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BUILDING MATERIALS REALIZED WITH ULTRA-FINE FLY ASH AND SILICA FUME

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The author's experimental researches presented in this paper were focused on the building materials obtained by using ultra-fine fly ash and silica fume (like heavy mortars or compacted lightweight concretes).

From experimental determinations there have been studied the following characteristics: the water absorption in function of mass, apparent density, tensile and compression strength (at 7 and 28 days), technical efficiency at 28 days and shrinkage.

1. Introduction

The ultra-fine fly ash produced from the burning of pulverized coal in a coal-fired boiler is a ultra-fine grained usually collected from the flue gas by means of electrostatic precipitators, baghouses or mechanical collection devices such as cyclones.

Silica fume (microsilica) is a product of manufacturing silicon metal or ferrosilicon alloys. It is a very reactive pozzolan.

The use of industrial wastes like ultra-fly ash and silica fume represent a positive position regarding the conservation and the protection environment.

The authors experimental researches presented in this paper were focused on the building materials obtaining (like heavy mortars or compacted lightweight concretes) by using ultra-fine fly ash and silica fume.

From experimental determinations there have been studied the following characteristics: the water absorption in function of mass, apparent density, tensile and compression strength (at 7 and 28 days), technical efficiency at 28 days and shrinkage.

2. Experimental Researches

The experimental researches were realized on mixtures with the following composition: a) water – 15%; b) dry material – 85%.

The dry material was proposed with the following percent combination: a) sand 0...3 mm sort – 50%; b) blended binders – 50%. For establishing of blended binders was used the next model:

$$\%\sum \text{blended binders} = \%\sum (\text{classic binders} + F + M) = 100\%,$$

where: classic binders–cement (C) and lime (L); F – ultra-fine fly ash from power plant; M – silica fume.

The composition of classic binders was established by using lime (L) – 10%, cement (C) – 10%, 20% and 30% from blended binders.

Silica fume (M) was 10% from blended binders.

Ultra-fine fly ash (F) was obtained from relation

$$\%F = 100\% - \% \sum(\text{classic binders} + M).$$

The samples were realized in two steps:

a) on first step was prepared a manual mixture from sand, fly ash, silica fume lime and cement;

b) in the second step was added water with superplasticizer and the mixture was mechanical mixed 2 min at low speed and 1 min at high speed.

During the mixing was added water to realize minimum workability mixture; in the end final water quantity was 17.5%.

The compactness was performed on the jolting table in two sequences: 30 jolts in 30 s for the first half of material and 30 jolts in 30 s for the mould filled with all material.

The prismatic samples have the dimension of $40 \times 40 \times 160$ mm.

There was used the ultra-fine fly ash from Timişoara Power Plant. Silica fume was supplied from Tulcea Factory (Romania).

Sand was 3 mm maximum size of granules and continues grading.

The composition of tested building materials are presented in Table 1.

Table 1
The Composition Mixtures with Industrial Recycling Waste (Ultra-fly Ash and Silica Fume)

Batch	Water %	Lime %	Cement %	Silica fume %	Fly ash %	Sand 0...3 mm %
Series 1 – L10 C10	17.5	4.12	4.12	–	33.01	41.25
Series 2 – L10 C10 M10	17.5	4.12	4.12	4.12	28.89	41.25
Series 3 – L10 C20 M10	17.5	4.12	8.24	4.12	24.77	41.25
Series 4 – L10 C30 M10	17.5	4.12	12.36	4.12	20.65	41.25

N o t e: during the mixing was added 0.5% additive (polycarboxylatether) from blended binders sum.

3. The Physical and Mechanical Characteristics

The water absorption in function of mass, apparent density, tensile and compression strength (at 7 and 28 days), technical efficiency at 28 days and shrinkage were determined.

After 28 days age the samples were dried until to constant mass and kept 12 h into water for water absorption determination.

In the Table 2 is presented the water absorption in function of mass for materials researched.

Table 2
Water Absorption in Function of Mass

Water absoption	Series 1 L10 C10	Series 2 L10 C10 M10	Series 3 L10 C20 M10	Series 4 L10 C30 M10	Lightweight concrete	Ceramic brick
a_m, [%]	20.4	19.6	19.0	18.4	≤ 45	≤ 20

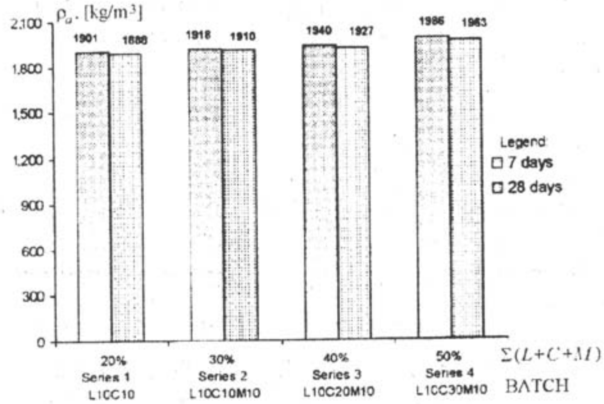


Fig. 1.- The apparent density.

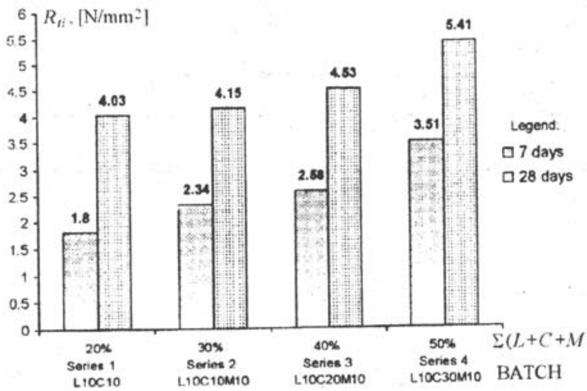


Fig. 2.- The tensile strength.

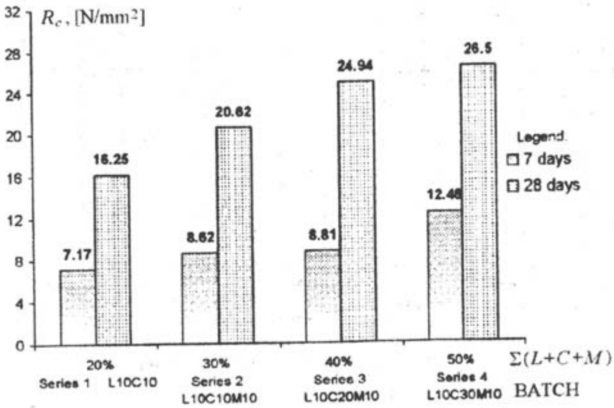


Fig. 3.- The compressive strength.

The results obtained for density, tensile and compression strength at 7 and 28 days are presented in Table 3 and Figs. 1...3. The apparent density for different types of batches is showed in Fig. 1. The tensile strength, R_t, is presented in Fig. 2, the compression strength, R_c, in Fig. 3 and technical efficiency, R_c/ρ_a, in Fig. 4, for different samples.

Table 3

Physical and Mechanical Properties of Hardened Mixtures at 7 and 28 Days

Batch	Apparent density ρ_a, [kg/m^3]		Tensile strength R_t, [N/mm^2]		Compression strength R_t, [N/mm^2]		$\frac{R_c}{\rho_a}$
	7 days	28 days	7 days	28 days	7 days	28 days	$\frac{\text{kN}\cdot\text{m}}{\text{kg}}$
Series 1 L10 C10	1,901	1,888	1.80	4.03	7.17	16.25	8.61
Series 2 L10 C10 M10	1,918	1,910	2.34	4.15	8.62	20.62	10.80
Series 3 L10 C20 M10	1,940	1,927	2.58	4.53	8.81	24.94	12.94
Series 4 L10 C30 M10	1,986	1,963	3.51	5.41	12.46	26.50	13.50

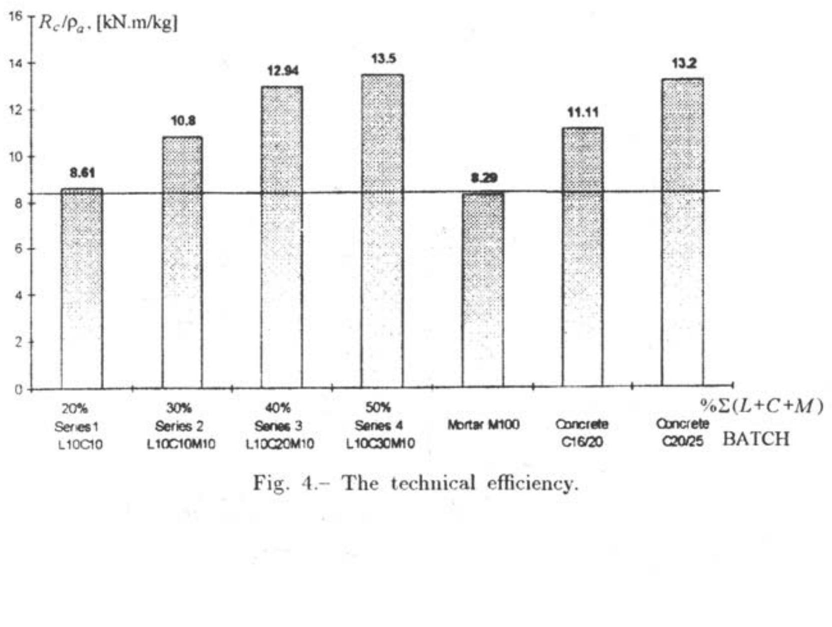
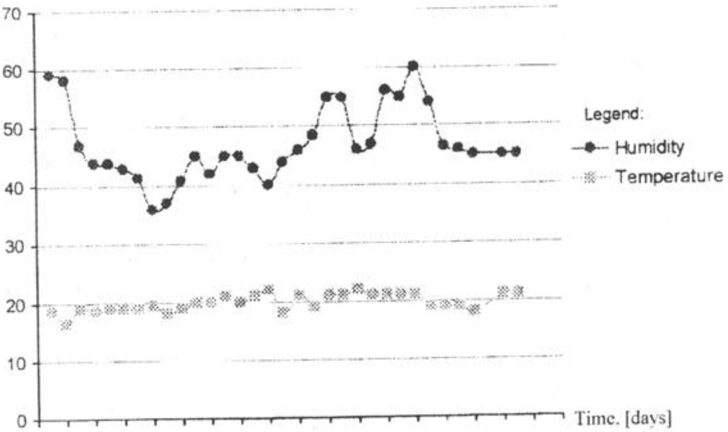


Fig. 4.– The technical efficiency.



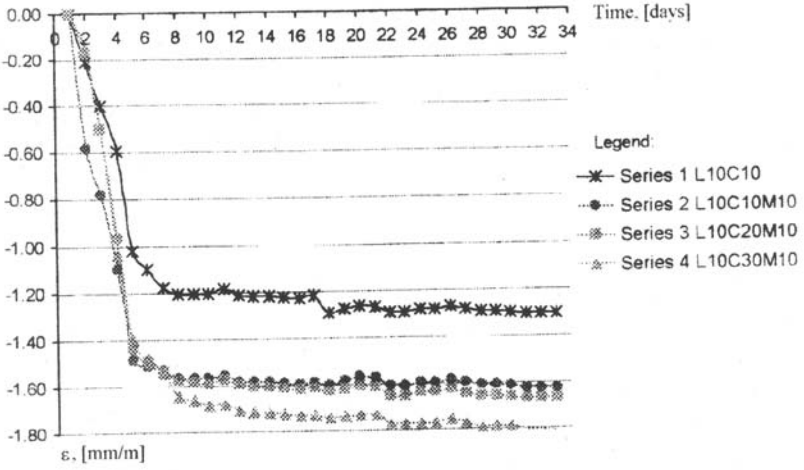


Fig. 5.– Shrinkage.

For shrinkage determination were recorded dates during 33 days. The shrinkage at 28 days old is presented in Table 4.

The variation of temperature, relative humidity and shrinkage *versus* time are showed in Fig. 5.

Table 4
Materials Shrinkage at 28 Days Age

Shrinkage	Series 1 L10 C10	Series 2 L10 C10 M10	Series 3 L10 C20 M10	Series 4 L10 C30 M10	Mortar	Ordinary concrete
ε_c, [mm/m]	−1.29	−1.61	−1.66	−1.79	≤ 2	0.3...0.8

4. Conclusions

1. The apparent density at 28 days for different batches, represented in Fig. 1, have a value comprised between 1.888 and 1.963 kg/m^3 which framed the materials in medium heavy mortars category or compacted lightweight concretes.

2. At 28 days the tensile strength, R_t, has big values comprised between 4.03 N/mm^2 and 5.41 N/mm^2 (Fig. 2) and the compressive strength, R_c, between 16.25 N/mm^2 and 26.50 N/mm^2 (Fig. 3) like M 100 mortar, bricks and C 8/10...C 16/20 compacted lightweight concrete class.

3. The technical efficiency coefficient represented in Fig. 4 shows that the new materials with recyclable waste have the same technical efficiency like classical building materials.

4. The biggest increased values were obtained for increasing percent of cement (30%) and silica fume (10%) for series 4 L10 C30 M10.

5. The adding of 10% of silica fume (series 2 L10 C10 M10), by comparison with series 1 L10 C1.0 (control sample) without silica fume, produced an increase of 4.37 N/mm^2 for compressive strength, R_c, that means 26.9%.

6. The limit of the water absorption in function of mass for materials researched is situated under lightweight concrete limit and near to ceramic brick limit.

7. The shrinkage has the values situated between –1,29 mm/m and –1,60 mm/m, which are greater than ordinary building materials.

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MATERIALE DE CONSTRUCŢII REALIZATE CU CENUŞĂ ULTRAFINĂ ŞI SILICE ULTRAFINĂ

(Rezumat)

Problema valorificării acestor deşeuri industriale este de actualitate atât sub aspect economic cât mai ales **ecologic**.

S-au obţinut amestecuri care se pot încadra în categoria mortarelor grele sau a betoanelor compacte uşoare.

Se prezintă rezultatele unor cercetări experimentale efectuate de autori pe diferite amestecuri bazate pe cenuşă de electrofiltru ultrafină, silice ultrafină, lianţi clasici (var+ciment), nisip, apă şi aditivi în vederea obţinerii unor materiale de construcţii eficiente.

Prin determinările efectuate s-au urmărit următoarele caracteristici fizico-mecanice ale amestecurilor întărite: absorbţie de apă, densitate, rezistenţa la întindere prin încovoiere, rezistenţa la compresiune, contracţia la uscare.