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# AREVIEW ON STUDIES OF THE MECHANICAL PROPERTIES OF SELF COMPACTING CONCRETE

**M. Alsheltat*[1], A. Ramadhan[1]**

*[1]G Student, Department of Civil Engineering, Cyprus International University, Cyprus*
*Corresponding author/ E-mail address: mohamed.alsheltat@gmail.com

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**ABSTRACT.** *In this study ,We have reviewed many researches and papers that have recently been interested in the self-compacting concrete, its properties and additives, some of the studies focused on the use of specific additives in the self compacting concrete and the study of the effectiveness of these additives and their impact on the different properties of the concrete and its durability and performance, and we summarized the most important results, especially the results related to mechanical properties. Through the data available in recent previous studies, we studied the mechanical properties of self compacted concrete compared to normal vibrated concrete. the comparison was for compressive strength and tensile strength. We also presented a summary of the effect of use of various admixtures on the mechanical properties of self-compacted concrete, which may be useful in comparing the additives on the basis of their effect on the properties of self compacting concrete And to know the characteristics that need to be studied or increased research around them.*

**Keywords:** self compacting concrete, flowability, compressive strength, tensile strength, silica fume. Slag, Metakaolin. glass fiber.

## 1.INTRODUCTION

Self compacting concrete (SCC) was produced at the end of 1980 and is considered one of the high performance concrete types. For more than 20 years, concrete has been used in applications ,Several studies were conducted in this period [1].

In recent years there has been worldwide interest to study Self compacting concrete and its properties, especially in the last 5 years , Several research papers were presented at International Rilem Symposium on self compacted Concrete 2016 , Washington conference , in which the papers were classified on the basis of concrete properties.

Self compacting concrete (SCC) is a high performance concrete that consolidates under its own weight and adequately fills all voids without separation segregation, bleeding or any other heterogeneity of materials without need for mechanical uniformity , It also improves the resistance and durability of the hardened concrete and this makes it suitable in practical applications. use of plasticizers and powders admixtures is very important to achieve flow ability ,stability and impermeability of ( SCC ), Self - compacting concrete also improves the durability of hardened concrete. It increases compressive strength, tensile strength and bending. The concrete resistance of sulphates & chlorides increases . It is environmentally friendly . it reduces carbon dioxide emissions and reduces noise resulting from dynamic compaction. [1]

The following are the main results of some research: V. R . Sivakumar. et al (2017) investigated the effect of glass fiber and Metakaolin on mechanical, and durability properties of self- compacting concrete and the results was GF increase spelt strength, no effect on compressive strength, improve chloride resistance, decrease workability ,MK improve strength and durability of SCC The optimum cement replacement ratio was 0.8 % in GF reinforced SCC

[2]. And Serkan Subas . et al ( 2017 ) studied the use of waste ceramic powders as filler material in self compacting concrete , they found that WCP increase the flow ability , But decrease the compressive strength and bond strength. [3]. O.R. Kavitha. et al (2016) studies on friendly and durable Self- compacting concrete blended with metakaolin, it found : SCC with MK substitution improve the durability such as resistance to sulfate attack and decrease the permeability, also decrease the CO2 emission, and SCC containing 10%MK are considered the optimal [4]. Also Payal Painuly, and Itika Uniyal (2016) conducted a study on the many researches carried out during ( 1989 to 2011 ) and Search papers were classified based on SCC admixtures, He has proposed appropriate tests for fresh concrete. for plasticizer the Slump flow, V - funnel, L - flow, U-box are used . and we use the slump flow, J-ring test, L-box test and U-tube tests for mineral admixture SCC [1]. S.S. Vivek, G. Dhinakaran. (2017). An Experiment study on SCC durability by using binary blend self compacting concrete using GGBFS, SF and MK as mineral admixtures He found that Cement replacement with 50% GGBFS, 20% MK and 5 to 10% of SF was the optimum of SCC mixes [5]. A. Farzampour . et al ( 2016 ). The effect of temperature on concrete is discussed , and notes that cured concrete at low temperatures can never reach the strength of the concrete

the usage of lower water-cement ratios is recommended in cold weather curing [6]. Wu - Jian Long . et al (2016). The study concluded that , The compressive strength and splitting tensile strength decrease , and the shrinkage strain increases by using recycled aggregates. In SCC and decrease the workability .Use fibers improve the strength of recycled aggregates SCC [7]. Peiyu Yan, and others (2016) . studied creep behavior of high self -strength consolidation of concrete and they found The creep coefficient of concrete increases with the decrease of concrete strength at same loading age , and Chinese standards. for calculating the creep coefficient need to be adjusted [8]. Yudong Dang , et al ( 2016 ) . Under the experimental condition of this study , the difference in drying shrinkage between SCC with and without internal curing for large specimens is less pronounced than the small specimens . It is indicated that , for real concrete structures with larger cross-section, the laboratory tested shrinkage of internally cured SCC might be overestimated [9]. Ying Ma and Jueshi Qian. et al (2016). found that Cement with low alkali sulphate content will be useful for performance of SCC. compressive strength and drying shrinkage of SCC will be increasing [10]. B. Craeye , et al (2016 ).Based on an experimental study, they conclusions were: Gamma radiation during hard SCC negatively affects the development of strength the porosity of cementitious materials increases due to the gamma rays placed on the concrete [11] . Surong Luo , et al (2016). The study of Effect of Fly Ash on Resistance to Chloride Ion Penetration of SCC under Abrasion found that : fly ash increase to chloride resistance of SCC and The abrasion resistance strength of SCC increased with curing age and decreased with the increase of addition of fly ash. [12] . Katotriotou , (2016 ). studied Self-compacting concrete (SCC) with Multiwall carbon nanotubes (MWCNTs) .the properties of 28 days 0.1%w MWCNTs SCC were compared with control SCC without the nanoscale fiber. Observed that the flexural strength increased by 53 % , Young`s modulus by ( 68 % ) , also improving workability of SCC [13] . Qi Cao, Yinliang Cheng, (2016). studied the effects of fibers on properties of SCC, by using Hooked end steel fibers and polypropylene fibers in the mixes. they resulted no effect on compressive strength. And increasing split tensile strength was observed [14]. Yakhlaf1, et al (2016). Case Study of mechanical properties of carbon fiber on reinforced self compacting Concrete ( CFRSCC ).the study results were carbon fibers improved the segregation resistance , filling ability, passing ability, splitting tensile strength , flexural strength ( w/b < 0.40 ) , and The toughness ( w/b = 0.35 ).but the compressive strength decreased by increasing carbon fiber [15] . Mohamed K. , et al (2016). The study of the Effect of Crumb Rubber (RC) Content on SCC Structure by testing reinforced SCRC beams . Their conclusions were; Increasing the CR caused reduction in the flow ability , passing ability, and compressive strength . 10% to 15% CR replacement improve ductility, and toughness but reduction in the flexural strength [16] . Mohamed K. Ismail and Assem. A. Hassan. (2016). Studied Bond Strength of SCRC And Their conclusions were : Increasing CR in both SCRC and VRC mixes caused a reduction in workability , compressive , tensile strengths and bond strength. [17] . Iris González-Taboada1, et al (2016). Used the Recycled coarse aggregate (RCA) in self compacting concrete mixes. and investigated time - dependent fresh of SCRC . the result of experimental test was : the concrete with Recycled coarse aggregate have high water absorption, low workability ,and low strength [18]. Yasser Khodair , Mahmood Raza. (2016) They Investigated the quality of concrete made from recycled asphalt pavement RAP and SCC, by testing the properties of the produced concrete . they tested other mixtures containing SCC and a different proportions of fly ash, slag, recycled asphalt pavement . the Conclusions were 75% FA and 75% S can be used in concrete mixtures as a partial replacement portland cement using RAP as a replacement for coarse aggregate decreased the workability , compressive strength , and tensile strength [19]. Marco daSilva , ( 2015 ) . investigated the fresh, and hardened properties of high strength fiber reinforced self compacting concrete containing rounded river aggregates , The study concluded that . the river aggregates ( RA ) increases the workability of the concrete than the crushed gravel . but the adding ( RA ) decreases the compressive strength and tensile strength of SSC. the adding steel fiber in concrete mix increase the ductility of concrete significantly [20]. S. M. Dumne , ( 2014 ). investigated effect of superplasticizers on properties of fiber

self compaction concrete contained fly ash ( FASCC) , by experimental study , and he found that use fly ash improves the workability of concrete. also increases compressive strength .concrete ( 10% fly ash ) is The optimum to the best workability and strength [21]. Deepika ,et al (2014). used the fly ash and silica fume in self compacting concrete mixes by investigated the fresh, and hardened properties , he used binary blend as replacement material of cement contained from 50%fly ash and 50% silica fume, and he tested mixes with varies binary blend by replaced cement ( 10%,15%,20%,30%) of cement weight. the results were: At 10% binary blend resulted good compressive strength. but adding of fly and silica fume decreased the compressive strength and no improvement workability [22]. K . S . Johnsirani , et al ( 2013). Studied the properties of Quarry Dust SCC, with sand replacement of quarry dust ( QD ) ( 0% . 25% . 50% . 75% . 100% ) , using fly ash and supperplasticizer in mixtures. and they concluded the following: QDSCC (50%) or more ,the flowability , filling ability and segregation resistance was not satisfied because of the high fineness of quarry dust . and SCC with QD (25%) or more , the compressive strength decreased. w/c (0.4) was the optimum for using quarry dust in SCC [23]. Dhiyane, shwaran , S al (2013). Investigated the durability of self compacting concrete with fly ash And their fresh and hardened properties They made durability tests such as Sulphate Attack test, and Water Absorption test ,and they found that 30%fly ash were the best for workability, strength and durability . They also noticed that the slight change in VMA dosage causes a significant change in the properties of the (FASCC). [24]

## 2 . THE MECHANICAL PROPERTIES OF SELF COMPACTING CONCRETE

Studies of mechanical properties of SCC have been very interesting recently. The main mechanical properties of concrete are compressive strength, tensile strength, the modulus of elasticity.

### 2.1 Compressive Strength

Compressive strength is the main characteristic in the list of concrete properties generally And is affected by several factors such as water, shape, properties, aggregates properties, ( SCC ) offers higher compressive strength to normal vibrated concrete ( NVC ) due to improved internal microstructure, reduced voids , increased bond strength between concrete particles, bond strength between concrete and reinforcement in reinforced concrete with reduced water admixture ( HRWR ) and improved viscosity modify agents (VMA) The type and quantity of plasticizer,(VMA), and mineral admixtures affect the compressive strength of the SCC produced. Therefore, the proper type and the optimum quantity should be selected by testing the experimental mixtures, [25] . The following (table.1, figure .1) shows a comparison between the compressive strength of both NVC and SCC. data from the previews papers for some SCC types .

**Table -1:** The compressive strength of NVT and SCC

| N0 | NVT compressive strength (Mpa) /28 days | SCC compressive strength (Mpa) /28 days | SCC Mix type | Data source |
|---|---|---|---|---|
| 1 | 62.5 | 65.2 | Without mineral admixtures | [5] |
| 2 | 35 | 31 | RCA | [26] |
| 3 | 57.9 | 62.4 | flow slump(700-800)mm | [27] |
| 4 | 30.12 | 48.44 | FA, W/C 0.3 | [28] |
| 5 | 27.55 | 46.33 | FA, W/C 0.4 | |
| 6 | 21.66 | 39.55 | FA, W/C 0.5 | |
| 7 | 35.47 | 38.07 | Lime stone , flow slump(550 - 650)mm | [29] |

| | | | | |
|---|---|---|---|---|
| 8 | 35.85 | 38.21 | Lime stone , flow slump(660- 750)mm | |
| 9 | 37.87 | 39.22 | Lime stone , flow slump(760 - 850)mm | |
| 10 | 39.52 | 38.89 | 10% SF | [30] |

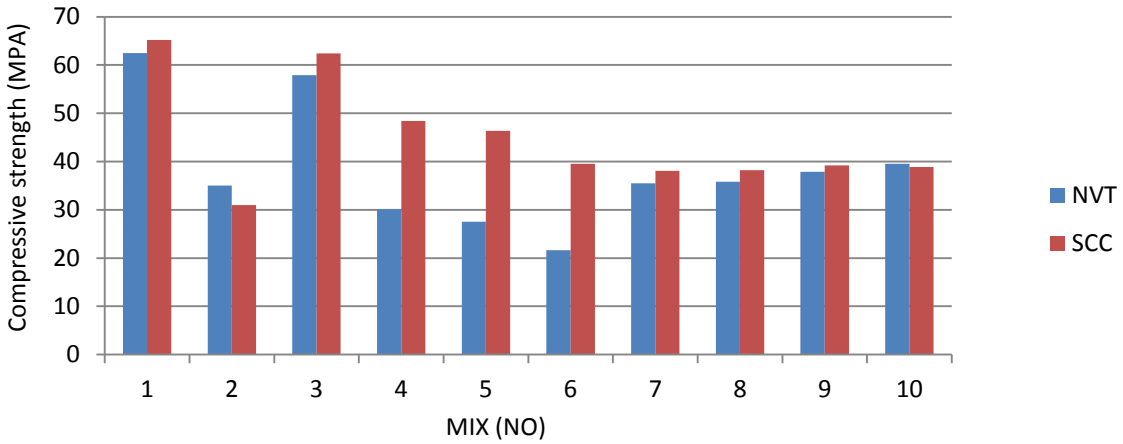


**Fig -1:** Compressive strength for NVT, SCC

## 2-2 Tensile Strength

The tensile strength is considered to be an indicator of the cracks in the concrete. tensile strength value is about ( 0.15 to 0.2 ) compressive strength. Three test methods to determine the tensile strength , direct tensile test, the split tensile test and the flexural tensile test. A direct tensile test is difficult in practice, and the test of split tensile gives greater values than direct tensile results and is higher than the flexural tensile test. Fibers and Powder clearly affect the tensile strength of SCC, [25]. The following (table.2, figure . 2) shows a comparison between the tensile strength of both NVC and SCC. data from the previews papers for some SCC types.

**Table -2:** The tensile strength of NVT and SCC

| N0 | NVT Split tensile trength (Mpa)/28 days | SCC Split tensile strength (Mpa) /28 days | SCC Mix type | Data source |
|---|---|---|---|---|
| 1 | 4.5 | 4.25 | RCA | [26] |
| 2 | 3.9 | 4.2 | flow slump(700- 800)mm | [27] |
| 3 | 3.71 | 3.69 | 10% SF | [30] |
| 4 | 2.92 | 3.77 | W/C 0.3 | [31] |
| 5 | 2.6 | 3.37 | W/C 0.4 | |
| 6 | 2.07 | 2.76 | W/C 0.5 | |

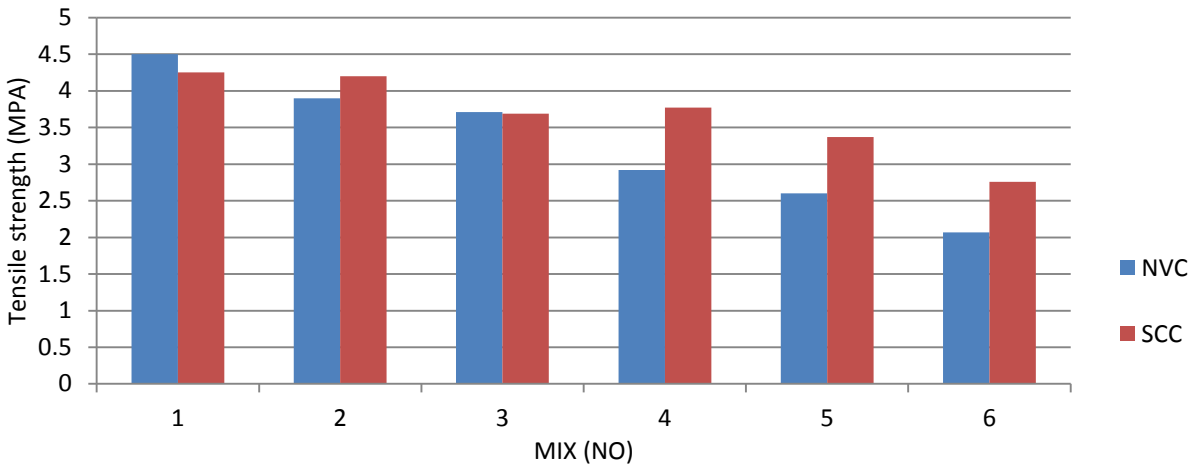


**Fig -2:**Tensile strength for NVT, SCC

## 2-3 Modulus of elasticity

Modulus of elasticity is the ratio between stress and strain and is influenced by the elasticity coefficient of the used aggregate, the volume of aggregate and the ratio of the binder in concrete mix. The type , grade , and amount of aggregates in self compacting concrete have an important effect on the elasticity coefficient by using a high elastic modulus of aggregates that gives higher elastic modulus of concrete [25]. In general, self compacted concrete is usually better in terms of compressive and tensile strength due to the ratio of the binder which improves the microstructures and reduces the permeability, which is reflected greatly on the performance of concrete. Various admixtures were used in the self compacted concrete industry which had a direct effect on the mechanical properties of SCC as indicated in the recent studies, which we will discuss as follows.

# 3. DISCUSSIONS

From table 1,2, and Figure 1,2, we note that the compressive & tensile strength of SCC was approximately equal to or greater than the normal vibrated concrete NVC for most data . Thus , the most important objectives achieved by the SCC is to keep strength of concrete at the same level without the need for a vibrated compaction.

By comparing the types of SCC based on additives with their mechanical properties, in order to compile the above list of points of interest in previous studies in a table in a short and useful manner as shown in Table 3:

**Table -3:** the different admixtures types and properties of self compacting concrete

| Type of SCC | SCC PROPERTIES | | | | | | | Ref No |
|---|---|---|---|---|---|---|---|---|
| | workability | Comp. strength | Tensile strength | Flexural strength | Sulfate resist | Chloride resist | Optimum replace % | |
| SF | + | + | + | + | + | | 5-10 | [1] |
| GGBFS | + | + | + | + | + | | 50 | |
| MK | + | + | + | + | + | | 20 | |
| MK | + | + | + | + | | | 10 | [4] |
| GF | - | 0 | + | + | | + | 0.8 | [2] |
| WCP | + | - | - | | | | | [3] |
| RCA | - | - | - | | | | | [7] |
| RCA | - | | | | | | | [18] |
| MWCNTs | + | + | | + | | | | [13] |
| Type of SCC | SCC PROPERTIES | | | | | | | Ref No |
| | workability | Comp. strength | Tensile strength | Flexural strength | Sulfate resist | Chloride resist | Optimum replace % | |
| HSF,PP | - | 0 | + | - | | | | [14] |
| CF | + | - | + | + | | | | [15] |
| CR | - | - | | - | | | | [16] |
| CR | - | - | - | | | | | [17] |
| RAP | - | - | - | | | | | [19] |
| RA | + | - | - | | | | | [20] |
| FA | + | + | | | | + | 10 | [21] |
| FA | + | + | + | + | + | + | 30 | [24] |
| 50%FA + 50%SF | + | - | | | | | 10 | [22] |
| QD | - | - | + | | | | 25 | [23] |

* (+) positive effect . (-) negative effect . (0) no significant effect . ( ) no investigated

It could be derived from table as follow:

▪ The admixtures : fly ash ( FA ) , silica fume (SF), ground granulated blast furnace slag (GGBFS) , and Metakaolin ( MK). have excellent effects on self compacting concrete, they clearly improve the workability, strength and durability of self compaction concrete in many papers as mentioned above , Also note that Admixture : Multiwall carbon nanotubes ( MWCNTs ) have very good effect on compressive and tensile strength and therefore we have to study the durability conditions on SCC by using this material.

▪ The admixtures : glass fiber ( GF ) , carbon fiber ( CF ) , Hooked end steel fibers and polypropylene fibers ( HSF,PP ) , are good materials that improve tensile strength only, but have a negative effect on some of other properties , especially strength of concrete thus may be useful to use along with other admixtures .

▪ The materials : waste ceramic powders (WCP) used as an replace to cement ,and river aggregates. (RA) used as an replace to crushed aggregates, increased the workability .and negative effect on the other properties. also the use of quarry dust (QD) as an replace to sand in SCC. increased the tensile strength only.

▪ The use of the recycled coarse aggregate ( RCA) , recycled asphalt pavement ( RAP) ,and Crumb Rubber (CR) have a negative effect on SCC properties.

▪ In the paper [23] the using binary blend contained (50%fly ash+50% silica fume) which is why the weak results of the properties of self compacting concrete .

▪ In these papers, Table 1 shows the emphasis on the study of the properties of fresh concrete and strength of hardened concrete tests. Despite the importance of the properties of the durability , many of these properties have been overlooked , such as chloride resistance.

## 4. CONCLUSION

Based on the review of above research papers , the following concludes:

▪ In general, self compacting concrete has a positive effect on the mechanical properties of concrete in the case of the most suitable choice of mixtures.

▪ Self compacting concrete usually improves mechanical properties compared with normal vibrated concrete.

▪ Choosing the appropriate tests of fresh self compacting concrete depends on the type of admixtures ( mineral admixtures - or plasticizers )

▪ The curing temperature affects the target concrete strength .

▪ As a result of the significant development in this area, it is necessary to revise and amend the standards if necessary.

▪ The size of the samples in the laboratory does not give accurate results in the drying shrinkage, test which is higher than what actually occurs .

▪ Cement with low alkali sulfate content will be useful for performance of self compacting concrete.

▪ For all types of admixtures , an optimal ratio should be determined by testing experimental mixes.

▪ In the case of admixtures consisting of two or more materials , the optimum proportions of the components of admixture should be determined through experimental mixtures.

▪ fly ash , silica fume, ground granulated blast furnace slag , and Metakaolin are more effective in improving concrete performance.

▪ glass fiber and carbon fiber increase the tensile strength but they have negative affect on the other properties.

▪ The results of the studies conducted on recycled materials such as waste ceramic powders , recycled asphalt pavement, recycled coarse aggregate, are not encouraged to be used in the self compacting concrete industry.

▪ Studies have shown little benefit from the use of certain materials such as crumb rubber , river aggregates and quarry dust in the concrete industry.

▪ Good results for workability and resistance tests on self compacting concrete may not achieve high performance concrete if the durability properties are neglected.

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