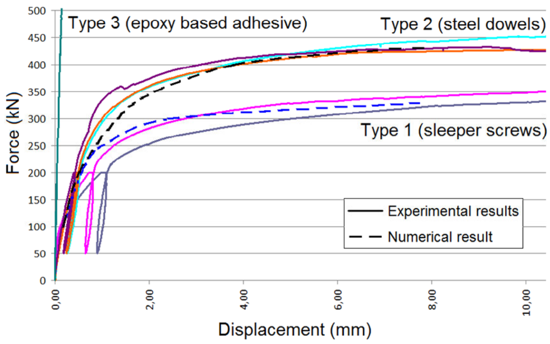

Fig. 4: Force-Displacement diagrams for samples subject to push-out test

	Exp. analysis		Num. analysis	
	F_{max} [kN]	K_{ser} [kN/mm]	F_{max} [kN]	K_{ser} [kN/mm]
Type 1	29.4	32.3	27.5	34.3
Type 2	37.0	39.7	35.0	36.4

Tab. 1: Bearing capacity (F_{max}) and slip modulus (K_{ser}) of a connector obtained by experimental and numerical analysis

5. References

[1] EN 26891, “Timber structures – Joints made with mechanical fasteners – General principles for the determination of strength and deformation characteristics”, CEN, Brussels, 1991.

[2] Steinberg E., Selle R., Faust T., “Connectors for Timber–Lightweight Concrete Composite Structures”, Journal of Structural Engineering, vol. 129, no. 11 (2003), 1538-1545.