RESEARCH OF INFLUENCE OF TRADITIONAL AND NONTRADITIONAL ADMIXTURES ON MORTAR AND CONCRETE

Vincas Gurskis, Karolis Bunevičius, Rytis Skominas
Lithuanian University of Agriculture,
Department of Building Construction
vgurskis@hidro.lzuu.lt; rytis.skominas@lzuu.lt

ABSTRACT

During the research the influence of several traditional and nontraditional admixtures on mortar/concrete was investigated. Plasticizers were used as traditional admixtures and dishwashing liquids – as nontraditional ones. The influence of admixtures was established according to the properties of cement paste, fresh mortar /concrete, hardened mortar/concrete. The results show that all analyzed additives are plasticizing but the nontraditional admixtures have the side-effect (air entraining effect). Due to this effect the water absorbability of mortar/concrete increased; the density and strength of mortar/concrete decreased.

Keywords: concrete/mortar, plasticizer, dishwashing liquid

INTRODUCTION

Nowadays, ninety-nine of hundred concretes and mortars are made using admixtures (Hewlett, 1989). Admixtures are mineral or organic materials, which are used for the preparation of concrete or mortar. The purpose of these materials is the regulation of solidification and technological properties of concrete/mortar. Admixtures can increase the workability, reduce the water content of fresh concrete/mortar, speed up or speed down the hydration of the concrete/mortar, increase the strength and durability, reduce damage during freeze-thaw cycles of hardened concrete/mortar.

Generally, admixtures are aqueous solutions made from mineral or organic materials. There are two types of admixtures which are used for mixtures with mineral binder (cement, lime, gypsum): mineral and chemical. Mineral admixtures are materials in the form of powder, which are added to the mix to improve the properties of the mixture or as a replacement for binder. Chemical admixtures are chemical materials that are added to mixtures in negligible quantity and which have special effectiveness. The effectiveness of admixture is characterizing the ability to change the properties of the mixture or hardened material without harmful effects. Mostly chemical admixtures are materials in the form of fluid but sometimes they can be in the form of powder. The concentration of admixtures in the fluid form describes the quantity of the active substance, which determines the effectiveness. The effectiveness can be evaluated in various values. For example, the effectiveness of plasticizers is evaluated by the reduction of the water amount for mixture in percents.

Chemical admixtures can bring a harmful effect (retard the solidification and hardening, cause the corrosion of concrete or reinforcement, reduce the strength) in mixtures. Due to this effect chemical admixtures are used only under the recommended proportions of the producers.

Admixtures of analogical purpose are produced in many countries with different branded titles. These materials are relatively expensive, therefore, sometimes cheaper nontraditional materials (dishwasher liquids), which have a plasticizing effect on concrete/mortar, are used in local building as well. A lot of experimental researches concerning traditional plasticizers (Alsayed, 1998; Green et al., 1999; Paivaa et al., 2009) were carried out, but the influence of nontraditional materials on the properties of fresh and hardened concrete/ mortar was not investigated.

The aim of the present work is to research and compare the influence of traditional and nontraditional admixtures on concrete and mortar.

MATERIALS

During the research plasticizers STACHEPLAST 125 (based on lignosulfonates) and Glenium ACE 430 (based on polycarboxylic ethers) were used as traditional admixtures and dishwashing liquids BANGA, TOMIK and FAIRY were used as nontraditional admixtures. The latter admixtures are often used by Lithuanian builders, which work by business license.

Mortar was prepared using the Portland cement CEM II/A–LL–42,5N, natural sand (fraction 0…4 mm) and water. Sand and water meet the requirements described in the European standards EN 13139:2002 and EN 1008:2002.

Concrete was prepared using the Portland cement CEM II/A–LL–42,5N, natural gravel (fraction 4…16 mm), natural sand (fraction 0…4 mm) and water. Gravel, sand and water meet the requirements described in the European standards EN 12620:2002+A1:2008 and EN 1008:2002.

TEST METHODS

In order to compare the effectiveness of admixtures the concentration was estimated by the desiccation method according to the European standard EN 480-8:1996.

The admixtures were dozed under dry material up to 2 % (from cement mass). The amount of water (for the achievement of the normal consistency of cement paste) was estimated according to the European standard EN 197-2:2000.

The consistency of fresh concrete was estimated according to two methods: Slump-test (EN 12350-2:2009) and Flow table test (EN 12350-5:2009). The consistency of fresh mortar was evaluated by the embed depth of standard cone (height 150 mm, angle of spike 30°, mass with stick attached to base 300±2 g), according to LST L 1346:2005.

The density, compression strength and water absorbability of hardened concrete were established according to standard methods (EN 12390-7:2009, EN 12390-3:2009, EN 13369:2004). The size of the tested concrete specimens was 100×100×100 mm with the age of 28 days. In order to evaluate the water absorbability, compression and flexural strength of mortar, the specimens (40×40×160 mm) were prepared and tested after 28 days by standard test methods (EN 196-1:2007).

RESULTS AND DISCUSSION

The concentration (amount of dry materials) test results (Table 1) show us, that the differences between the used admixtures are more than 3 times.

The effectiveness of admixtures was established according to the amount of water necessary for normal consistency of cement paste (Table 2). The paste was prepared using only water and water with 0.5; 1.0; 2.0 % (from cement mass) of admixtures.

Table 1

Concentration of admixtures

Admixture	Concentration %
STACHEPLAST 125	37.9
Glenium ACE 430	27.7
BANGA	8.9
TOMIK	10.7
FAIRY	11.4

Table 2

Amount of water necessary for normal consistency of cement paste

Admixture/Amount of admixture, %		Amount of water, %	Coefficient of effectiveness
Without admixture		29.00	1.00
Glenium ACE 430	0.5	24.48	0.84
	1.0	22.62	0.78
	2.0	20.05	0.69
BANGA	0.5	30.53	1.05
	1.0	26.55	0.92
	2.0	24.32	0.84
TOMIK	0.5	27.95	0.96
	1.0	25.38	0.88
	2.0	22.07	0.76
FAIRY	0.5	27.73	0.96
	1.0	25.43	0.88
	2.0	25.85	0.89

Table 3

Slump and flow table test results

Admixture used	Slump, mm	Coefficient of effectiveness	Slump class	Flow, mm	Coefficient of effectiveness	Flow class
Without admixture	16	**1.00**	S1	378	**1.00**	F2
Glenium ACE 430	205	12.81	S4	510	1.35	F4
BANGA	62	3.88	S2	425	1.12	F3
TOMIK	49	3.06	S2	398	1.05	F2
FAIRY	185	11.56	S4	425	1.12	F3

Table 4

Test results of fresh concrete density

Admixture used	Density of fresh concrete kg/m^3	Coefficient of effectiveness
Without admixture	2374	1.00
Glenium ACE 430	2380	1.00
BANGA	2185	0.92
TOMIK	2120	0.89
FAIRY	2110	0.89

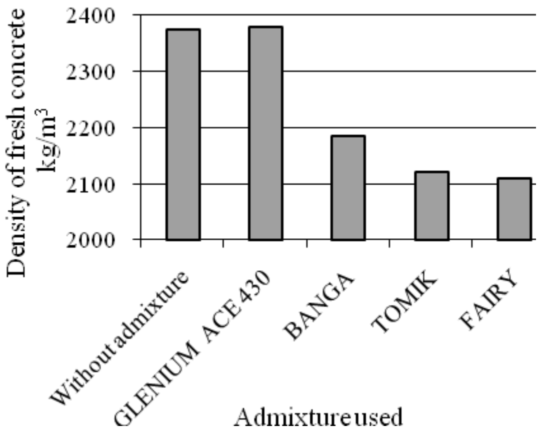

Figure 1. Dependency of used admixtures (0.5 % from cement mass) on density of fresh concrete.

The test results confirm the effectiveness of the traditional admixtures Glenium ACE 430 and STACHEPLAST 125. These materials reduced the amount of water most of all (18-31 %). The effect of the nontraditional admixtures is less: the dishwashing liquid BANGA reduced the amount of water by 16 %, TOMIK – by 24 % and FAIRY – by 11 %.

Test results of fresh concrete

In practice it was confirmed that nontraditional admixtures increase the plasticity of concrete/mortar. It is the main reason for the use of admixtures in building. The effect of admixtures on the properties of fresh and hardened concrete was estimated on mixture made from cement (c=380 kg/m^3), water (w = 180 kg/m^3), natural gravel (940 kg/m^3) and sand (900 kg/m^3). The ratio of cement and water was w/c=0.47. The consistency of fresh concrete was estimated by slump and flow table test methods using 0.5 % (from cement mass) of the admixture (Table 3).
The test results show that all admixtures increase the plasticity of fresh concrete. The most effective admixtures are GLENIUM ACE 430 and FAIRY, which increased the slump more than 10 times.
The effect of admixtures to the flow of fresh concrete is less expressed in comparison with the slump. Glenium ACE 430 increased the flow most of all (35 %). According to the test results of fresh concrete density it is seen that some admixtures (especially nontraditional) decreased this parameter (Table 4, Fig. 1). The admixtures BANGA and FAIRY decreased the density of fresh concrete most of all (11 %). Such change is connected with the air-entraining effect.

Test results of hardened concrete

With the decrease of the density of fresh concrete, which was modified with nontraditional admixtures, let us assume that these admixtures will have a negative effect on the properties of hardened concrete. In order to approve this assumption the density, compression strength and water absorbability of hardened concrete with different admixture were established (Table 5, Fig. 2, 3).
The results show us that all nontraditional admixtures reduced the density of hardened concrete by 6÷9 % and compression strength by – 38÷53 %. We can see an opposite effect with the traditional admixture Glenium ACE 430. This admixture increased the density by 2 %, compression strength by 1 % and water absorbability decreased by 20 %. The nontraditional admixtures had a negative effect on water absorbability too. FAIRY increased it by 16 % and TOMIK – by 8 %. Such decrease of the density and compression strength of concrete modified with nontraditional admixtures is connected with the air-entraining effect, because every percent of entrained air decreases the compression strength of concrete by 6 %. The linear dependency of the concrete density on the compression strength was estimated (Figure 3).

Table 5

Test results of density, compression strength and water absorbability of hardened concrete modified with traditional and nontraditional admixtures (0.5 % from cement mass)

Admixture used	Compression strength $f_c=\beta \cdot F/A$ N/mm²; β=0.95	Density kg/m³	Water absorbability %	Coefficient of effectiveness		
				For density	For compression strength	For water absorbability
Without admixture	38.0	2380	6.21	1.0	1.0	1.0
Glenium ACE 430	38.4	2426	4.97	1.02	1.01	0.80
BANGA	22.5	2204	6.16	0.93	0.59	0.99
TOMIK	23.5	2244	6.68	0.94	0.62	1.08
FAIRY	17.7	2163	7.20	0.91	0.47	1.16

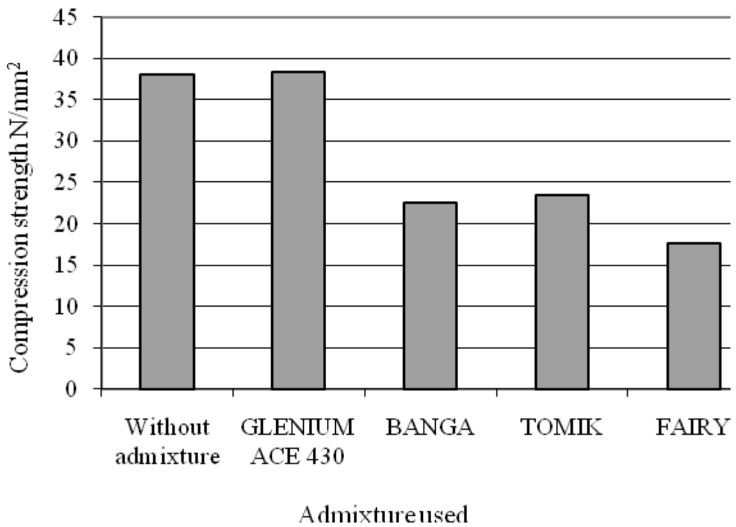

Figure 2. Dependency of used admixtures (0.5 % from cement mass) on density of hardened concrete.

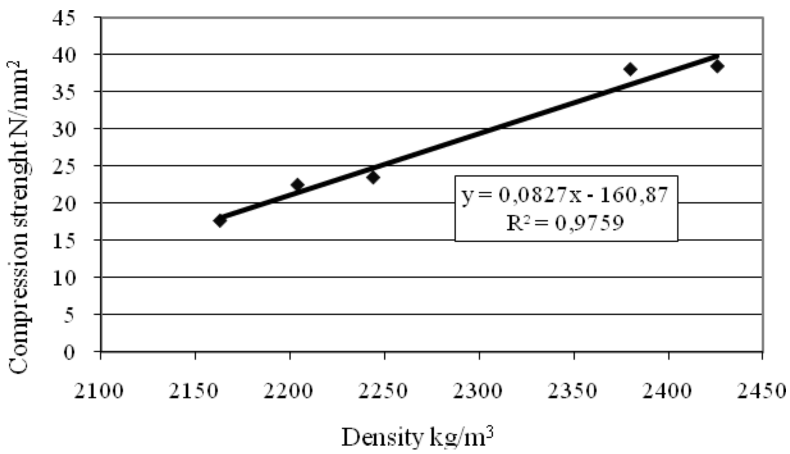

Figure 3. Dependency of concrete density on compression strength.

The test results of concrete water absorbability show us, that these nontraditional admixtures form the open pore structure of concrete, which notes enlarged water absorbability. Therefore, the concrete will be less frost resistant.

Table 6

Test results of consistency of fresh mortar

Admixture used (0.5 % from cement mass)	Embed depth of cone, mm	Coefficient of effectiveness
Without admixture	41	1.00
STACHEPLAST 125	105	2.56
FAIRY	114	2.78
BANGA	103	2.51
TOMIK	110	2.68

Table 7

Test results of water absorbability, flexure and compression strength of hardened mortar modified with traditional and nontraditional admixtures (0.5 % from cement mass)

Admixture used	Compression strength, N/mm^2	Flexure strength, N/mm^2	Water absorbability, %	Coefficient of effectiveness		
				For compression strength	For flexure strength	For water absorbability
Without admixture	44.7	6.93	9.22	1.00	1.00	1.00
STACHEPLAST 125	36.0	6.03	8.04	0.80	0.87	0.87
BANGA	19.1	4.63	9.62	0.43	0.67	1.04
TOMIK	22.2	4.41	10.64	0.50	0.64	1.15
FAIRY	15.6	4.01	10.22	0.35	0.58	1.11

Test results of mortar

In order to estimate the influence of traditional and nontraditional admixtures on fresh and hardened mortar the mixture (1 part of cement, 3 parts of natural sand and 0.44 part of water) was made. The ratio of cement and water was w/c=0.44. The amount of admixtures made 0.5 % from the cement mass. The test results (Table 6) of the consistency of fresh mortar evaluated by embed depth of standard cone show us that all admixtures increased the plasticity of mortar. The nontraditional admixture FAIRY had the best effect on this parameter (increased it by 178 %).

In order to evaluate the influence of admixtures on the properties of hardened mortar specimens (40×40×160 mm) with different admixture were made and they were tested after 28 days of solidification (1 day in the form and 27 days in water). The test results of the water absorbability, flexure and compression strength are presented in Table 7. The test results show us that nontraditional admixtures have a negative effect on the mechanical properties of mortar. The compression strength of mortar has decreased by 20÷65 % and flexure strength – by 13÷40 %. This negative effect is higher than that with hardened concrete, which is maybe connected with the different condition of solidification (mortar specimens were solidified in water and concrete specimens – in moist air). Like in concrete specimens the nontraditional admixtures increased the water absorbability of the mortar specimens, too. This effect confirms the existence of the open pore structure. Besides, it is not advisable to solidify mortar or concrete in water using air-entraining admixtures, because in the length of time the air pores of mortar or concrete fill with water to a higher degree and raise the negative water effect on the strength of the material.

CONCLUSIONS

1. According to the amount of water necessary for normal consistency of cement paste (with traditional and nontraditional admixtures) all admixtures have a plasticizing and water reducing effect. Using 2 % (from cement mass) of nontraditional admixtures to prepare normal consistency of cement paste the amount of water reduces by 11– 24 %.
2. Traditional and nontraditional admixtures increased the slump class of concrete from S1 to S4 and the flow class – from F2 to F4. The traditional admixture Glenium ACE 430 has the best effect.
3. All admixtures used in the research increased the plasticity of mortar evaluated by embed depth of standard cone up to 2.8 times.
4. Nontraditional admixtures have an air-entraining effect. Due to this the density, compression and flexure strength of concrete and mortar decreased.
5. According to the test results nontraditional admixtures are not suitable to concrete and masonry mortar for load-bearing structures due to the decreasing strength.

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