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IMPACT RESISTANCE OF SFRM MODIFIED BY VARIED SUPERPLASTICIZERS

The paper presents results of examinations of steel fiber reinforced mortar (SFRM) modified by superplasticizers based on different chemical substances. The described SFRM were made on the basis of fine aggregate cement matrix modified by the addition of hooked steel fibers. The examination was a drop-weight test. Results allowed to specify influence of the specific superplasticizer on SFRM dynamic features.

Introduction. Development of modern civil engineering includes an urgent need to develop higher performance engineering materials possessing high strength, toughness, energy absorption, durability, etc [3]. One of such steel developing high performance engineering materials is steel fiber reinforced mortar (SFRM). This paper carried out an experimental investigation on three series of SFRM. Steel fiber-reinforced mortar is more difficult to mix and place than plain concrete. Adding any type of steel fiber to a mortar reduces fluidity of the mixture because of the needlelike shape and high specific surface of the fibers. The geometry and water requirements of SFRM are an obstacle to its workability [1, 2, 12]. These factors lead to a reduction in consistency and the necessity to use superplasticizer. This study examines the effect of different new generation superplasticizers on the dynamic properties of SFRM.

It is much more difficult to quantitatively investigate dynamic properties of material than to qualitatively study static or quasi-static properties [3, 13]. Static and quasi-static properties of SFRM are already well-known and described [6, 7, 8, 9], but there is still lack of research programs concerning dynamic properties of such composites.

Materials and test method. Materials consisted of ordinary Portland cement with 28-day compressive strength of 32.5 MPa (CEM I 32.5), natural fine aggregate of maximum size 2mm, tap water for mixing and curing and three superplasticizing admixtures. The superplasticizers are codified as PC3, PE and CRSP. The PC3 is a superplasticizer based on polycarboxylate, the PE superplasticizer is based on polyether, and the CRSP superplasticizer contains silica fume. The density of PC3, PE and CRSP superplasticizers was equal to 1.1 g/cm^3, 1.1 g/cm^3 and 1.45 g/cm^3 respectively. The superplasticizing admixture was batched in quantity equal to 1% (by mass of cement). The water to cement ratio (w/c) was 0.50. Aggregate used in the examinations was described in detail in previous works [4, 5]. Hooked steel fibers of a length equal to 50mm and circular cross-section, with an aspect ratio l/d = 50 and breaking strength of 1100 MPa were used in this research study. The mortar was modified by the addition of steel fibers used of volume fractions varying between 0 and 2.8 %. Mixing, vibrating and curing of SFRM was applied according to the procedures described in [10, 11].

The specimens were in a form of beams and plates. Before testing, beams (100•100•400mm) were cut into three cube specimens. These specimens were used to determine the compression strength f_{cube} and density ρ. For the impact test, a drop-weight apparatus was used. A steel ball of 2381g was falling onto the center of a freely supported plate (250•250•50mm) from a fixed height of 500mm. Energy passed to the plate during one weight drop was equal to 11.7J. Number of dropping the weight until the appearance of the first crack n_{crack} and until ultimate destroying the plate n_{max} was counted. In total, 15 mixtures were made, including 5 mixtures modified by superplasticizing admixture PC3, 5 mixtures modified by the PE, and 5 mixtures modified by the CRSP. These three groups of mixtures had the same contents (fine aggregate =1780kg/m^3, cement =400kg/m^3, water =200kg/m^3, superplasticizer =4kg/m^3). The only difference between them was the volume of the applied steel fiber.

Test results. Compressive strength and density of the hardened concrete are shown in Fig.1, 2 and 3 independently for each of the applied admixtures in relation to the quantity of batched steel fibers. Compressive strength of cement mortars with the admixture PC3 decreased from f_{cube} = 32.20 MPa for plain cement mortar to a value of f_{cube} = 27.90 MPa at a V_f = 1.4 %. Thereafter the strength increased again with further increase in the quantity of fibers until it reaches f_{cube} = 39.90 MPa at the maximum addition of fibers. Plain cement mortar is characterized by a density ρ = 2104 kg/m^3. The density increased with an increase in the addition of fibers until it reaches ρ = 2208 kg/m^3 at V_f = 1.4 %. Further dosing of fibers slightly decreased the density of mortar which is characterized by ρ = 2183 kg/m^3 at a maximum addition of fibers. In case of mortar modified by admixture PE, together with the increase of fiber content there is a decrease of both strength from f_{cube} = 40.20 MPa to f_{cube} = 25.80 MPa, and the density from ρ = 2095 kg/m^3 to ρ = 1997 kg/m^3. The addition of the admixture CRSP increased the density of mortar from ρ = 2174 kg/m^3 for plain matrix to ρ = 2414 kg/m^3 for mortar modified by a maximum quantity of fibers. Compressive strength increased from f_{cube} = 46.80 MPa for plain matrix to f_{cube} = 53.30 MPa for concrete of fiber contents V_f = 2.1 %.

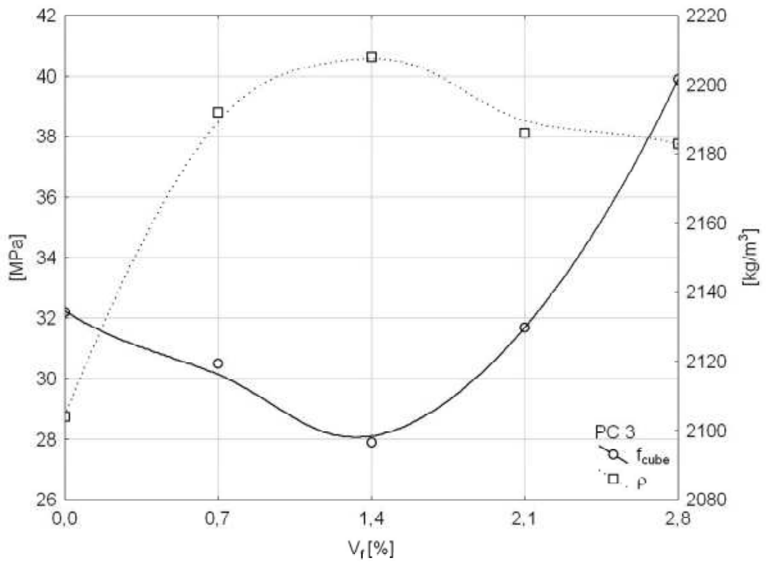

Fig.1. Compressive strength and density of SFRM modified byPC3 admixture

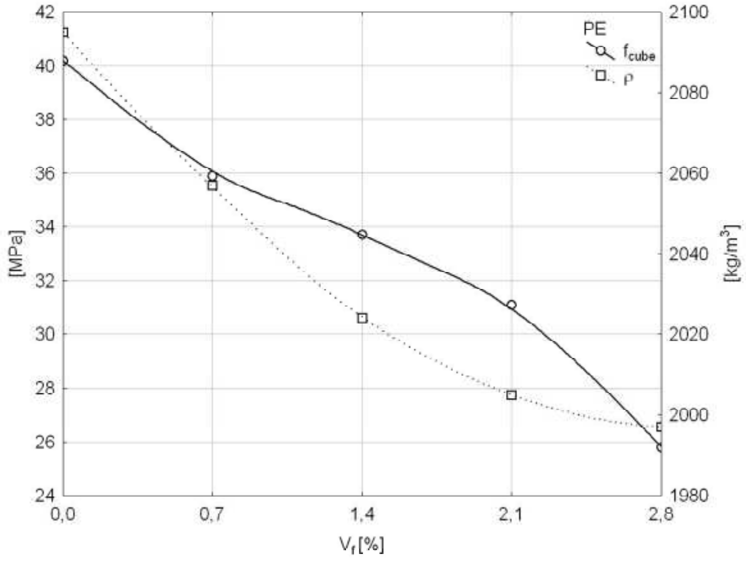

Fig.2. Compressive strength and density of SFRM modified by PE admixture

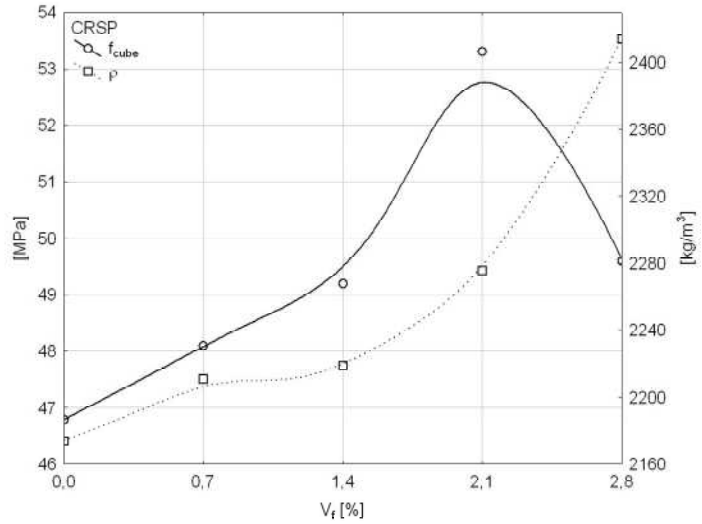

Fig.3. Compressive strength and density of SFRM modified by CRSP admixture

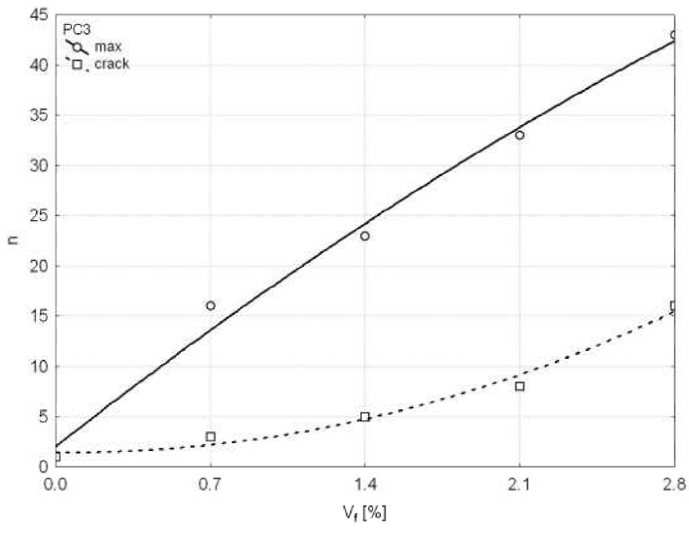

Fig.4. Number of dropping the weight until the appearance of the first crack n_{crack} and until ultimate destroying the plate n_{max} was counted for SFRM modified by PC3 admixture

The number of dynamic loading until the appearance of the first crack n_{crack} and the number of dynamic loading until ultimate destroying the plate n_{max} are shown in Fig.4, 5 and 6 independently for each of the applied admixtures in relation to the quantity of batched steel fibers.

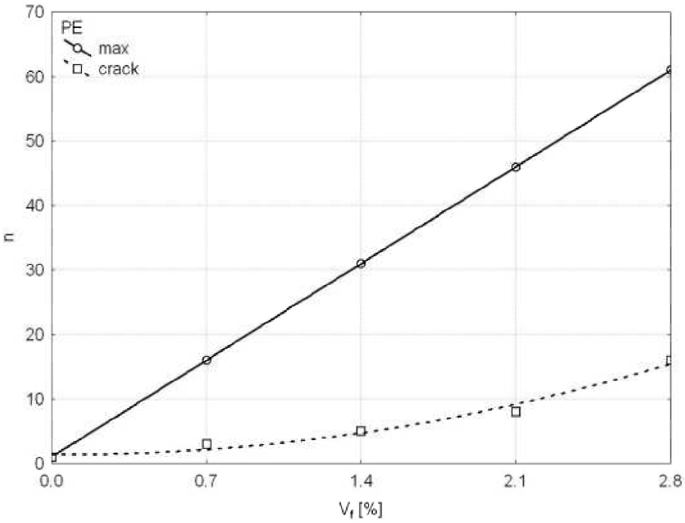

Fig.5. Number of dropping the weight until the appearance of the first crack n_{crack} and until ultimate destroying the plate n_{max} was counted for SFRM modified by PE admixture

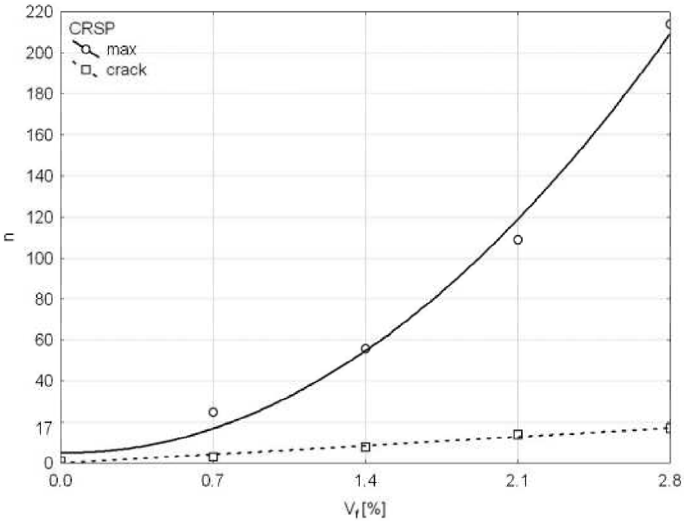

Fig.6. Number of dropping the weight until the appearance of the first crack n_{crack} and until ultimate destroying the plate n_{max} was counted for SFRM modified by CRSP admixture

The number of dynamic loading until the appearance of the first crack n_{crack} is equal to 16 for all three superplasticizers. The number of dynamic loading until ultimate destroying the plate n_{max} is equal 43, 61 and 214 for PC3, PE and CRSP admixture respectively.

Discussion and conclusions. The PC3, PE, and CRSP admixtures, represent three groups of most frequently used superplasticizers. Modifying the same mortar mixtures by each of the mentioned superplasticizers allowed to achieve fiber-reinforced mortars of entirely different features of density, strength and dynamic parameters. The choice of superplasticizer is shown to have marked influence on strength, The main advantage to SFRM beams mechanical properties resulting from the admixture of particular superplsticizer is the increase in number of dynamic loading until its failure. The number of dynamic loading until the appearance of the first crack n_{crack} is the same for all free superplasticizers. The total number of a dynamic loading of all SFRM plates modified by the CRSP admixture is the highest one. It is nearly four and five times higher then the number of a dynamic loading of plates modified by the PE and PC3 admixtures, respectively. Modifying the same mortar mixtures by each of the mentioned superplasticizers allowed to achieve fiber-reinforced mortars of entirely different features of density, strength and dynamic parameters. The choice of superplasticizer is shown to have marked influence on strength and impact resistance of SFRM.

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