

Evaluation of Basalt Fiber for Strength Self-Compacting Concrete

Mykhailo Stechyschyn

Building Production Department, Lviv Polytechnic National University, UKRAINE, Lviv, S. Bandery street 12,
E-mail: myhailo_2006@ukr.net

Abstract – *The effect of basalt fiber on the properties of cementing systems based on portland cement using active mineral additives microfillers and complex chemical additives for self-compacting of concrete.*

Key words – basalt fiber, superplasticizer, polycarboxylate, self-compacting fibre reinforced concrete, strength, metakaolin.

I. Introduction

Under current conditions in the building sector self-compacting concrete become more and more spread. Their special feature is that they together with the high stress-strain and performance properties are compacted and fully complete a form without the mechanical impact under own gravity. However, the tension and flexing strength in these concrete are next lower order of the compression capacity.

The development of self-compacting concrete (SCC) marks an important milestone in improving the product quality and efficiency of the building industry. Fibers in cementitious materials can have a very positive influence on the mechanical properties of the composite in its hardened state. Self-compacting fibre reinforced concrete (SCFRC) combines the benefits of SCC in the fresh state and shows an improved performance in the hardened state compared with conventional concrete due to the addition of the fibres.

One of the ways that can help improve the concrete its behaviour under the tension and raise its crack resistance provides the inclusion of fibers. Different types of metallic, polypropylene, polymeric and glass fibres are used for the fiber reinforcement. The usage of basalt fibre is respective given its low cost and the fact that some of the largest basalt deposits are in Ukraine.

The principal directions of using of self-compacting fibre reinforced concrete are: industrial floorings, high-rise construction, reservoirs, large-sized built-up constructions, bridges and tunnels constructions, plates for the airfields and roads constructions, power constructions.

II. Problem statement

Expansion of concrete use in construction, exaggeration of operating conditions of constructions make grow requirements for its strength, crack resistance, resistance to shock and dynamic impacts, abrasion, etc. Fiber reinforcement and additional reinforcement of continuous fiber reinforcement give concrete increased resistance to cracking, transverse and breaking loads allow to create required storage of strength maintaining structural integrity, even after through cracks occurring. Currently

suppressing factors in the introduction process of fiber reinforcement concrete products (glass, polymeric, metallic) is a low resistance to chemical attack of glass fibres in the hardening cement paste environment, the high cost of synthetic fibers with their low efficiency, metallic fibers lack. During reinforced concrete widespread use the composite materials gain the particular attention, in which the matrix takes the role of cement brick derived on the basis of Portland cement and basalt fibers used as reinforcement. Therefore, the basalt fibers using for increase cold resisting quality, resistance to effects of heat, abrasion resistance of concrete is a crucial task of self-compacting concrete [1].

III. Analysis of recent research and publications

The particular importance for basalt fiber reinforcement self-compacting concrete is its resistance to chemical attack in alkaline environment of the concrete. Recent researches [2] show that under certain conditions basalt fiber can be used for the concrete reinforcement. Fiber reinforcement can replace reinforcement of rod reinforcement in plate structures of the industrial floorings, road toppings and bending elements. Improvement of rheological properties of ready-concrete mix makes use of self-compacting fibre reinforced concrete multicomponent compositions using chemical and mineral supplements fibers and polyfractional filling matters [3]. The use of complex supplements allows to produce few and densely reinforced structures of smaller thickness increase pouring concrete capacity. Self-compacting fibre reinforced concrete production is to obtain a material with maximum density coefficient and minimum microcracks, pores. The basis of self-compacting fibre reinforced concrete is to increase ready-mix concrete smoothness by reduction of coarse aggregate maximum size, microfiller materials use for maximum density, the inclusion of superplasticizers to the concrete for maximum dilution of ready-mix concrete and fiber reinforcement of cement brick structure [4].

IV. Research Methods and materials

To produce self-compacting fibre reinforced concrete used such materials: portland cement CEM I-42,5 Volyn-cement JsCo. Dyckerhoff AG with the following characteristics: specific surface $S=395 \text{ m}^2/\text{kg}$, rest on a sieve 008 – 1,2 wt.%, initial set – 2 hours 35 minutes, final set – 4 hours 00 minutes, ultimate compressive strength after 2,7 and 28 days – 19,5; 29,5 and 52,5 MPa respectively. As fine aggregate for concrete used quartz sand with fineness modulus $M=1,77$ of Zhovkva field Lviv region. The mixture was dispersed reinforced by the basalt fibre diameter of 16 microns, made of basalt roving. To improve concrete consistency and reduce water demand superplasticizer based on polycarboxylate was added to concrete. As fine additives used metakaolin with the following characteristics: apparent density – 304,0 (to compaction), 447,0 (after compaction), rest on a sieve

0063 – 1,32 wt.%, specific surface - 15 m²/g, loss on ignition – 1,2 wt.%; chemical composition wt.%, Al₂O₃ - 43,8; SiO₂ - 53,42; Fe₂O₃ - 0,75; TiO₂ - 0,58; CaO - 0,45.

To study the fiber effect on the self-compacting concrete test beams size 4x4x16 sm were built up.

Base of the self-compacting concrete is free fluid ultrathin cement paste. Except high flowability cement paste must have a sufficient viscosity to avoid segregation.

V. Results of research

Flowability of cement systems that satisfies the requirements of self-compacting (spread RZ, indicated by use of cylinder Suttarda is over 300 mm), achieved through the use of polycarboxylate type superplasticizers 1,5-2,0 wt.%. To eliminate the negative effects of high flowability cement systems and increase their sedimentation stability, speed hardening necessary to use cement systems based on Portland cement using active mineral additives, microfiller and complex chemical additives.

The influence of mineral and chemical additives on viscosity of cement paste estimated by time of spreading cement paste for 250 mm (T₂₅₀) from cylinder Suttarda, on the flowability – in terms of spread cylinder Suttarda. So, lead-through 2 wt.% superplasticizer based on polycarboxylate provide increase flowability cement paste by W/C=0,25, spread of cylinder constitutes 335 mm, time T₂₅₀=4,5 s. Lead-through metakaolin to modified cement system composition increases its viscosity - time of spreading increases to 6 s., flowability of cement paste increases to RZ=360 mm. Comparative studies of the relative viscosity of cement paste without additives shown, that increasing amounts of water to ensure flowability of cement paste 330 mm leads to a significant decrease in its relative viscosity. As the results of testing the strength of cement stone strength based on Portland cement with the addition of superplasticizer and metakaolin is growing all the time hardening. So, stone strength based on Portland cement without additives after 2 days of hardening under normal conditions constitutes 60,6 MPa, under lead-through 2 wt.% superplasticizer and metakaolin stone strength grows up to 72,8 MPa (technical effect $\Delta R_{pr}^2=20\%$).

Research of influence on the properties of basalt fiber fine concrete set (fig.1), that the use of basalt fibers provide strength increase bend at all curing time.

So, bending strength fine-grained concrete without fibers after 28 days of hardening under normal conditions constitutes 10,2 MPa, under lead-through 1,5 wt.% bending strength fine-grained concrete increases to 13 MPa (technical effect $\Delta R_{bs}^{28}=28\%$).

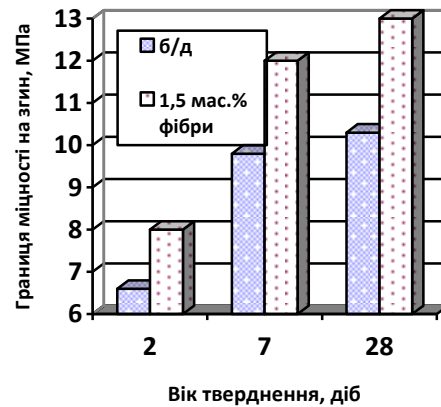


Fig. 1. Effect of basalt fiber for strength fine-grained concrete

Conclusion

As can be seen from the above sensitivity analysis and basalt fiber on rheology characteristics cement systems systematic approach in determining the quality self-compacting fibre reinforced concrete can predict and sent regulate its performance in wide use for manufacturing cast-in-place and precast topping of road, floor of bridge, floors of industrial buildings coast protection works and berths runways of airfields, foundations for heavy machinery, etc.

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