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# The Assessment of Crushed Sand Effects on the Properties of Self Compacting Concrete

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**Abstract:**

The crushed shape of aggregates, regarding its effect on the yield stress, plastic viscosity and the friction between concrete components play an important role in the performance of ordinary and also self-compacting concrete. In this research, the effect of standard crushed sand on the properties of SCC concrete has been studied. To do so, different mixture designs were tested to achieve a suitable mixture design that meets the minimum rheology and resistance requirements of self-consolidating concrete and as a result, five mixture designs with replacing different values of standard crushed sand with natural sand have been fabricated. Rheology Tests (slump flow, V-funnel, J-ring and L-box), Mechanical Resistance Tests (Compressive, tensile and flexural strength) and Durability Tests (capillary water absorption and freeze–thaw cycling resistance) tests have been assessed. It has been observed that by replacing a proportion of natural standard sand with crushed standard sand, filling ability and possibility of self-consolidating concrete have improved. Regarding the obtained results, the mechanical properties of SCC concrete in the specimens with crushed standard sand increased. Also, capillary water absorption has improved in these specimens which shows durability increase in specimens with crushed standard sand.

***Keywords:*** *Self-Consolidating Concrete, Crushed Standard Sand, Concrete Rheology, Mechanical Resistance, Concrete Durability.*

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**Extended Abstract:**

## 1. Introduction

In order to provide the requirements of rheological property, durability, and mechanical properties of concrete, the concrete materials must be selected more carefully. Aggregates and their physical and mechanical characteristics, especially geometrical properties (e.g. size and grading, shape and surface texture) and the aggregate fracture quality due to the increased interface surface, have a significant effect on fresh and hardened concrete properties.

Considerable research has been conducted on the influence of the geometrical characteristic of aggregates on the properties of different concrete. In this regard, studies by Poon et al. show that the specimens with higher values of crushed aggregates had higher compressive strength than mixtures containing natural aggregates [1]. Studies by Cordiero et al. Also show that the replacement of the crushed granite aggregates by silica type aggregates does not influence the mechanical properties significantly [2]. Tadyon et al. investigated the effects of aggregate shape on the strength of concrete by utilizing and combining the natural and crushed aggregates in different ratios [3]. According to the obtained results, the strength of concrete was directly correlated with the shape of concrete aggregates, so that mixtures in which the crushed sand was used had higher strength values. Also, the sand crushing way effects on the concrete durability has been studied by Vijayaraghavan and Wayal [4]. They observed that replacing industrial crushed sand instead of river sand would enhance concrete durability considerablly.

However, the fractures of aggregates, due to their effects on yield stress, plastic viscosity and friction between concrete components, play an important role in the performance of self-compacting concrete, so in this research and given the lack of scientific information in this area, the effect of the crushed sand content has been investigated on the properties of self-compacting concrete.

## 2. Methodology

In this study, self-compacting concrete was produced by replacing crushed sand with natural sand at different quantities and then the mechanical properties and durability of concrete were evaluated by performing compressive and tensile strength, flexural strength, freeze-thaw cycling resistance, and capillary water absorption tests.

The coarse aggregates was crushed and with uniform grading. River and crushed sand with uniform grading were also used. In all mixtures, type II cement was used. Polycarboxylate superplasticizer has also been used to maintain a suitable workability in the studied mixtures.

In this study, 5 mixtures with different replacement values of 0, 25, 50, 75 and 100% of crushed sand instead of natural sand were produced and tested (Table 1). In all mixtures, the water to cement ratio was equal to 0.4 and the amount of stone powder used was 250 $kg/m^3$ and the cement grade was 450 $kg/m^3$.

**Table 1.** Mix proportions of concrete ($Kg/m^3$)

| Mix No. | Mix-Design | Natura Sand | Crushed Sand | Coarse Aggregate | Fine Aggregate |
|---|---|---|---|---|---|
| 1 | SCC-CSS-0 | 924 | - | 541 | 252 |
| 2 | SCC-CSS-25 | 693 | 231 | 541 | 252 |
| 3 | SCC-CSS-50 | 462 | 462 | 541 | 252 |
| 4 | SCC-CSS-75 | 231 | 693 | 541 | 252 |
| 5 | SCC-CSS-100 | - | 924 | 541 | 252 |

## 3. Test Results and Discussion

The brief results of fresh concrete properties (rheological properties) and hardened concrete properties (mechanical properties and durability) for the studied mixtures are summarized in Tables 1 and 2.

According to Table 1, most of the rheological properties of mixtures containing 75% and 100% crushed sand, are not within the proposed EFNARC range and blockage and segregation phenomena are generally observed in the above mixtures, especially in SCC-S100. According to this table and the results obtained, it is not appropriate to use high amounts of crushed sand replacement in terms of worse impact on concrete rheology.

**Table 2.** Rheological properties of the studied mixture

| Test | Studied Mixture | | | | | Acceptable range of EFNARC |
|---|---|---|---|---|---|---|
| | SCC-S0 | SCC-S25 | SCC-S50 | SCC-S75 | SCC-S100 | |
| **Slump flow (mm)** | 755 | 745 | 740 | 680 | 655 | 550-850 |
| **T50cm (S)** | 2.32 | 2.46 | 2.83 | 6.22 | 10.34 | 2-5 |
| **J Ring(mm)** | 2.45 | 2.65 | 2.75 | 4.67 | 9.5 | <10 |
| **V-funnel (s)** | 10.35 | 9.62 | 6.6 | 10.58 | 38.54 | 6-12 |
| **L Box** | 0.97 | 0.97 | 0.97 | 0.97 | Blockage | 0.8-1 |
| **Summary** | Proper rheological properties (Suitable for producing self-compacting concrete) | | | Occurrence of blockage and segregation (Improper for producing self-compacting concrete) | | |

Table 3 presents the results of 28-day mechanical properties tests and capillary absorption of the studied specimens. According to this table, there is no clear trend of a discrepancy between the results and their changes. As can be seen from this table, the compressive strength of the specimens with 0%, 25% and 50% replacement of crushed sand is a small fraction of the values of the specimens with 75% and 100% replacement. However, the flexural and tensile strengths of these specimens are as high as those for replacement of crushed aggregates, and even more.

**Table 1.** Mechanical properties test results and capillary water absorption of studied mixtures

| Test | Mix-design | | | | |
|---|---|---|---|---|---|
| | **SCC-S0** | **SCC-S25** | **SCC-S50** | **SCC-S75** | **SCC-S100** |
| **Compressive strength** ***(MPa)*** | 60.8 | 58.4 | 58.03 | 61.93 | 62.13 |
| **Flexural strength** ***(MPa)*** | 15.27 | 11.76 | 14.63 | 14.72 | 11.04 |
| **Tensile strength** ***(MPa)*** | 5.01 | 4.44 | 4.26 | 4.73 | 4.85 |
| **Capillary Absorption (72 hours)** | 3.18 | 2.8 | 3.68 | 2.83 | 3.1 |

## 4. Conclusion

Overall, the obtained results from this investigation show that mixtures with 25% and 50% replacement of crushed sand instead of natural sand have desirable mechanical properties to manufacture reinforced concrete members and parts. Besides, these specimens have appropriate and acceptable rheological properties, which are among the essential properties of self-compacting concrete. Also, by replacing crushed sand with natural sand, no significant difference was observed in the results of the freeze-thaw cycling resistance.

## References

Poon CS, Shui ZH, Lam L, Fok H, and Kou SC. " Influence of moisture states of natural and recycled aggregates on the slump and compressive strength of concrete", Department of Civil and Structural Engineering, PP. 31-36, (2004).

Cordeiro CGC, Alvarenga LMSC, and Rocha CAA. "Rheological and mechanical properties of concrete containing crushed granite fine aggregate", Construction and Building Materials, No 111: pp. 766–773, (2016).

Tadyon M, and Mohajery P, "The investigation of aggregates shape effects on the compressive strength of concrete", The 4th Tehran International Conference on Concrete and Concrete Structures, Tehran, Iran, (2012).

Vijayaraghavan N, and Wayal AS. "Effects of manufactured sand on compressive strength and workability of concrete". International Journal of Structural and Civil Engineering Research, Volume 2. No 2: pp. 228-232, (2013).