STUDY OF CONCRETE WITH VARIOUS TYPES OF PLASTICIZERS AND THEIR EFFECTS ON SELECTED PROPERTIES

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Abstract- This objective of this article is to present concrete that differs by base of plasticizers used. The set of concrete contained four concrete recipes manufactured as traditional vibrated concrete containing identical basic components of concrete. The experiment focused on monitoring the resulting properties of hardened concrete, specifically the primary strength and modulus of the concrete elasticity and the developing parameters from 7 to 180 days were assessed.

Keywords- Concrete, Plasticizer, Water-cement Ratio, Compressive Strength, Modulus of Elasticity.

I. INTRODUCTION

The water-cement ratio is important part of concrete composition formula where the effect of plasticizers added for purpose to reduce the amount of mixing water and obtainment of sufficient workability of fresh concrete is reflected. Therefore through the feedforward the concrete strength is influenced with expected increase of resulting values. The reduction of water-cement ratio influences also concrete microstructures having substantial effect on mechanical behavior of the concrete.

EN 206 [1] determines the maximum permissible water-cement ratio to required grade of environment effects actuating on the concrete. Cement minimum amount is defined by environment effect class and maximum water amount by composition efficiency. The water-cement ratio is expressed by ratio of effective water content to cement weight in fresh concrete:

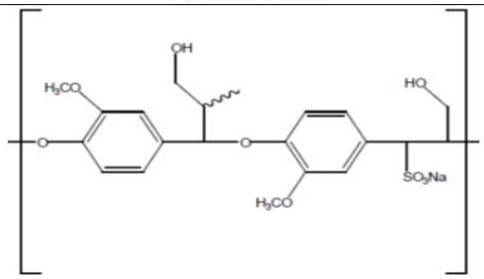
In present concreting building general practice the water-cement ratio moves within 0.25 to 0.8. Practical value of common concrete water-cement ratio moves within 0.35 to 0.60 depending on type and effect of added plasticizers or superplasticizers and required consistency of fresh concrete. Low water-cement ratios that may get under 0.25 is use namely with new modern types of concrete like RPC (Reactive Powder Concrete), characterised with very compact and consistent structure which is obtained using very effective hyperplasticizers enabling reduction of mixing water amount to minimal value and thus to obtain sufficient workability of fresh concrete.

1.1. Plasticizers and Superplasticizers

Most of producers of plasticizers (PL) and superplasticizers (SP) adapted to particular user requirements to influence properties of fresh and hardened concretes. The admixture should enable to reduce water-cement ratio while improving workability and it should maintain its efficiency during necessary time for transport and processing of fresh concrete [2].

PL and SP should not impair effects of other additives and on that ground it is necessary to select adequate technological process of concrete production with correct timing of dosing of particular admixtures.

Table1a: Chemical Composition of Plasticizers and Superplasticizers [3]

Lignosulfonate


Polycondensate of naphthalene sulfonate with formaldehyde

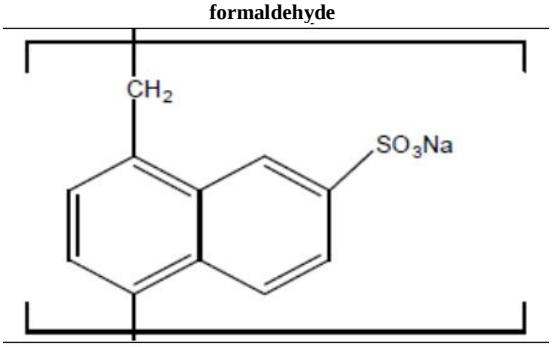
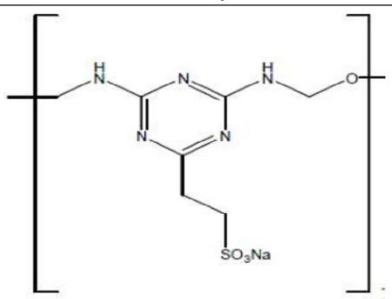
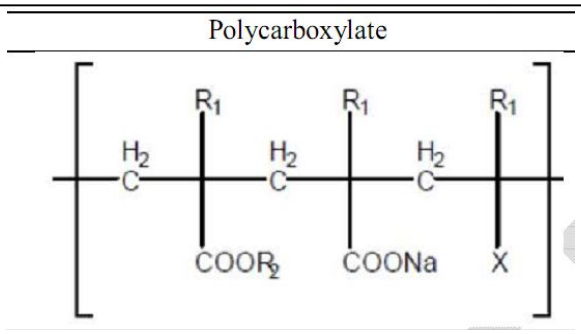


Table1b: Chemical Composition of Plasticizers and Superplasticizers [3]

Polycondensates of sulfonated melamine formaldehyde




PL's reduce water surface stress and thus increase wetting ability of mixing water [4]. On their own, PL do not influence the strength of concretes. Their influence is showed only when it has effect on water-cement ratio and concrete porosity [5]. SP significantly reduce necessary amount of mixing water without worsening the fresh concrete consistency [6]. SP may improve strength of the concrete even without changes in water-cement ratio due to higher hydration grade enabling better dispersion of cement particles [5].

The mechanism of new generation and modern SP marked as hyperplasticizers or 4th generation PL is different from the actuation of orthodox SP. In addition to characteristic dispersion effect of orthodox SP cement grains there is also so called spherical (spatial) repulsion [5]. Using one end of its macromolecular chain, the SP molecule links to cement grains while the other SP molecule chain end remains free and rotates around cement particle preventing thus other grains to approach [7]. SP dispersion mechanisms on polycarboxylate basis is invoked more due to negatively charged long chains than to presence of negatively charged anion COO^- groups causing polymer adsorption on cement grain surface [8]. The 4th generation SP of polycarboxylate type are synthesised in order to improve the spatial effect of branched molecules by modification of subsidiary chain which is decisive with PC [7]. Spherical and deflocculant effect is like bond formations between hydrating clinker materials and mineral admixtures influenced by formation of cross links among SP branched molecules. New formations (hydrates) created by initial reaction of Portland cement components with water may either on their own but mainly at SP presence strongly influence the consistency [10]. Molecule structure is formed by basic chains of polyacrylates or poly metal acrylates to which subsidiary polyethylenoxide or polypropyleneoxide chains bond. [9].

Polyether (PE) based SP's are characterised with much longer side ethylenoxide chains compared to polycarboxylate based SP's resulting in slower adsorption speed and reducing eventual retardation effect caused just by quick adsorption [8]. Almost all SP types have retardation effect which can be compared at sulfonated admixtures with retardation effect of gypsum in polycarboxylate based mixtures [10]. SP based on polycarboxylate andPE allow to reduce amount of water in concrete by more than 30 % [7].

II. EXPERIMENT

As binder Portland cement CEM I 42.5 R was selected. Aggregate fractions were represented by fine fraction 0-4 mm and coarse fraction of crushed aggregates 8-16 mm. Dosing of mixing water was changed considering the process of fresh concrete production when in tab 2 final value is registered which was really used during production of concretes. Plasticizers were selected from same producer (Chryso). Different types of plasticizers differing in effects on fresh concrete characteristics were selected. ChrysoPlast 460 is plasticizer based on lignosulfonate and on the other hand ChrysoFluid Optima 224 is a modern type of polycarboxylate based superplasticize. Formulas P_1 and P_2 were characterised by dosing with higher amount of mixing water and lower amount of plasticizer. On the other hand the SP_3 and SP_4 formulas were characterised with higher amount of superplasticizer with aim to reduce the amount of mixing water.

Table2: Mixture Proportions

Components	Weight [kg/m^3]			
	P_1	**P_2**	**SP_3**	**SP_4**
CEM I 42.5R	372	375	371	375
Aggregate 0-4	970	975	970	965
Aggregate 8-16	865	860	868	865
Water	176	180	169	165
Plasticizer	2.2	2.3	-	-
Superplasticizer	-	-	3.2	3.4
Dosage of admixtures [%]	0.60	0.61	0.86	0.91
water-cement ratio [-]	0.47	0.48	0.46	0.44

Water-cement ratio values 0.47 and 0.48 were set for formulas P_1, 2 and values 0.44 and 0.46 for formulas SP_3 and SP_4. Just in this phase of concrete composition the functionality effect is evident where in addition to practical reduction of mixing water also cement-water ratio is reduced.

In all cases the fresh concrete obtained identical consistency of fresh concrete S3, in Table 3. Density of fresh concrete moved from 2 370 kg/m^3 to 2 390 kg/m^3.

Table3: Fresh Concrete Properties

	P_1	**P_2**	**SP_3**	**SP_4**
Density [kg/m^3]	2 370	2 380	2 370	2 390
Slump [mm]	100	140	120	130
Class of Slump [-]	S3	S3	S3	S3

For each formula 8 test cubes and 6 test beams were produced. Specimens were stored in water

environment for 28 days and the left in laboratory environment. Obtained results of concretes P_1 to SP_4 are summed in Table 4 and Table 5.

Table4: Hardened Concrete Properties

		P_1	P_2
Compressive Strength[MPa]	7 days	38.5	35.4
	28 days	40.5	38.7
	90 days	41.2	42.3
	180 days	43.1	45.6
Elasticity Modulus[GPa]	7 days	24.0	23.5
		25.0	24.0
		23.0	23.0
	Average	24.0	23.5
	28 days	26.0	25.5
		26.5	26.0
		26.0	27.0
	Average	26.0	26.0
	90 days	26.0	27.5
		25.5	26.0
		27.0	27.0
	Average	26.0	27.0
	180 days	26.0	28.0
		27.0	29.5
		27.5	27.5
	Average	27.0	28.5

Table5: Hardened Concrete Properties

		SP_3	SP_4
Compressive Strength[MPa]	7 days	44.1	46.2
	28 days	45.8	49.6
	90 days	46.1	52.3
	180 days	47.4	54.2
Elasticity Modulus[GPa]	7 days	25.5	26.0
		27.0	27.5
		26.5	27.0
	Average	26.5	27.0
	28 days	26.5	29.0
		29.5	29.5
		29.0	30.5
	Average	28.5	29.5
	90 days	28.5	31.0
		28.0	29.5
		27.5	30.5
	Average	28.0	30.5
	180 days	27.5	32.5
		29.5	30.0
		30.0	30.5
	Average	29.0	31.0

Compressive strength of the concrete registered the expected trend of higher compressive strengths with SP_3 and SP_4 concretes containing in its composition design modern type of superplasticizer admixtures in all monitored concrete ages. At 28-day age the compressive strength was 40.5 MPa, 38.7 MPa (P_1 and P_2), or 45.8 MPa and 49.6 MPa (SP_3 and SP_4). Therefore it is the difference of one strength class of the concrete. Static modulus of elasticity was characterised with consistent trend. For entire monitoring period there was a difference of approx. 2.0 GPa between the concretes with orthodox plasticizer (P_1 a 2) and concretes with superplasticizers (SP_3 a 4).

Upon the set compressive strengths the monitored concretes were classified to particular strength class of concrete. In particular, the concretes P_1 and 2 (plasticizer) met C 30/37 and concretes SP_3 a 4 (superplasticizer) were filed in the strength class C 35/45. Despite the positive effect of superplasticizer on higher values of modulus of elasticity, these values did not met the model values declared by Eurocode 2 [11], when they were lower by approximately 5.5 GPA.

Table6: Comparison of Guide Modulus of Elasticity and RealValues of Concrete at Age 28 Days.

	P_1	P_2
Compressive Strength[MPa]	40.5	38.7
Concrete Class [-]	C 30/37	C 30/37
Guide Value of Modulus of Elasticity[GPa]	33.0	33.0
Real Value of Modulus of Elasticity[GPa]	26.0	26.0

Table7: Comparison of Modulus of Elasticity Guide and Measured Values of Concrete under Pressure at Age 28 Days.

	SP_3	SP_4
Compressive Strength[MPa]	45.8	49.6
Concrete Class [-]	C 35/45	C 35/45
Guide Value of Modulus of Elasticity[GPa]	34.0	34.0
Real Value of Modulus of Elasticity[GPa]	28.5	29.0

CONCLUSIONS

The experiment was involved with difference between two types of concretes with different plasticizers. Relatively constant values of compressive strengths and static moduli of elasticity were registered.

1. From the obtained results it is possible to accept the preposition based on assumption of increasing moduli of elasticity depending on growing compressive strength.
2. In the compressive strength setting phase the values were in average by 8.5 MPa higher with concretes containing superplasticizer. The same trend was found also with values of modulus of elasticity development when they got moduli by approx. 2.0 GPa higher at all monitoring periods.
3. Comparison of static moduli of elasticity of all concrete formulas showed the trend of higher value with concretes containing superplasticizer.
4. Reduction of water cement ratio showed as suitable for increase of modulus of elasticity. On

that ground it is reasonable to apply highly efficient superplasticizer which together with increase of compressive strength may also increase the modulus of elasticity to certain extent. Lower amount of mixing water may reduce the risk of decrease of modulus of elasticity.

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