BULETINUL INSTITUTULUI POLITEHNIC DIN IAȘI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iași
Volumul 65 (69), Numărul 1, 2019
Secția
CONSTRUCȚII. ARHITECTURĂ

MECHANICAL CHARACTERISTICS OF HIGH STRENGTH CONCRETE WITH WASTE

BY

GABRIEL BEJAN[*] and MARINELA BĂRBUȚĂ

Technical University “Gh. Asachi” of Iasi,
Faculty of Civil Engineering and Building Services

Received: February 18, 2019
Accepted for publication: March 28, 2019

Abstract. The paper presents the experimental results obtained for high strength concrete prepared with different types of cement and addition of fly ash. Mechanical characteristics such as: compressive strength, flexural strength and split tensile strength are determined and compared function de type of cement and dosage of fly ash. Compressive strength and flexural strength were increased with the increase of cement strength and split tensile strength was improved by increasing the fly ash dosage.

Keywords: fly ash; crushed rock; compressive strength; flexural strength; split tensile strength.

1. Introduction

Do not use footnotes or endnotes. High strength concrete is one of the most important materials in construction industry because it has a lot of

[*]Corresponding author: *e-mail:* ing.bejan.gabriel@gmail.com

advantages in comparison with traditional concrete such as: high mechanical strength, improved durability characteristics, better elasticity and deformation characteristics, etc. (Papayianni & Anastasiou, 2010; Poon *et al*., 2004; Kamala *et al*., 2018; Han & Zhang, 2018; EL-Dieb, 2009; Sung-woo *et al*., 1995). High strength concrete is used in a lot of domains such as: high buildings, bridges, TV towers, stadiums, etc. Near high strength cements that must be used in obtaining high strength concrete, cementitious materials such as: fly ash, slag, microsilica, metakaolin, rice husk ash, , etc and different types of fibers are needed as additions in the mix (Chena *et al*., 2017; Oertel *et al*., 2014; Brand & Roesler, 2015; Manso *et al*., 2004; Safiuddin *et al*, 2010; Wibowo *et al*., 2018; Mello *et al*., 2014; Mahmoud & Mohammed, 2018).

The paper presents the experimental results obtained for different mixes prepared with addition of fly ash. Mechanical characteristics are analyzed and compared function de type of cement and dosage of fly ash.

2. Experimental Program

2.1. Materials

High strength concrete was prepared with following materials:

• cement of two types: CEM I-42.5 Holcim and CEM I-52.5 Holcim, produced in Romania, in a dosage of 550 kg/m^3;

• aggregates from crushed rock of three sorts, in following dosages: 457 kg/m^3 of sort I (0-4mm); 359 kg/m^3 of sort II (4-8 mm) and 815 kg/m^3 of sort III (8-16 mm).

• water, in a dosage of 153 l/m^3;

• superplasticizer type SKY GLENIUM from BASF, in a dosage of 1% from the cement dosage;

• fly ash as addition in the mix, in different dosages: 10% from cement dosage for mix C1- with CEM I-42.5 and 5% and 10% from cement dosage for mixes C2 and C3, respectively, with CEM I-52.5.

2.2. Samples

The experimental samples were prepared according to Romanian standard (SR EN 12390-1, 2005). Cubes of 150 mm sizes and prisms of 100x100x500 mm were poured. They were kept in water for 7 days, after that, at a temperature of + 200C for 28 days. The compressive strength (fc), flexural strength (fti) and split tensile strength (ftd) were determined according to Romanian standard (SR EN 12390-3, 2010; SR EN 12390-5, 2005; SR EN 12390-6, 2010).

3. Results and discussions

3.1. Compressive Strength

The results obtained for fc are represented in Fig. 1.

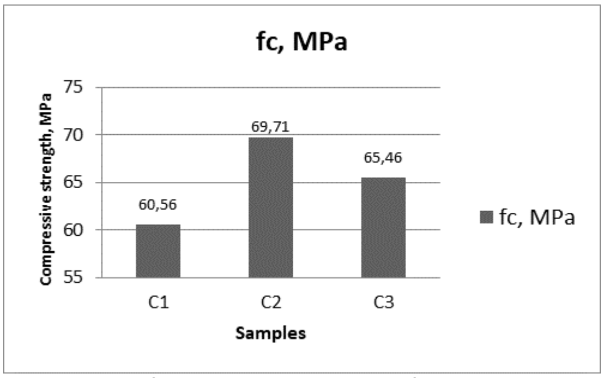

Fig. 1 – Variation of compressive strength of high strength concrete.

From experimental data it can observe that all concretes presents values of fc bigger than 50 MPa, that means all mixes are classified as high strength concretes. The highest value of compressive strength (fc = 69.71 MPa) was obtained for sample C2, mix that has an addition of fly ash of 5% from the cement dosage. A higher addition of fly ash will not increase the compressive strength. The type of cement influenced the compressive strengths: for a higher strength of cement, the values of fc were bigger.

3.2. Flexural Strength

The results obtained for fti are represented in Fig. 2.

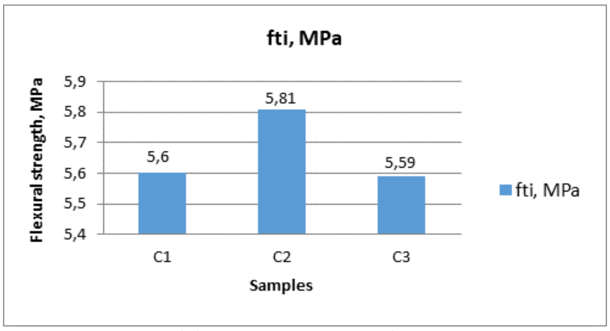

Fig. 2 – Variation of flexural strength of high strength concrete.

From experimental data it can observe that the highest value of flexural strength (fti = 5.81 MPa) was obtained for sample C2, mix that has an addition of fly ash of 5% from the cement dosage. A higher addition of fly ash will not increase the flexural strength. The type of cement influenced the flexural strengths: for a higher strength of cement, the values of fti were bigger in the case of a dosage of fly ash of 5%.

The relation between fc and fti is presented in Fig. 3.

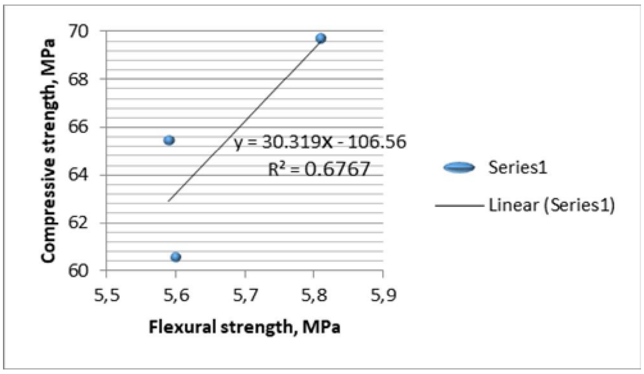

Fig. 3 – Relation compressive strength-flexural strength.

From the graph of Fig. 3 it can observe that if fc is increasing, the fti does not increase, so there is an important influence of changing of components type and dosage. A dosage of 10% fly ash addition for both types of cement results in same values of fti.

3.3. Split Tensile Strength

The results obtained for ftd are represented in Fig. 4.

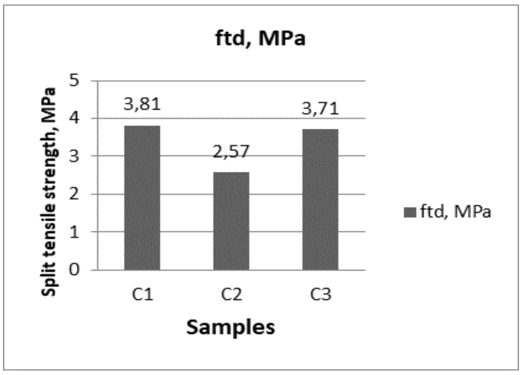

Fig. 4 – Variation of split strength of high strength concrete.

From experimental data given in Fig.4, it can observe that the highest value of split tensile strength (ftd = 3.81 MPa) was obtained for sample C1, mix that has an addition of fly ash of 10% from the cement dosage and cement type CEM I 42.5. The strength of cement does not influence the split tensile strength because the values of ftd for concrete C2 and C3, with cement type CEM I-52.5 were smaller than that of C1.

The relation between fc and ftd is presented in Fig. 5.

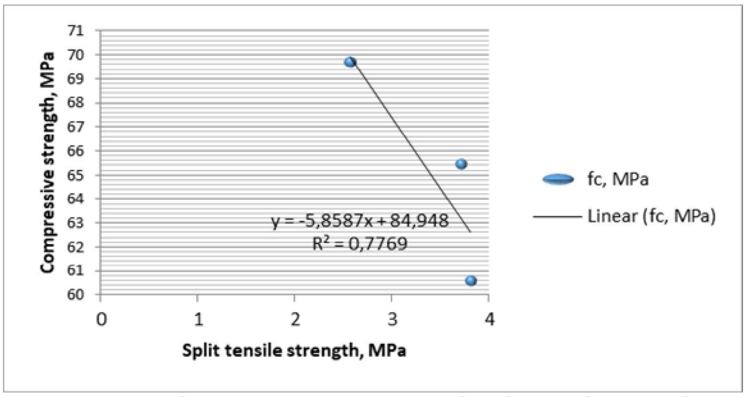

Fig. 5 – Relation compressive strength-split tensile strength.

From the graph of Fig. 5 it can observe that if fc is increasing, the ftd does not increase, so there is an important influence on changing the type and dosage of components. A dosage of 10% fly ash addition for both types of cement results in same values of ftd.

4. Conclusions

The paper presents the experimental results obtained for different mixes of high strength concrete prepared with addition of fly ash. Cement type CEM I-42.5 and CEM I-52.5 were used in the same dosages with addition of fly ash in dosages of 5% and 10%. Mechanical characteristics such as: compressive strength, flexural strength and split tensile strength were experimentally determined. Compressive strength and flexural strength were increased with the increase of cement strength and split tensile strength were influenced by the fly ash dosage. The use of different additions in obtaining high strength concrete influences the mechanical strengths For better understanding the addition influence, it is necessary optimization of mixes and prediction of mechanical strength and after that, an experimental checking will confirm the optimum design.

REFERENCES

Brand A.S., Roesler J.R., *Steel Furnace Slag Aggregate Expansion and Hardened Concrete Properties*, Cem. Concr. Compos., **60**, 1-9 (2015).

Chena J., Ngbc P.L., Lid L.G., Kwan A.K.H., *Production of High-performance Concrete by Addition of Fly Ash Microsphere and Condensed Silica Fume*, Procedia Engineering, **172**, 165-171 (2017).

EL-Dieb A.S., *Mechanical, Durability and Microstructural Characteristics of Ultrahigh-Strength Self-Compacting Concrete Incorporating Steel fibers*, Mater. Des., **30**, 4286-4292 (2009).

Fanghui Han, Zengqi Zhang, *Hydration, Mechanical Properties and Durability of High-Strength Concrete under Different Curing Conditions*, Journal of Thermal Analysis and Calorimetry, **132**, 823-834 (2018), https://doi.org/10.1007/s10973-018-7007-3.

Kamala M.M., Safana M.A., Bashandya A.A., Khalil A.M., *Experimental Investigation on the Behavior of Normal Strength and High Strength Self-Curing Self-Compacting Concrete*, Journal of Building Engineering, **16**, *3*, 79-93 (2018).

Mahmoud Mazen Hilles, Mohammed M Ziara, *Mechanical Behavior of High Strength Concrete Reinforced with Glass Fiber Reinforced Polymer*, J. Civil Environ. Eng., **8**, *4*, 318-326 (2018).

Manso J.M., Gonzalez J.J., Polanco J.A., *Electric Arc Furnace Slag in Concrete*, J. Mater. Civil Eng., **16**, *6*, 639-645 (2004).

Mello E., Ribellato C., Mohamedelhassan E., *Improving Concrete Properties with Fibers Addition*, International Journal of Civil and Environmental Engineering, **8**, *3*, 249-254 (2014).

Oertel T., Hutter F., Helbig U., et al., *Amorphous Silica in Ultra-High Performance Concrete: first Hour of Hydration*, Cem. Concr. Res.,**58**, 131-142 (2014).

Papayianni I., Anastasiou E., *Production of High-Strength Concrete Using High Volume of Industrial By-Products*, Constr. Build. Mater., **24**, *8*, 1412-1417 (2010).

Poon C., Shui Z., Lam L., *Compressive Behavior of Fiber Reinforced high Performance Concrete Subjected to Elevated Temperatures*, Cement & Concrete Researches, **34**, *12*, 2215-2222 (2004).

Safiuddin Md., West J.S., Soudki K.A., *Hardened Properties of Self-Consolidating High Performance Concrete Including Rice Husk Ash*, Cem. Concr. Compos., **32**, 708-717 (2010).

Sung-woo S., Satyendra K., Ghosh, Moreno J., *Flexural Ductility of Ultra-High Strength Concrete Members*, ACI Struct. J., **4**, 394-400 (1995).

Wibowo Wibowo, Mediyanto A., Dharmawan E.A., *Study on Effect of Variations of Meta-Kaolin Addition on Self-Compacting Parameter of High Strength Concrete*, **10**, *2*, 93-97 (2018).

* * * *Testing Hardened Concrete. Part 3: Compressive Strength of Test Specimens*, Romanian Standard Association, SR EN 12390-3:2010.

* * * *Testing Hardened Concrete. Part 5: Flexural Strength of Test Specimens*, Romanian Standard Association, SR EN 12390-5:2005.
* * * *Testing Hardened Concrete. Part 6: Split Tensile Strength of Test Specimens*, Romanian Standard Association, SR EN 12390-6:2010.
* * * *Testing Hardened Concrete. Shape, Sizes and Other Requirements for Specimens and Moulds*, Romanian Standard Association, SR EN 12390-1:2005.

CARACTERISTICILE MECANICE ALE BETONULUI DE ÎNALTĂ REZISTENȚĂ CU DEŞEURI

(Rezumat)

Sunt prezentate rezultatele experimentale obținute pentru betoane de înaltă rezistență preparate cu diferite tipuri de ciment şi adaos de cenuşă de termocentrală. Caracteriticile mecanice cum ar fi: rezistența la compresiune, rezistența la întindere prin încovoiere şi rezistența la întindere prin despicare au fost determinate şi comparate funcție de tipul de ciment şi dozajul de cenuşă de termocentrală. Rezistența la compresiune şi rezistența la întindere prin despicare au crescut cu creşterea rezistenței cimentului, iar rezistența la întindere prin despicare s-a îmbunătățit prin creşterea dozajului de cenuşă de termocentrală.