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SELF COMPACTING CONCRETE WITH BRICK DUST

BY

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Abstract. Because of the high amount of concrete used everywhere in the world, and the big necessity of aggregates and cement the science community has to come with a solution for this problem. The article presents a study of self compacting concrete using recycled aggregates, in this case brick dust, for satisfaction of mechanical properties. Self compacting concrete seems to be the best solution to stop pollution when we talk about concrete because it doesn’t need compacting technologies and offers the opportunity to add to it in limited dosage recycled aggregates or fly ash as substitution of a small portion of cement. The study presents a number of 18 recipes who are using brick dust divided in three categories according to the dimensions of particles such as: 0-4mm; 4-8mm; 8-16mm. The brick dust is replacing the same category of aggregate in three separate percentages: 10%, 20% and 30%. The replacement of cement with fly ash has also been done for the 18 recipes in two percentages: 5% and 10% and the results for fresh state and mechanical properties and density is discussed.

Keywords: friendly environment, brick dust, fly ash, green concrete, sustainable.

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1. Introduction

Self Compacting Concrete represents a type of concrete that has the ability to fill the shapes that he is poured without vibration. It can easily flow into high reinforcement density concrete elements avoiding segregation. SCC offers several economical and technical benefits and has been used in many countries since it has been developed in Japan in the late 1980s (P.L. Domone,2006).

It is considered to be a non-polluting material because it doesn't need vibrating and can absorb a series of recycled materials in certain percents due to its increased workability. Many studies have been made on SCC using waste materials. (Chang Sun et al, 2020). Recycled aggregates are used for obtaining concrete and it was demonstrated in various researches that workability is not affected. Compressive strength can be the same as in the case of structural concrete or even higher by reducing the ratio water/cement. (Thomas et al., 2014; Yazdi et al., 2015). Among the recycled materials used in self compacting concrete we can point out: blast furnace slag, brick dust, crumb rubber, fly ash etc.

The present study describes the use of brick dust in self compacting concrete. Brick dust has been chosen because it represents a large amount of the waste that is found on the construction sites for either new buildings, demolition buildings or rehabilitated ones that require compartment change.

For this purpose, a number of 18 recipes were mixed to find out the fresh state properties, mechanical resistance and density. The brick dust have been split in three types: 0-4 mm; 4-8 mm; 8-16 mm and has been replacing the same aggregates in different percents: 10%, 20% and 30%.

In combination with other additions fly ash concrete can present improved properties (higher durability, a lower shrinkage) (Dinakar et al., 2008; Leung et al., 2016). Fly ash was added to each recipe in 5% and 10% replacing cement. For each recipe a number of three cubes with the side of 150 mm has been poured to find the compressive strength and the results were compared.

2. Experimental program

For the SCC reference recipe, the following materials were used: river washed aggregates separated in three different categories such as 0-4 mm, 4-8 mm, 8-16 mm, water, sika superplasticizer additive, cement 42.5R from Carpatcement, fly ash and limestone for increasing the fine part.

Table 1
Mix proportions of the concrete specimens

Mix	Cement kg/m^3	Limestone kg/m^3	Sort 1 0-4 kg/m^3	Sort 2 4-8 kg/m^3	Sort 3 8-16 kg/m^3	Water litres	Additive %	Fly ash kg/m^3	Brick dust kg/m^3	Water/cement ratio
C0	380	120	918	306	540	145	0.8	0	0	0.38
5%/0-4/10	361	120	642.6	306	540	145	0.8	19	275.4	0.38
5%/0-4/20	361	120	367.2	306	540	145	0.8	19	550.8	0.50
5%/0-4/30	361	120	0	306	540	145	0.8	19	918	0.56
5%/4-8/10	361	120	918	214.2	540	145	0.8	19	91.8	0.45
5%/4-8/20	361	120	918	122.4	540	145	0.8	19	183.6	0.53
5%/4-8/30	361	120	918	0	540	145	0.8	19	306	0.53
5%/8-16/10	361	120	918	306	378	145	0.8	19	162	0.52
5%/8-16/20	361	120	918	306	216	145	0.8	19	324	0.47
5%/8-16/30	361	120	918	306	0	145	0.8	19	540	0.50
10%/0-4/10	342	120	642.6	306	540	145	0.8	38	275.4	0.54
10%/0-4/20	342	120	367.2	306	540	145	0.8	38	550.8	0.55
10%/0-4/30	342	120	0	306	540	145	0.8	38	918	0.64
10%/4-8/10	342	120	918	214.2	540	145	0.8	38	91.8	0.58
10%/4-8/20	342	120	918	122.4	540	145	0.8	38	183.6	0.58
10%/4-8/30	342	120	918	0	540	145	0.8	38	306	0.50
10%/8-16/10	342	120	918	306	378	145	0.8	38	162	0.50
10%/8-16/20	342	120	918	306	216	145	0.8	38	324	0.55
10%/8-16/30	342	120	918	306	0	145	0.8	38	540	0.58

Notations:

C0 - Reference recipe.

5%/0-4/10 -SCC recipe with replacement of cement with 5% fly ash and replacement of 10% of 0-4 mm aggregate with brick dust.

5%/0-4/20 -SCC recipe with replacement of cement with 5% fly ash and replacement of 20% of 0-4 mm aggregate with brick dust.

5%/0-4/30 -SCC recipe with replacement of cement with 5% fly ash and replacement of 30% of 0-4 mm aggregate with brick dust

5%/4-8/10 -SCC recipe with replacement of cement with 5% fly ash and replacement of 10% of 4-8 mm aggregate with brick dust.

5%/4-8/20 -SCC recipe with replacement of cement with 5% fly ash and replacement of 20% of 4-8 mm aggregate with brick dust.

5%/4-8/30-SCC recipe with replacement of cement with 5% fly ash and replacement of 30% of 4-8 mm aggregate with brick dust.

5%/8-16/10 -SCC recipe with replacement of cement with 5% fly ash and replacement of 10% of 8-16 mm aggregate with brick dust.

5%/8-16/20 -SCC recipe with replacement of cement with 5% fly ash and replacement of 20% of 8-16 mm aggregate with brick dust.

5%/8-16/30 -SCC recipe with replacement of cement with 5% fly ash and replacement of 30% of 8-16 mm aggregate with brick dust.

10%/0-4/10 -SCC recipe with replacement of cement with 10% fly ash and replacement of 10% of 0-4 mm aggregate with brick dust.

10%/0-4/20 -SCC recipe with replacement of cement with 10% fly ash and replacement of 20% of 0-4 mm aggregate with brick dust.

10%/0-4/30 -SCC recipe with replacement of cement with 10% fly ash and replacement of 30% of 0-4 mm aggregate with brick dust.

10%/4-8/10 -SCC recipe with replacement of cement with 10% fly ash and replacement of 10% of 4-8 mm aggregate with brick dust.

10%/4-8/20 -SCC recipe with replacement of cement with 10% fly ash and replacement of 20% of 4-8 mm aggregate with brick dust.

10%/4-8/30 -SCC recipe with replacement of cement with 10% fly ash and replacement of 30% of 4-8 mm aggregate with brick dust.

10%/8-16/10 -SCC recipe with replacement of cement with 10% fly ash and replacement of 10% of 8-16 mm aggregate with brick dust.

10%/8-16/20 -SCC recipe with replacement of cement with 10% fly ash and replacement of 20% of 8-16 mm aggregate with brick dust.

10%/8-16/30 -SCC recipe with replacement of cement with 10% fly ash and replacement of 30% of 8-16 mm aggregate with brick dust.

The first part of the experiment represents the fresh state of the concrete in which he must obtain a series of results on certain tests such as:

1. Filling ability is the ability to flow into all spaces within the formwork under its own weight and can be done with the slump flow test and the V-funnel. For the slump test you need an Abrams cone, a ruler, a square base plate of a non-absorbing material with at least 1m length with a marked center where you put the Abrams cone, fill it with concrete and lift. After the concrete stops spreading measure the diameter and the class is obtained.

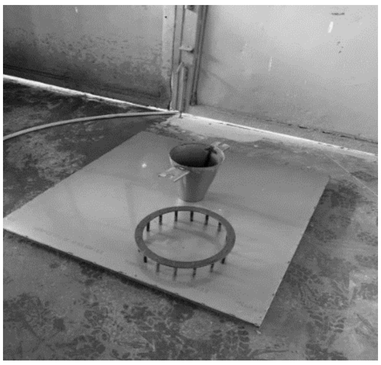

Fig. 1 – Slump flow test setup.

2. Passing ability is the ability to pass through elements with dense reinforcement without producing segregation. Passing ability can be determined by using the L-box test.

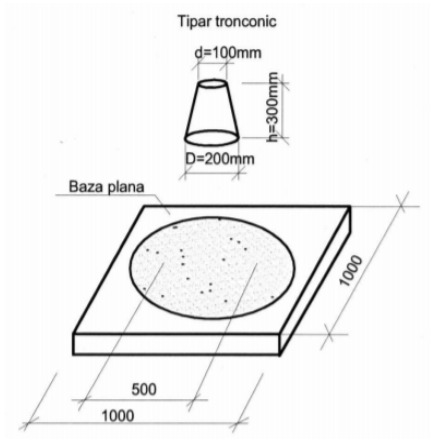

Fig. 2 – Slump flow test example.

3. Workability can be determined by doing all the tests and classifying the results in each according class after its obtained value.

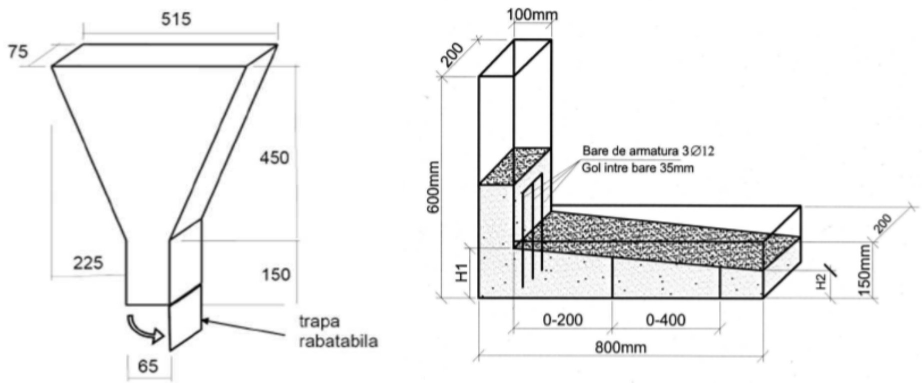

Fig. 3 – L-box test.

Table 2
Mix proportions of the concrete specimens

Recipe	Slump flow (cm)	V funnel (sec)	L-box (0.8-1)	Additive percent
C0	67	3.7	0.8	0.8
5%/0-4/10	68	5,2	0.9	1.2

5%/0-4/20	67	5,2	0.8	1.65
5%/0-4/30	67	5,4	0.8	1.7
5%/4-8/10	64	5	0.9	1.5
5%/4-8/20	67	5,4	0.8	1.8
5%/4-8/30	71	4	0.8	2.0
5%/8-16/10	60	5,5	0.8	1.3
5%/8-16/20	72	3,4	0.8	1.4
5%/8-16/30	74	3,5	0.8	1.4
10%/0-4/10	67	4,2	0.8	1.7
10%/0-4/20	76	3,2	0.8	1.9
10%/0-4/30	74	3,4	0.8	2.3
10%/4-8/10	72	3,3	0.8	1.7
10%/4-8/20	69	4,0	0.8	1.7
10%/4-8/30	68	5,4	0.8	1.8
10%/8-16/10	73	3,5	0.8	1.6
10%/8-16/20	73	3,4	0.8	1.6
10%/8-16/30	75	3,3	0.8	1.6

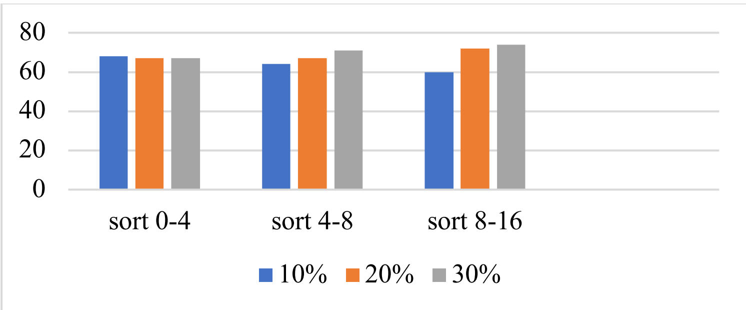

Fig. 4 – Slump flow for 5% fly ash replacement.

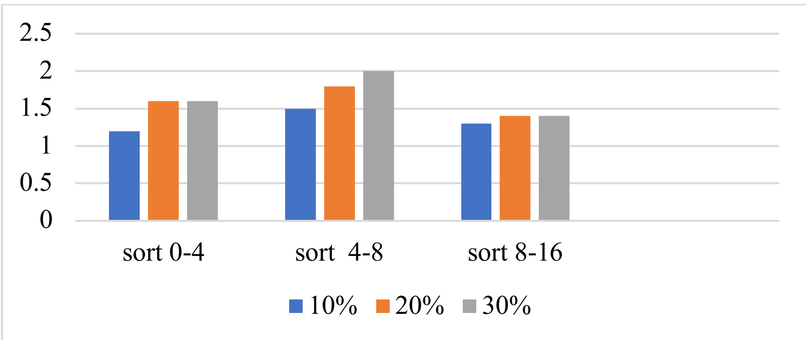

Fig. 5 – Percent of additive for every recipe.

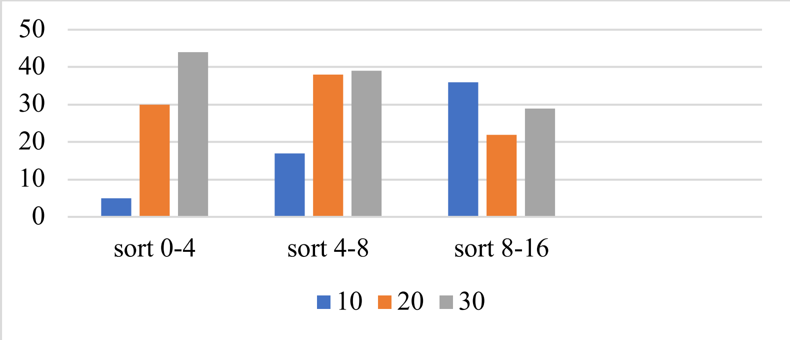

Fig. 6 – Water excess.

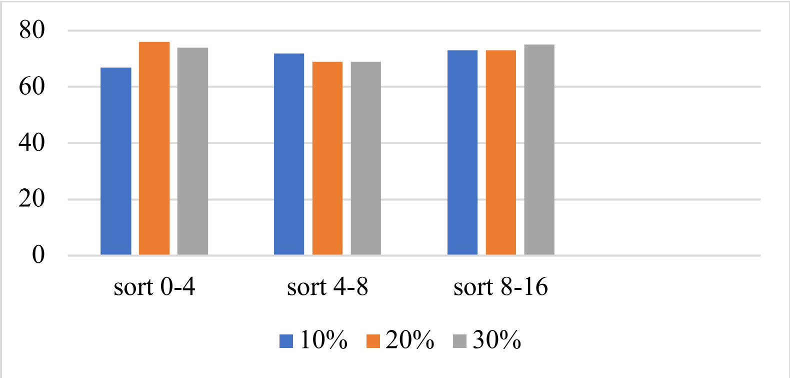

Fig. 7 – Slump flow for 10% fly ash replacement.

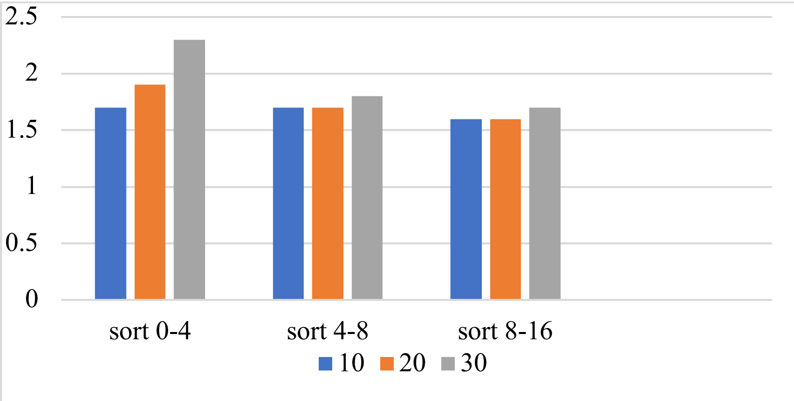

Fig. 8 –

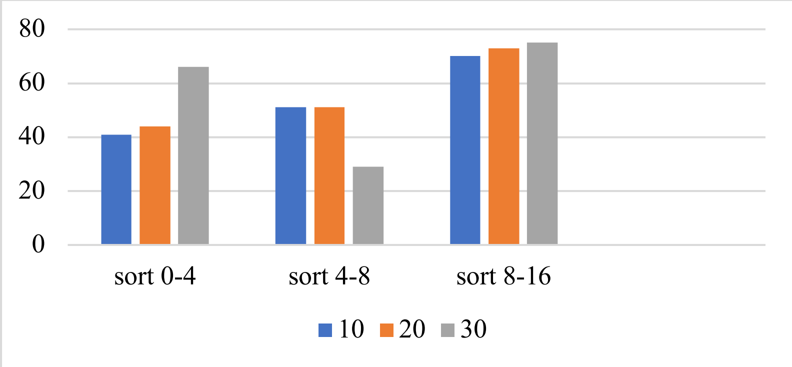

Fig. 9 – Water excess.

After the fresh state testing, we can move forward to finding the mechanical properties. For that purpose, for every recipe a number of three cubes with a side of 150 mm have been poured and tested with hydraulic press. The density in hardened form for every recipe has been determined with the following formula ro=density/volume and the result are presented in Table 3.

Table 3

Mix proportions of the concrete specimens

Number	Recipe	Medium weight	Density [kg/m^3]
0	Reference	(7886+8065+7980)/3=7977	2363.60
1	5%/0-4/10	(7569+7541 + 7720)/3= 7610	2283.00
2	5%/0-4/20	(7563 + 7714+ 7855)/3 = 7710,66	2313.20
3	5%/0-4/30	(7990+ 7877 + 7854)/3 = 7907	2372.10
4	5%/4-8/10	(7711 + 8082 +8060)/3 = 7951	2385.30
5	5%/4-8/20	(7743+ 7695 +7732)/3 =7723.33	2317.00
6	5%/4-8/30	(7751 + 7652 + 7923)/3 = 7775.33	2332.60
7	5%/8-16/10	(7557 + 7799 + 7858)/3 =7738	2321.40
8	5%/8-16/20	(7621+ 7708+ 7530)/3 = 7619.66	2285.90
9	5%/8-16/30	(7289 +7500 + 7633)/3 =7474	2242.20
10	10%/0-4/10	(7672+ 7889 + 7845)/3 =7802	2340.60
11	10%/0-4/20	(7608 + 7849+ 7750)/3 =7735.66	2320.70
12	10%/0-4/30	(7757 + 7640 + 7751)/3 =7716	2314.80
13	10%/4-8/10	(7750+ 7738 + 7693)/3 =7727	2318.10
14	10%/4-8/20	(7856 + 7721 + 7780)/3 = 7785.66	2335.70
15	10%/4-8/30	(7839 +7912 + 7952)/3 =7901	2370,30
16	10%/8-16/10	(7711+ 7784 + 7724)/3 =7739.66	2321.90
17	10%/8-16/20	(7029 + 7109 + 7187)/3 =7108.33	2132.50
18	10%/8-16/30	(7306 + 7463 + 7068)/3 = 7279	2183.70

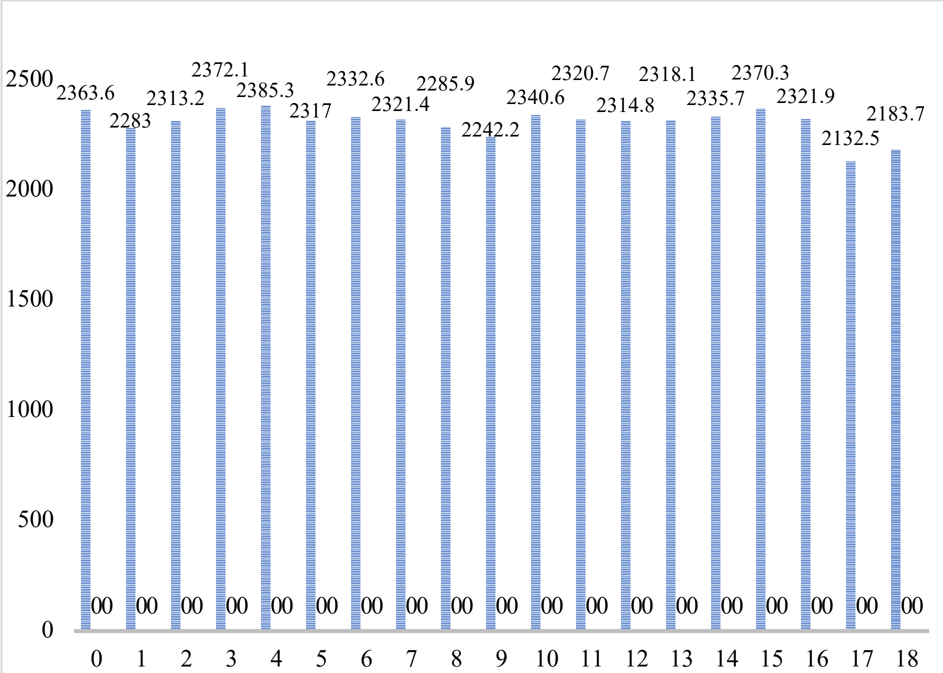

Fig. 10 – Solid state density.

After the density was determined, the resistance was also determined using the following formula fc=P/S.
were:
P = the force were the cub brakes;
S = contact surface of the force.
The results are presented in Table 4.

Table 4
Mechanical properties of SCC mixtures

Number	Recipe	Medium force	Compression strength Fc [N/mm^2]
0	Reference	1045+1070+1090=3205/3=1068.4	47.5
1	5%/0-4/10	785 + 795 + 735 = 2315/3=771,66	34,3
2	5%/0-4/20	1030 + 1055 + 1085 =3170/3 =1056,66	47,0
3	5%/0-4/30	1050+1120 + 1065 = 3235/3=1078,33	47.9
4	5%/4-8/10	890 + 940 + 910 = 2740/3 = 913,33	40,6
5	5%/4-8/20	940 + 910 + 910 = 2760/3= 920,00	40,9
6	5%/4-8/30	920 + 1000 + 850 = 2770/3= 923,33	41,0
7	5%/8-16/10	815 + 835 + 825 = 2475/3 = 825,00	36,7
8	5%/8-16/20	905 + 905 + 885 = 2695/3 = 898,33	39,9
9	5%/8-16/30	800 + 910 + 815 = 2525/3=841,66	37,4

10	10%/0-4/10	930 + 920 + 890 = 2740/3= 913.33	40,6
11	10%/0-4/20	925 + 925 + 960 = 2810/3=936.66	41,6
12	10%/0-4/30	1025 + 960 + 980 = 2965/3=988.33	43,9
13	10%/4-8/10	825 + 790 + 815 = 2430/3=810.00	36,0
14	10%/4-8/20	920 + 1000 + 1005 = 2925/3=975.00	43,3
15	10%/4-8/30	865 + 950 + 815 = 2730/3=910.00	40,4
16	10%/8-16/10	920 + 895 + 865 = 2680 /3= 893.33	39,7
17	10%/8-16/20	920+895+950 = 2765/3=921.66	40,9
18	10%/8-16/30	1055 + 1100 + 1085 = 3240/3=1080.00	48

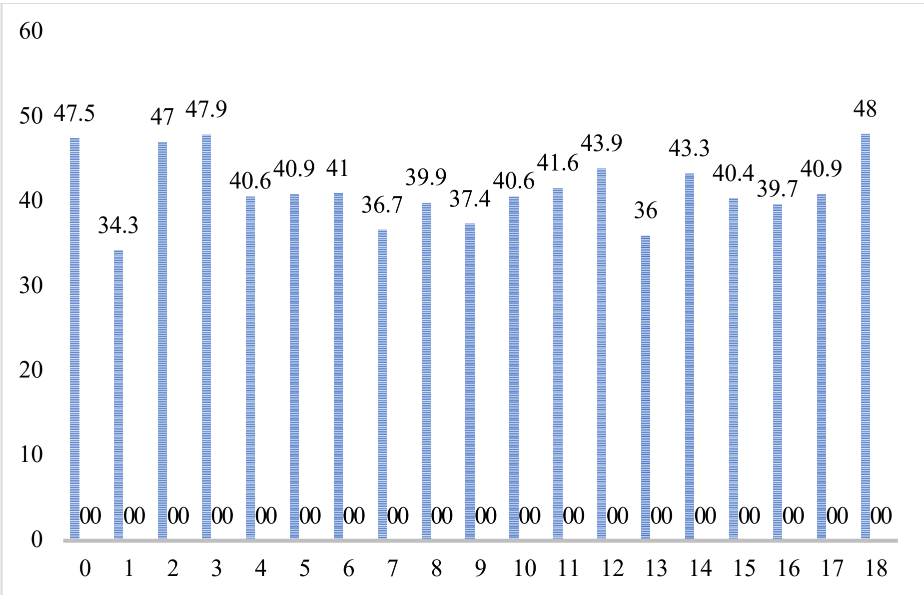

Fig. 11 – Compression strength.

3. Conclusions

After the compression strength results, we can conclude the following:

For the 0-4 sort replacement we can observe that the strength has increased as the amount of crushed brick increases for both the 5% and 10% fly ash replacement. When replacing the 4-8 aggregate, there is a slight increase in resistance with increasing the amount of crushed brick for the 5% ash replacement, but in the case of mixes with a 10% replacement, the maximum resistance is observed at the 20% replacement of crushed brick, after which a decrease in resistance for the mix with 30% replacement.

When replacing the 8-16 aggregate, there is a maximum resistance for the mix with 20% replacement with crushed brick, after which a decrease for the recipe of 30% in the version with 5% ash. On the other hand, for the 10% ash replacement, an increase in resistance is observed with the increase in the percentage of crushed brick.

The recipe with the highest resistance is the one in which the 8-16 percentage is replaced in a percentage of 30% with crushed brick in the variant with 10% ash, namely 48kN/mm3 being classified for the C35/45 mark and the lower is the recipe with a 5% ash replacement and 10% crushed brick replacement of the 0-4 aggregate with a resistance of 34kN/mm3, falling into mark C25/30.

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BETON AUTOCOMPACTANT CU ADAOS DE PRAF DE CARAMIDA

Din cauza cantitatii mari de beton utilizata la nivel Mondial si a necesarului mare de agregate si ciment comunitatea stiintifica lucreaza la gasirea unei solutii pentru aceasta problema. Articolul prezinta un studiu al betonului autocompactant care are in componenta materiale reciclate, in cazul de fata caramida sparta, pentru satisfacerea cerintelor mecanice ale acestuia. Betonul autocompactant pare a fi solutia cea mai potrivita pentru a diminua poluarea pentru ca nu necesita compactare si ofera oportunitatea de a adauga in cantitati limitate materiale reciclate sau cenusa de termocentrala pentru a inlocui o mica cantitate de ciment. Prezentul studiu descrie un numar de 18 retete in care s-a folosit praf de caramida impartit in trei categorii in funtie

de dimensiunea particulelor, si anume: 0-4mm; 4-8mm si 8-16mm. Caramida sparta inlocuieste acceasi categorie de agregat in trei procente diferite: 10%, 20% si 30%. Inlocuirea cimentului cu cenusa de termocentrala s-a realizat pentru cele 18 retete in doua variante de procent: 5% si 10%. Pentru toate retetele au fost analizate rezultatele betonului in stare proaspata, densitatea in stare uscata si proprietatile mecanice ale acestuia.