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RESEARCH NOTE

Performance of High-strength Concrete Made with Recycled Ceramic Aggregates

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ABSTRACT

Recent scientific concerns to achieve sustainability in construction have suggested the implementation of using recycled aggregate in concrete; because it has the potential to reduce the demand for extraction of natural raw materials and decrease the volume of wastes landfilled. In this respect, this study aims to investigate the suitability of using ceramic tile (CT) and ceramic sanitary (CS) wastes as coarse aggregate in production of high-strength concrete (HSC). Different concrete mixes were produced by partial replacement of 10, 20 and 30% of natural coarse aggregate with recycled aggregates. Besides investigating the characteristics of recycled aggregate, slump, compressive strength, initial and final absorption and chloride ion penetration depth of HSC specimens were evaluated and compared with that of plain HSC. Results showed that using recycled ceramic aggregates increased the superplasticizer dosage to maintain the target slump. Although by incorporation of high percentage of CT or CS aggregate, compressive strength of HSCs was reduced compared with reference HSC, it is possible to produce HSC with 28-days compressive strength higher than 60.7 MPa. Moreover, the absorption and chloride ion penetration depth of recycled aggregate incorporated HSC were higher than those of estimated for plain concrete. Generally, waste ceramic aggregate at optimum replacement ratio can be used in the sustainable development of HSC.

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1. INTRODUCTION

Nowadays, one of the significant environmental concerns in engineering society is the challenge of facing the problem of solid waste. From the viewpoint of environmental preservation and effective utilization of resources, the disposal of solid waste in landfill sites is not a solution for adequate waste management. At the global aim of a sustainable environment, a growing consensus is held to reuse all types of waste material in a new production cycle. In this respect, the recycling of the solid waste in cement and concrete manufacturing is becoming a hot research topic [1] with an interesting outlet. Concrete is the most widely used construction material and owing to its simple mixture design, it can be potentially considered as a sustainable resource opportunity for recycling waste materials. Furthermore, a large amount of virgin natural resources is consumed by the concrete industry. Therefore, the management of waste materials by introducing them into concrete can offer environmental and economic benefits .

Today, different types of waste materials such as brick [2, 3], recycled aggregate concrete [4-7], PET waste [8] and recycled glass aggregate [9] have been utilized as a substitution for natural aggregate in the concrete production. Besides these, the suitability of waste ceramic aggregates in concrete has been examined by some researchers. In this respect, García-González et al. [10] investigated the effect of ceramic ware waste as coarse aggregate in concrete and showed a feasible alternative for the sustainable management of recycled ceramic is reusing it in the production of concrete. Medina et al. [11] observed that the interfacial transition zone (ITZ) between ceramic sanitary ware industry waste aggregate and paste was narrower, more compact and less porous than in the case of natural aggregate and paste. Moreover, an improvement in the freeze-thaw resistance of recycled concrete containing ceramic sanitary ware

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aggregate was reported by Medina et al. [12]. Senthamarai and Manoharan [13] showed that ceramic electrical insulator industrial wastes incorporated concrete have the strength characteristics comparable to those of the conventional concrete. The performance of concrete made with ceramic aggregates obtained from sanitary product wastes after exposure to high temperature was investigated by Canbaz [14]. Anderson et al. [15] explored the mechanical properties of concrete mixtures made with unused ceramic floor tiles as well as unused and waste ceramic wall tiles sourced from a demolition site. Accordingly, waste ceramic is a possible practicable natural coarse aggregate (NCA) replacement in concrete with minimal changes in mechanical properties. The effect of waste ceramic wall and floor tiles aggregate sourced from construction and demolition wastes on the mechanical characterization of concrete mixtures have been reported by Awoyera et al. [16]. The effect of tile ceramic waste, red clay brick and ceramic sanitary ware on the structural concrete properties was demonstrated by Pitarch et al. [3]. It was observed by Keshavarz and Mostofinejad [17] that red ceramic waste increased concrete water absorption by up to 91%. Furthermore, the autogenous shrinkage of high-performance concrete by the replacement of porous ceramic aggregates recovered from the waste of a local ceramic production plant has been reported by Suzuki et al. [18].

This study was initiated to extend the database on the properties of high-strength concrete (HSC) with partial replacement of NCA by recycled ceramic aggregates. HSC is receiving increased attention throughout the world, not only for its economic benefits in comparison to conventional-strength concrete [19] but also for its better mechanical properties and durability. Regarding the large volumes of waste materials, it can be considered that it is very beneficial from different perspectives to utilize recycled aggregates in HSC. Nevertheless, recycled aggregates may have different characteristics than natural aggregates and it might be recommended that the use of waste aggregates in HSC should be limited unless further researches are carried out. This has been considered in this paper for recycled ceramic aggregate. In view of the research needs discussed above, seven concrete mixtures were designed with two different types of recycled ceramic aggregates at three different levels of replacements. Besides investigating the characteristics of recycled aggregates, compressive strength, absorption and chloride ion penetration depth of HSC specimens were evaluated. The results of this study can provide useful information for civil engineers and contractors to utilized waste aggregate in designing HSC which can facilitate its usage in full-scale field construction. The structure of this paper is divided into three parts. In the first part, the experimental plan including the used materials, concrete mixture proportions and the test procedure were illustrated. In the second part, apart from the characterization of recycled aggregates, the engineering properties and durability of HSC made with recycled aggregate were compared with those obtained for normal concrete. Conclusion is the last part which summarized the main results of this study.

2. EXPERIMENTAL PLAN

2. 1. Materials Portland cement (PC) type II, which supplied from Peyvand Golestan cement factory with Blaine specific surface area of 3250 cm^2/g and a specific gravity of 3.15 was used in all mixtures. Silica fume (SF) with a specific gravity of 2.12 was also used in the production of HSC mixtures. The chemical compositions of PC and SF in accordance with the producer's brochure are presented in Table 1. Natural aggregate consisted of gravel with a maximum size of 12.5 mm and well-graded sand with fineness modulus of 2.57. In addition to this, following the source of raw materials, two types of recycled ceramic aggregates labeled by "CT" and "CS" were used in this study. CT aggregate was derived from unused fractured pieces of ceramic tiles and CS aggregate is obtained from ceramic sanitary (squatting toilet pan) waste. The photographs of CT and CS aggregates are presented in Figures 1 and 2, respectively. It should be noted that recycled materials were initially crushed by using a steel hammer and to ensure recycled aggregates have a particle size close to that of coarse aggregate, the amount of aggregate passing through a 12.5 mm (½ in) sieve and retained on 4.75 mm sieve was chosen. Commercially available polycarboxylate-based superplasticizer (SP) with a specific gravity of 1.15±0.05 was used in this study .

2. 2. Mixture Proportions From the scope of this study on the recycling of ceramic waste as coarse aggregate in HSC, 7 HSC mixtures were produced. Table 2 described the details of mixture proportions. As can be seen in this table, the first batch was Plain HSC which was made without any recycled aggregate. In addition to this, three HSC mixtures called CTA10, CTA20 and CTA30 were prepared by partial replacement of NCA with CT aggregate at the levels of 10, 20 and 30%, respectively. Additionally, three mixtures denote by CSA10, CSA20 and CSA30 were made by replacing 10, 20 and 30% of NCA with CS aggregate. In all mixes, SF was used at a constant ratio of 10% by weight of total cementitious materials and the water/binder was kept at 0.26.

All mixtures were proportioned based on the historical data and preliminarily studies to meet a target compressive strength higher than 60 MPa. The SP was added during mixing to obtain a slump value of 50±5

TABLE 1. Chemical composition and physical properties of Portland cement type II and silica fume

	SiO_2	**Al_2O_3**	**Fe_2O_3**	**CaO**	**MgO**	**SO_3**	**K_2O**	**Na_2O**
Cement	21.46	5.55	3.46	63.95	1.86	1.42	0.54	0.26
Silica fume	95	1.32	0.87	0.49	0.97	0.1	1.01	0.31

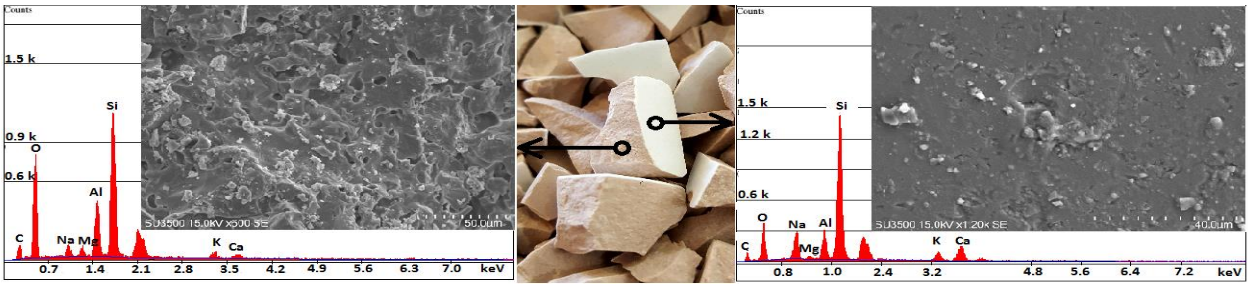

Figure 1. Scanning electron microscopy (SEM) and EDX of Internal and External part of CT aggregate

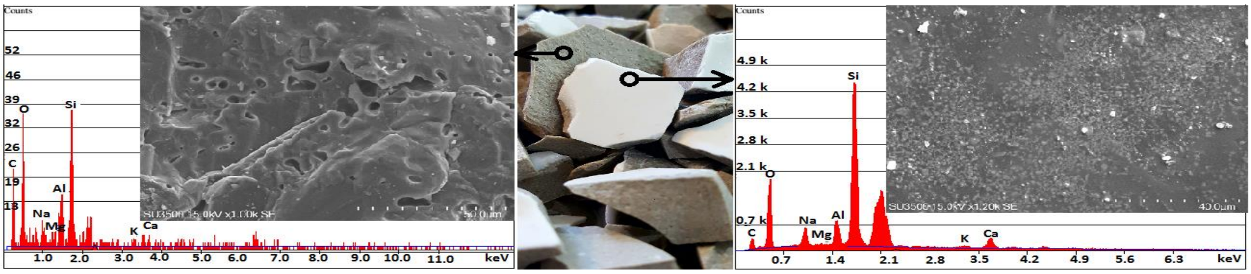

Figure 2. Scanning electron microscopy (SEM) and EDX of Internal and External part of CS aggregates

TABLE 2. Mix details of concrete containing recycled aggregate

Mix. ID.	**Cement (kg/m^3)**	**Silica fume (kg/m^3)**	**Water (kg/m^3)**	**Sand (kg/m^3)**	**Gravel (kg/m^3)**	**CTA (%)**	**CSA (%)**	**SP (kg/m^3)**
RHSC	450	50	130	842	1030	-	-	6.5
CTA10	450	50	130	842	927	10	-	7.5
CTA20	450	50	130	842	824	20	-	8.3
CTA30	450	50	130	842	721	30	-	8.8
CSA10	450	50	130	842	927	-	10	8.1
CSA20	450	50	130	842	824	-	20	8.9
CSA30	450	50	130	842	721	-	30	9.7

mm. In order to prepare HSC, natural and recycled aggregates were mixed for 30 s. After that, adding about 1/3 of mixing water into the mixer while mixing goes on for 1min. Then, cementitious materials were added at two steps. In each step, half of the remaining water and SP were introduced to the wet mixture. Mixing was going on for 3 min and finally, after 1min rest, the mixing sequence was resumed for an additional 2min. The recycled aggregates were used in saturated surface dry condition by soaking in water for 24 h.

2. 3. Test Procedures

The slump value of fresh concrete mixtures were measured as per ASTM C143. As presented in Figure 3, compressive strength of 100 mm cubic specimens was tested in a compression testing machine with a loading capacity of 2000 KN at different curing ages of 7, 28 and 90 days. The loading rate was consired as 3 kN/s. The reported compressive strength is the average of at least three samples. It should be noted that for all ages, the variation of individual values from the average was lower than 10%.

Figure 3. Compressive strength test (a) CT30 and (b) CS30

100 mm cubic HSC specimens were tested for initial and final absorption. 28-days 100 mm cubic specimens were placed in an oven to attain a constant weight. Next, the samples were placed in water and the mass gain of the specimens was evaluated at different times. Absorption were evaluated according to Equation (1).

$$WA=\frac{M_1-M_0}{M_0} \quad (1)$$

where M_0 is the oven dried mass, and (M_1-M_0) is the mass gain of HSC samples. For initial absorption, (M_1-M_0) is determined after 30 min and for final absorption is calculated for the point at which the increase in mass at 12h was almost negligible. It is well known that chloride ion penetration into concrete structures by accelerating the corrosion process of reinforcement can decrease the life of those structures [20]. In this respect, the colorimetric method was used to determine the chloride ion penetration depths. 100×100×300 mm prism specimens were initially cured for 28 days, and after that, the specimens were submerged in 5% NaCl solution for another 90 days. The specimens were split into two halves and the freshly fractured surface was sprayed with 0.1 N silver nitrate solutions. The $AgNO_3$ solution reacts with the free chloride on the concrete surface and the white color boundary forms from the precipitate of AgCl revealed the chloride penetration zone. This method is easy to perform and can be used to judge an area at risk for steel reinforcement corrosion area [21]. Totally, more than 77 cubic specimens and 14 prismatic specimens were cast in this study. Figure 4 presented an overview of the research methodology.

3. RESULTS AND DISCUSSIONS

3. 1. Characterization of Recycled Aggregates

Giving the critical role of coarse aggregates on the performance of HSC, different characteristics of natural and recycled aggregates were investigated. Furthermore, as presented in Figures 1 and 2, the microstructure of CT and CS aggregates were analyzed by the scanning electron microscope (SEM) equipped with an energy-dispersive X-ray (EDX) analytical system.

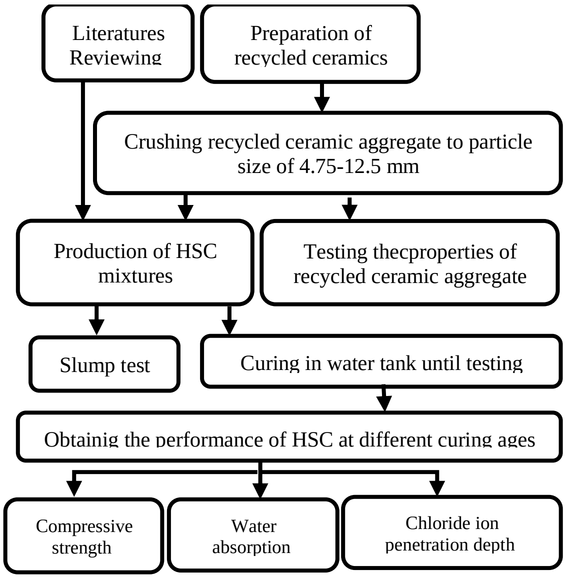

Figure 4. The flowchart of the experimental program

Particle size distribution: In HSC, a significant emphasis is placed on the particle size distribution and characteristics of coarse aggregate due to its paramount role in the properties of concrete. In this respect, the grain size distribution of the natural and recycled aggregates compared with the grading requirements recommended in ASTM C33 was given in Figure 5. As can be seen, a little difference existed between particle size distribution of CT and CS aggregates and both recycled ceramic aggregates grading are in the range of requirements in ASTM C 33 for coarse aggregates.

Chemical characterization: In order to analyze the chemical characterization of aggregates, the EDX test was conducted on the two distinct parts of each recycled aggregate: (i) outer side (corresponded to the glaze) and (ii) inner side. EDX spectrum of CT and CS aggregates were presented in Figures 1 and 2, respectively. It can be seen that the dominant peaks for the internal and external parts of both recycled aggregates are O, Si, Al. The internal part of recycled ceramic aggregate used by

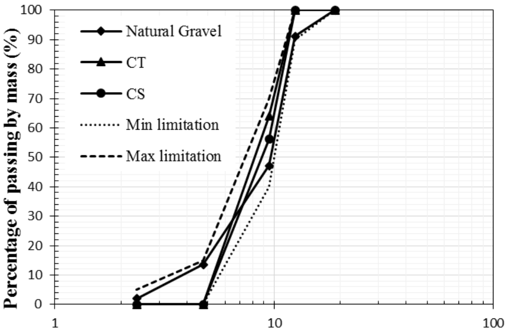

Figure 5. Grain-size distribution of aggregates

Medina et al. [22] reported that contained Si, Ca, Mg, O and Fe together with a lesser proportion of Zr. The external part was also contained the same elements with a much higher proportion of Zr.

Absorption and density: Special attention must be received to the water absorption of aggregate, especially in HSC with a low water/cement, to ensure the availability of required water calculated for cement hydration. Water absorption of NCA was measured as 0.39%, while the absorption of CT and CS aggregates were 2.54 and 1.54%, respectively. The higher absorption of recycled aggregates is attributed to the porous structure of both recycled CT and CS aggregates. This is evident from SEM images of recycled aggregates presented in Figures 1 and 2. The higher water absorption of old recycled concrete aggregate was also reported by researchers [6]. CT and CS aggregates had a specific gravity of 2257 Kg/m^3 and 2373 Kg/m^3, respectively. These values are lower than that of determined for NCA as 2747 Kg/m^3. This can be attributed to the higher porosity of CT and CS aggregates compared with NCA. The lower specific gravity of CT and CS aggregates are agreed with their high absorption value. Pitarch et al. [3] calculated lower specific gravity and more water absorption for tile ceramic waste and ceramic sanitary ware compared to those of the natural aggregate. The same behavior was also observed by Anderson et al. [15] for unused ceramic floor tiles as well as unused and waste ceramic wall tiles and by Tavakoli et al. [23] for ceramic tile aggregate.

Resistance to fragmentation: To measure aggregate resistance to fragmentation, the Los Angeles (LA) test was conducted following the ASTM C131. The LA test results not only provide a good correlation with the actual wear of aggregate in concrete, but also with the compressive and flexural strengths of concrete [24]. the LA coefficients of CT and CS aggregates were 23.7% and 23%, respectively. These values are lower than that of determined for NCA as 25.4%. A lower LA value for ceramic aggregate was reported by researchers [10,25]. Nevertheless, all coarse aggregate had a LA coefficient higher than 50%, which complies with those prescribed in the ASTM C33 for use in structural concrete.

3. 2. SP Demand

As previously mentioned, the slump values of all HSC mixtures were kept in the range of 50±5 mm by adjusting the SP dosage which is presented in Table 2. Accordingly, the SP dosage of plain HSC was determined as 6.5 kg/m^3 which was increased between 7.5 and 8.8 kg/m^3 for HSC containing 10-30% waste CT aggregate and between 8.1 to 9.7 kg/m^3 for HSC with 10-30% CS aggregate. This can be attributed to the surface texture and angularity of ceramic aggregate compared to NCA. In this regard, Medina et al. [26] revealed that the slump of reference concrete declined by the incorporation of recycled aggregate due to the differences between the physical properties of the natural and recycled ceramic aggregates. Tavakoli et al. [23] observed that the decrease in the slump value of concrete made with ceramic tile is attributed to high water absorption or the blunt forms of aggregate .

3. 3. Compressive Strength

Figures 6 and 7 illustrated the compressive strength of HSC mixtures made with CT and CS aggregates at different curing ages of 7, 28 and 90 days, respectively. Compressive strength was between 62.1 and 80.7 MPa for CT aggregate incorporated mixtures and by the inclusion of CS aggregate, the compressive strength values are varied between 54 and 85.2 MPa. All concrete mixture had 28-days compressive strength higher than 60.7 MPa, which meets the expected compressive strength (≥ 60MPa) considered in this study for HSC. As can be observed in Figure 6, the incorporation of CT aggregate not only had no significant reduction effect on the compressive strength of HSC (maximum strength reduction of 6.2% compared to the reference concrete) but also the highest compressive strength at all curing ages was achieved for HSC made with 20% CT aggregates. In this mixture, compressive strength is increased by 2.4, 7.96 and 6.62% at 7, 28 and 90 days in comparison to those of plain mixture. This trend is consistent with findings presented by Tavakoli et al. [23] who reported using tile as a coarse aggregate had no negative impact on compressive

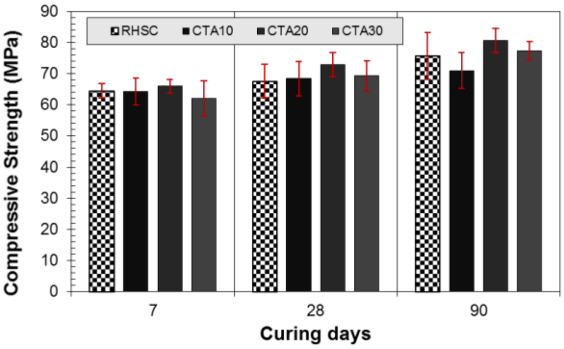

Figure 6. Compressive strength of HSC made with CT

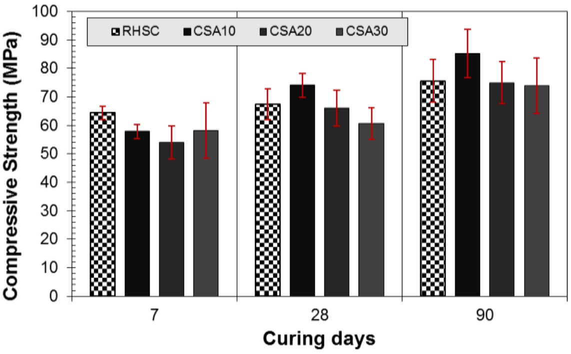

Figure 7. Compressive strength of HSC made with CS

strength. Anderson et al. [15] illustrated the maximum strength decrement for concrete samples made with 100% floor and wall tile ceramic is 4.3 and 5.6%, respectively, compared to reference concrete, indicating aggregate replacement proportion had little effect on the compressive strength.

Improving the density and bonding characteristics of the interfacial transition zone between cement paste and aggregate can play a significant role in the strength of concrete. In this respect, aggregate properties such as surface texture, shape and modulus of elasticity would also have some bearing on the final strength values [27]. A higher angularity and roughness of CT aggregate than it is in the case of NCA may result in improvement in interfacial bonding and better mechanical interlocking. Nonetheless, when analyzing the effect of ceramic aggregate on compressive strength, it should take into account that the top surface of CT aggregate is glazed and smoother than the fracture surface, which can result in lower bond strength to the cement paste. This can be observed by analyzing the microstructure of the interfacial transition zone between cement paste/outer sides of CT aggregate in the fractured surface of CTA30 by using a SEM, as presented in Figure 8. In the sample studied, due to the low cohesion between the cement paste and the outer side of CT aggregate, cracks were formed along with the aggregate/paste interface. Furthermore, the mechanical properties of the CT aggregate and the used NCA can also influenced on the compressive strength of concrete samples. Concerning the effect of CS aggregate on the compressive strength of HSC presented in Figure 7, encouraging results were obtained for 28 and 90 days compressive strength of CSA10 mixture with 9.88% and 12.6% improvement over plain HSC. 20% and 30% CS aggregate incorporated HSC had comparable 90 days compressive strength to those obtained for plain HSC.

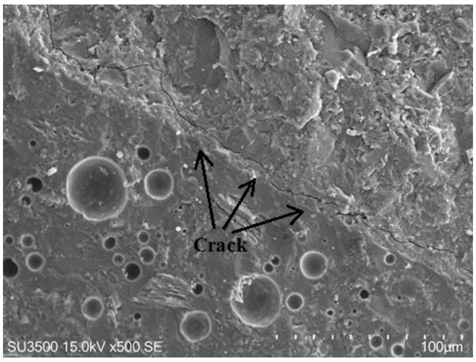

Figure 8. SEM of fractured surface of CTA30 mixture

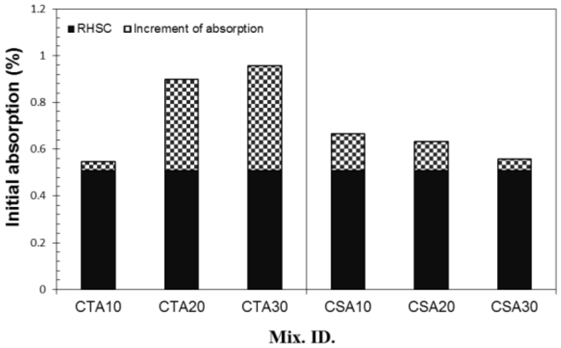

Figure 9. Initial absorption of HSC samples

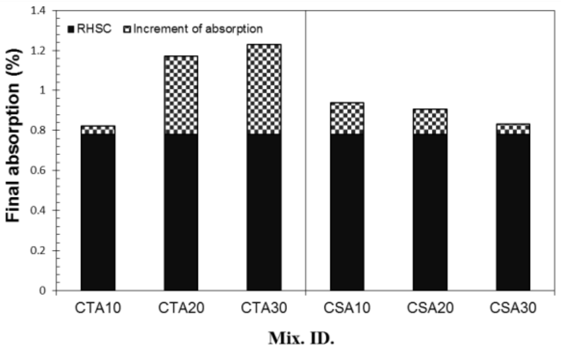

Figure 10. Final absorption of HSC samples

3. 4. Durability Aspects

Water absorption: The variations in the initial and final water absorption of concrete mixtures with respect to the percentage of recycled materials are given in Figures 9 and 10, respectively. According to the CEB-FIB [28], quality of concrete mixtures is considered as poor, average and good for initial water absorption values of ≥5%, 3-5% and ≤3%, respectively. In this study, initial absorption of concretes was determined to be ≤3% and accordingly, the quality of both recycled aggregate HSCs is good. Furthermore, as can be seen in Figure 9, final water absorption of plain HSC was determined at 0.78% while final water absorption of HSC with CT and CS aggregates was in the range of 0.86 to 1.52% and 1.07 to 1.27%, respectively. According to Pachideha et al. [29], the lower water absorption shows that the less harmful materials can penetrate into the concete. The substitution of NCA with recycled aggregate seems to have a significant effect on the water absorption of HSC mixtures. As can be seen from Figures 9 and 10, the lowest initial and final water absorption belongs to plain HSC as 0.51 and 0.78%, respectively. In the case of concrete mixes with 10-30% CT aggregate, the initial absorption was varied between 0.55 and 0.96% and final absorption was in the range of 0.86 to 1.52%. For the CS aggregate incorporated concrete, these values were calculated within the range of 0.56 to 0.67% and 1.07 to 1.27%, respectively. According to these results, it can be observed that the absorption values of HSC specimens increased by the inclusion of recycled ceramic as coarse aggregate in concrete. This can be described in reference to the porous nature of recycled ceramic aggregate which had a higher capacity of absorption as compared with NCA. These results are in agreement with those reported in the literature. According to Keshavarz and Mostofinejad [17], water absorption of concrete containing different levels of red ceramic wastes increased by up to 91% as a result of the high water absorption of the red ceramic wastes. Furthermore, medina et al. [26] revealed that the total water absorption values for recycled ceramic aggregate concrete increased by 36 and 46% at replacement ratios of 20 and 25%, respectively. They also reported that this increase was due to both the higher water absorption coefficient in recycled aggregate and the effect of this recycled aggregate on the pore system. The same pattern was also observed for recycled sanitary ceramic waste aggregates [30].

Chloride ion penetration depth: The variations in chloride ion penetration depth into HSC samples are obtained by $AgNO_3$ spray method for different recycled aggregate replacement ratio and results are illustrated in Figure 11. It should be noted that however, $AgNO_3$ spray method had been recently employed to evaluate the chloride ion penetration depth of HSC with recycled aggregate [31], in this study, the relatively dense matrix of HSC mixtures which is not sensitive to ingress of the chloride ion, caused the measurement of chloride penetration in some depth were hardly accomplished. Nonetheless, it was found that the influence of recycled ceramic aggregate on the chloride penetration depth is very similar to that of observed for water absorption test. As shown in Figure 11, chloride penetration depth of reference HSC after 90 days of exposure to 5% NaCl was determined to increase from 2.17 to 2.33, 4.35 and 4.98 mm by the substitution 10, 20 and 30% of CT aggregate, respectively. The same observation is also noted for HSC containing CS aggregate. When 10-30% of NCA replaced with CS aggregate, chloride ion penetration depth of plain HSC is increased to 4.6, 3.76 and 3.95 mm. According to the literature [32], aggregate permeation characteristics, as typified by water absorption, play a significant impact on chloride ingress into structural concrete, more significant than that of increasing cement content. In this respect, using recycled ceramic aggregates with higher porosity compared with the natural aggregate may result in the higher chloride penetration depth. These results were confirmed with previous reports. Medina et al. [33] illustrated that chloride penetration was a slight 4 and 8% higher in the concretes containing 20 and 25% ceramic sanitary ware aggregate than in the conventional material. Adamson et al. [34] showed that the increase in the chloride penetration of concrete samples containing coarse crushed brick aggregate compared to that plain concrete which measured after six months of exposure to chloride solution could be attributed to the more porosity of brick aggregates compared to that in natural aggregates. This is while Pacheco-Torgal and Jalali [35] revealed that concrete mixture with ceramic aggregates performing better than the control concrete mixture concerning chloride diffusion, capillarity water absorption and oxygen permeability. The higher chloride penetration of concrete made with other type of recycled aggregate was reported by researchers [36].

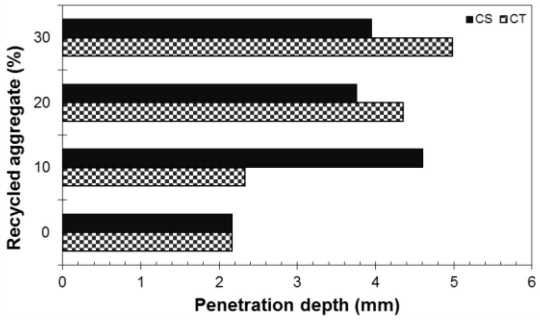

Figure 11. Chloride ion penetration depth of HSC samples

4. CONCLUSIONS

In this paper, the effects of CT and CS aggregates on the properties of HSCs were investigated. The used CT and CS presents higher absorption, lower density and better resistance to fragmentation values compared with natural coarse aggregate. Furthermore, it was observed that dominant peaks for both recycled aggregates are O, Si and Al. According to the results, it is possible to produce HSC containing up to 30% ceramic aggregate with 28-days compressive strength higher than 60.7 MPa. Moreover, the recycled aggregate HSC showed higher absorption than plain HSC. This is mainly due to the higher absorption of CT and CS aggregates which was 2.54 and 1.54% in comparison with that of determined for NCA as 0.39%. Nonetheless, all of HSC mixtures had 30 min absorption less than 0.96% can be classified as “good” concrete quality. However, chloride penetration depth assessment for HSC mixtures by colorimetric method was hardly accomplished in some depth, it can be observed that by using CT and CS aggregates, the ingress of chloride ion into HSC is increased due to the higher porosity of recycled aggregates in compare to NCA.

5. ACKNOWLEDGMENT

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Persian Abstract

چکیده

دستاوردهای علمی اخیر در راستای دستیابی به ساخت و ساز پایدار، استفاده از مصالح بازیافتی در ساختار بتن را به علت کاهش استخراج مواد طبیعی اولیه و همچنین کاهش حجم ضایعات دفن شده در طبیعت، پیشنهاد می‌دهد. بر این مبنا، این مطالعه با هدف امکان سنجی استفاده از دو نوع ضایعات کاشی سرامیکی و سرامیک بهداشتی به عنوان درشت دانه در تولید بتن پر مقاومت انجام گردید. اختلاط‌های مختلف بتن پرمقاومت حاوی ۱۰٪، ۲۰٪ و ۳۰٪ سنگدانه درشت ضایعاتی تولید شد. علاوه بر ارزیابی خصوصیات فیزیکی سنگدانه ضایعاتی، مقاومت فشاری، جذب اولیه و نهایی، همچنین میزان عمق نفوذ یون کلرید در نمونه‌های بتن پرمقاومت حاوی سنگدانه‌های سرامیکی ضایعاتی مورد بررسی قرار گرفت و با ویژگی‌های بتن پرمقاومت مبنا مقایسه شد. نتایج نشان داد که استفاده از ضایعات سرامیکی، نیاز به فوق‌روان کننده را برای رسیدن به اسلامپ مورد نظر در بتن پرمقاومت افزایش می‌دهد. هرچند استفاده از میزان بالای ضایعات سرامیکی، مقاومت فشاری مخلوط‌های بتنی پرمقاومت را در مقایسه با بتن مبنا کاهش داده است، با اینحال می توان بتن با مقاومت فشاری ۲۸ روزگی بالاتر از ۶۰/۷ مگاپاسکال تولید نمود. همچنین، میزان جذب آب و عمق نفوذ یون کلرید بتن پرمقاومت حاوی سنگدانه ضایعاتی از آنچه که در بتن پرمقاومت مبنا تخمین زده شده است، بیشتر می باشند. به طور کلی، ضایعات سرامیک در نسبت جایگزینی بهینه می تواند در توسعه پایدار بتن با مقاومت بالا مورد استفاده قرار گیرند.