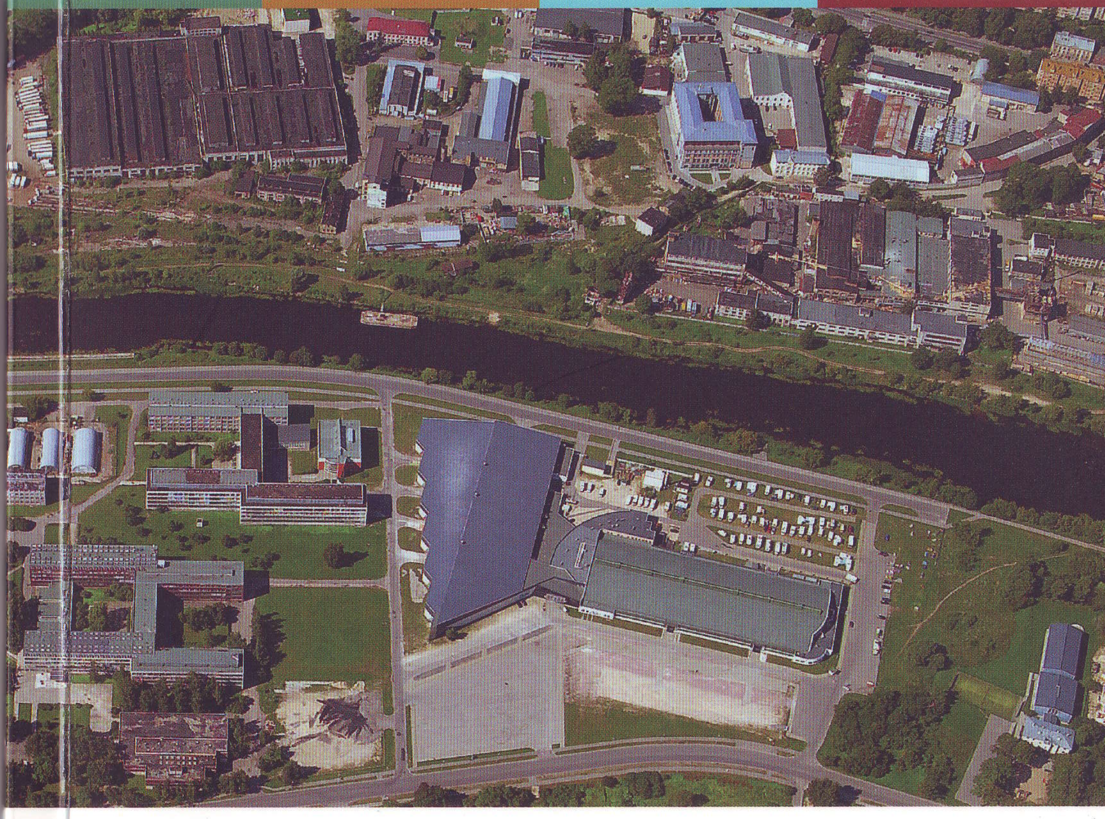
RIGA TECHNICAL UNIVERSITY
Faculty of Civil Engineering

2nd International Conference
Innovative Materials, Structures and Technologies

Book of Abstracts
Riga, Latvia, 30 September — 2 October 2015



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EFFECT OF SILICA FUME ON TWO-STAGE CONCRETE STRENGTH

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Two-stage concrete (TSC) is an innovative concrete that does not require vibration for placing and compaction. TSC is a simple concept; it is made using the same basic constituents as the traditional concrete: cement, coarse aggregate, sand and water as well as mineral and chemical admixtures. As the name suggests it is produced through a two-stage process. Firstly, the washed coarse aggregate is placed into the formwork in-situ. Later, a specifically designed self-compacting grout is introduced into the form from the lowest point under gravity pressure to fill the voids, cementing the aggregate into a monolith. The hardened concrete is dense, homogeneous and has in general improved engineering properties and durability. This paper presents the results of the research work aiming to study the effect of silica fume (SF) and superplasticizer admixtures (SP) on the compressive and tensile strength of TSC using various combinations of water to cement ratio (w/c) and sand to cement ratio (s/c). Thirty six concrete mixes were tested with different grout constituents. From each mix twenty four standard cylinder samples of size (150 mm x 300 mm) of concrete containing crushed aggregate were produced. The tested samples were made from the combinations of w/c equal to: 0.45, 0.55 and 0.85, and three c/s of values: 0.5, 1 and 1.5. Silica fume was added at a dosage of 6% of weight of cement, while the superplasticizer was added at a dosage of 2% of cement weight. The results indicated that both tensile and compressive strength of TSC can be statistically derived as a function of w/c and s/c with good correlation coefficients. The basic principle of the traditional concrete which states that an increase in water/cement ratio leads to the reduction in compressive strength was proved to be true for TSC specimens tested. Using both silica fume and superplasticisers caused significant increase in strength relative to control mixes.

FINITE ELEMENT MODELLING AND ANALYSIS OF CONVENTIONAL PULTRUSION PROCESSES

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Pultrusion process is a continuous and efficient process producing composite profiles with a constant cross-section. During pultrusion the fibre reinforcements are saturated with resin in a resin tank and then continuously pulled through a heated die by a puller. External electrical heaters are used for the heating of the die in conventional pultrusion technology. Inside the die, the resin gradually cures and solidifies to form a composite part with the same cross-section profile as in the die.

Curing process is exothermal chemical reaction (vulcanization) of polymer thermoset resins. Traditionally the degree of cure is approximated using the Arrhenius relationship and simple resin kinetic models. The curing rate depends on the resin properties and applied temperature.

Two numerical techniques based on the finite element method have been developed for the simulation of conventional pultrusion processes. The first one uses the general purpose finite element software ANSYS Mechanical, the second one is quite new and specialized on the fluid dynamic finite element software ANSYS CFX. The movement of resin-saturated composite is simulated as a semi steady process by using the general purpose finite element software. ANSYS Mechanical allows the obtaining of temperature distribution for the current time step by solving the remaining transient heat conduction problem. Within each time step, the species equation is solved outside the software using the control volume method to obtain the degree of cure at each nodal point. The effect of the convection and exothermic terms on temperature is computed from the known temperatures of the previous time step. The movement of the cured material is simulated by shifting the temperature and degree of cure fields after each calculation step. In pultrusion simulation made by the specialized fluid dynamic finite element software, the process is simulated as transient and the cure reaction is implemented as an additional variable.

The developed techniques have been validated by using the experimental and numerical results demonstrating the distribution of thbae temperature and degree of cure along the control line of pultured profile and published in open literature. Three test examples have been analysed: pultrusion of cylindrical rod [1]–[3], flat plate [3], [4] and I-beam [5]. The first test was chosen to validate the simulation of the exothermal curing reaction under constant external thermal conditions. To avoid the influence of other factors on the result of calculations only the pultruded composite material has been simulated in this test. 3-D model of pultured composite profile and steel pultrusion die was prepared for the simulation of the flat plate pultrusion in the second test. This test allowed the validation of the curing simulation techniques when an interaction of the pultured material with the heated die was observed. An important simplification used in this test was the simulation of zones with constant temperatures on the die surfaces instead of the applied heaters. This simplification was not used in the third test where the heaters were modelled as aluminium bodies with a heat generation equal to the electrical power of heaters. The temperature in the die was controlled by turning the heaters ON and OFF during the remaining transient solution.

Good agreement between the present finite element results and published numerical-experimental results showed that the developed techniques can be used successfully for an accurate simulation of the conventional pultrusion processes with different initial data, boundary conditions and new technological requirements.

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FIBRE REINFORCED POLYMERS (FRP) AS REINFORCEMENT FOR CONCRETE ACCORDING TO GERMAN APPROVALS

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Since more than 20 years that in Germany FRPs have been used as reinforcement for concrete.
The first application was for the strengthening of concrete constructions which are reinforced with reinforcement steel or pre-stressed steel. The first approvals in Germany for FRPs with Carbon Fibres were issued in mid-nineties of the last century. In most cases FRPs are used in the form of prefabricated Carbon Fibre Strips which are bonded with epoxy adhesives on the surfaces of the concrete parts for strengthening them. Since the beginning of 2000 there are also approvals for the strengthening with prefabricated Carbon Fibre Strips which are bonded in slits of the concrete.
Soon after that first applications for the strengthening of concrete constructions with Carbon Fibre Sheets began. The difference is that with Carbon Fibre Strips on site only the bond between the strips and the concrete is realised while with Carbon Fibre Sheets the bond between the fibres as well as the concrete is realised on site.
Since 2000, a lot of research for such strengthening kits has been done in Germany. The result of this development is the directive from DAfStb (German Committee for Reinforced Concrete) at the national level which considers the latest scientific investigations in this field. This directive has four parts.

Part 1: Design and Construction;
Part 2: Products and Systems for Strengthening;
Part 3: Execution;
Part 4: Supplementary Rules for the Planning of Strengthening Measures.

It is not foreseen to introduce the directive legally in the design practice. The first national approvals of this new type are expected to be issued in 2014.
Part 1 of this directive has been translated into English and is being discussed in CEN/TC 250/SC 2/WG 1/TG 1.
The national approval for the second type of FRP reinforcement was issued in 2008. It is the approval for the so called Schöck-ComBar which is a reinforcing bar of Glass Fibre Reinforced Polymers. This reinforcement bar is mainly used for new buildings not for the strengthening.
The third type of FRP reinforcement is the so called Textile-Reinforcement. The first approval for such a type of reinforcement was issued in July 2014 for the applicant TUDAG (Technical University Dresden Joint-Stock Company). After sewing the textile is coated to realise the bond between the single fibres of multifilament yarns. The first approval for such a type of reinforcement was issued in July 2014 for the applicant TUDAG (Technical University Dresden Joint-Stock Company). The approval has been issued for strengthening but this type of reinforcement also may be used for new concrete elements.
During the presentation the possibility of joint principles to develop the test programmes for national approvals or European Technical Assessments will be demonstrated and the limits of the different systems will be shown, which until now have been approved in Germany.