# International Journal of Engineering Sciences &Research Technology

(A Peer Reviewed Online Journal)
Impact Factor: 5.164

IJESRT

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

# EFFECT OF MICRO RUBBER ASH ON THE PROPERTIES OF SELF-COMPACTING CONCRETE

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**DOI**: 10.5281/zenodo.3540376

## ABSTRACT

This study aims to inspect the effectiveness of the micro rubber ash (MRA) as an addition from cement weight on the fresh and hardened properties of SCC with cement content 450 kg/m$^3$.The micro rubber ash was obtained from the factories of recycling waste rubber. The micro rubber ash is used as an addition from cement weight in SCC mixtures at five levels: 5%, 10%, 15%, 20%, and 25%. The tests conducted on the fresh state concrete are slump flow, slump flow time at T 50cm, J-rang, V-funnel, L-box, and GTM, their varied from 700 mm to 770 mm, 2.5 sec. to 6.0 sec., 4.0 mm to 12.0 mm, 5.5 sec. to 12.0 sec., 0.82% to 0.99 % and 5.43% to 14.55%, respectively. The results values were acceptable according to ESS 360/2007.Moreover, the hardened properties of SCC which were investigated are; compression test, flexural strength, splitting (tensile), Bond strength, and abrasion resistance. The SCC containing different levels of micro rubberash showed a reduction in values of compressive strength about 3.27%, 12.61%, 33.29%, 43.34% and 64.60%,Also, the bond strength underwent a reduction in values about 6.96%, 16.39%, 36.33%, 49.18% and 68.71%.The results of both compressive and bond strength were computed at percentages of MRA 5%, 10%, 15%, 20% and 25%,respectivelyat28 days. Whereas, the flexural and tensile strength occurred higher rates than control mix at 28 days, about13.8% and 18.31%for the mix containing 25% micro rubber ash. The tensile and flexural strength were evaluated as percentages compared with compressive strength. Furthermore, the SCC containing 5% to 25% micro rubber ash showed a higher resistance for abrasion compared with control mix.

**Keywords:** Self-Compacting Concrete, Micro rubber ash**,** Abrasion resistance.

## 1. INTRODUCTION

Self-Compacting Concrete (SCC) is characterized as the ‘‘most revolutionary step’’ in concrete industry technology during the last decades for its positive effect on economic and environmental sustainability in the industry of construction. Self-compacted concrete (SCC) was introduced initially in 1980’s by researchers in Japan to improve some of both fresh and hardened properties of concrete to be highly workable that can spread like "honey" through restricted sections with no blocking or bleeding compared with vibrating concrete, therefore SCC considered as sole solution for the placement problem of concrete in the structures sections with heavily reinforced. The advantages SCC lead to increase productivity rates, decreased number of manpower, and removal the noise and fuel consumption associated with vibrator plant. As compared with normal concrete, SCC has full ability to compact under self-weight with high flow ability and filling rates through everywhere, reduced blocking high reinforced areas, and high segregation resistance, besides high durability, high compressive strength, low permeability [1].

Solid waste is a dangerous environmental issue in all over the world. Generally, the inexpensive and simple way to dispose of used tires is by burning or burying them in the ground, this causes serious environmental problems. However, the pollution results from the massive amount of fume makes this method so rejected that it is considered illegal in most countries of in the world [2,3]. Also, storage these materials are unhealthy because they form a good environment for insects and bacteria growth.[4]. Disposing of tires waste in through landfills is no longer acceptable because of the fast depletion of available landfill sites. Moreover, tires may break through landfill covers, floating upward with the time. [5].For the previous reasons, it becomes necessary to find alternative solutions. Among the most hopeful solutions are: recycle the waste rubber comes from the tires of vehicles in various product, burning of waste tires for electricity production, and use tire rubber in pavement woks and concrete mixtures [6,7]. Regrettably, the growing of waste tires quantities far exceeds its current recycling applications. Previous literature studies on adopted using limited percentages of waste tires rubber in pavement mixes were very hopeful. They concluded that the rubberized asphalt has better slip resistance,

reduced shrinkage and cracking, and get longer asphalt pavement durability than traditional asphalt pavement [6].However, the used tires in concrete has not been inspected as much as their use in pavements of asphalt. Most of the previous studies treated with tires waste as a single case replacing coarse or fine aggregates [7].These studies have indicated that concrete mixes containing rubber possess lower unit weight, increased toughness, improved ductility, better impact resistance, lower compressive and splitting tensile strengths, lower durability to freezing and thawing damage, and more effective of sound and heat insulation [8,9]. Also, they carried out so far show that waste tires concrete is especially recommended for concrete structures existing in areas of severe earthquake hazard and also for applications subjected to different dynamic actions. Moreover, rubber can be also used for elements used for non-loading purposes such as noise reduction barriers [10]. The increment of fine rubber in the mixtures of concrete has a slight effect on decreasing the workability of the mixes [11]. The test results indicate a decreasing of mechanical properties of concrete when substituting rubber with coarse aggregate rather than fine aggregate [12].A partial substituting of rubber for aggregate or cement in concrete raised a reduction in its compressive strength, flexural strength, the bond strength, permeability and increased the absorption in the case of using coarse aggregate replacement but reduced absorption w cement weight replacement [9].However, little studies have reported about the use of micro rubber ash in the concrete mixes. This study investigates the effect of using micro rubber ash waste as an addition from cement weight on the fresh and the hardened properties of SCC

## 2. MATERIAL PROPERTIES

Ordinary Portland Cement (OPC) CEM I 42.5 N. Manufactured by EL-Suez Cement Company, conforming to Egyptian Standard Specifications ESS 4756-1/2009 [14], Specific gravity of used cement is 3.15. The local natural silica sand was used. The specific gravity of the used sand is 2.65.The coarse aggregates used in the experimental program of this study were dolomite from (Attakaquarries in Ismailia, and fine aggregate from Fayed quarries) Egypt. Coarse aggregate with one size of 10 mm was used which conforms to the Egyptian Code No. 203-2016 [15], and ESS 1109/2002 [16]. Micro rubber ash waste was supplied by MARSO company of rubber industries and floors, 10th of Ramadan, Egypt. Micro rubber ash waste sizes were between; 12 to 45 micron, as seen in Fig.1. Bulk density and Specific gravity of the micro rubber ash was 528 kg/m$^3$ and 0.97, respectively. The chemical composition of micro rubber ash is given in Table 1. The micro-rubber ash has a dark color and a specific surface area of 1.54 m$^2$/g. The local silica fume was used, brought from factories of Sika Egypt for Construction Chemicals, Egypt. Its physical properties are stated in Tables 2 and chemical analysis are in Tables 3 as obtained from the manufacturer. Class F fly ash was used, according with ASTM C 618 Class F[17]. The chemical composition of the fly ash as determined by x-ray fluorescence (XRF) analysis is given in Table 4. The fineness of the fly ash was 77.82% passing 45µ sieve. The physical properties and XRF analysis are stated in the Table 4andTable 5, respectively. For keeping slump flow constant for all mixes the superplasticizer SP was used as additive supplied by the Sika Egypt for Construction Chemicals. It meets the requirements of superplasticizer (ViscoCrete-3425) according with ASTM C494 type G and F [18]. Its technical data are illustrated in Table 6 supplied by the manufacturer. The dosage of superplasticizer used in this work varied from 1.00 % to 1.50 % by weight of the cementitious materials (cement+ silica fume + fly ash + micro rubber ash).

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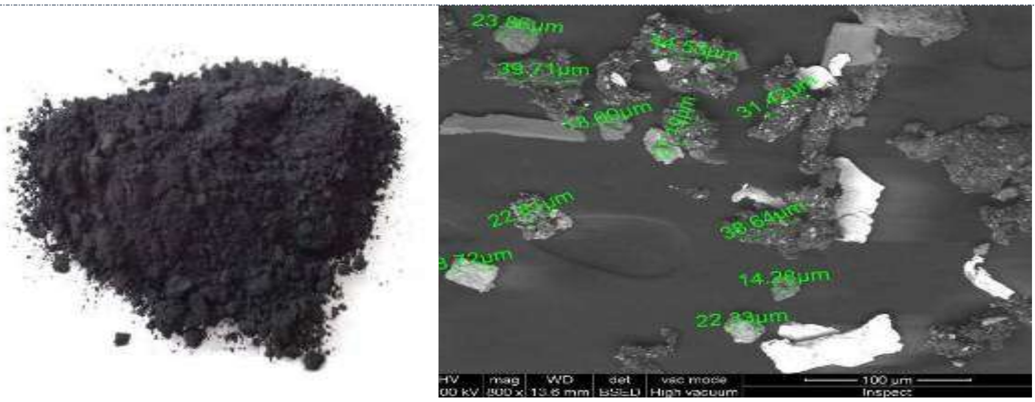

*Fig., 1particlesizedistribution for microrubber ash(MRA)*

*Table 1:Chemical analysis of the used microrubberash (MRA)*

| Chemical composition* | Content % |
|---|---|
| Acetone extract | 14.85 |
| Industrial fabrics | 4.65 |
| Carbon black | 30.28 |
| Rubber hydrocarbon | 50.15 |

*Chemical composition provided by the supplier.

*Table 2:Physical properties of the usedsilica fume*

| Property | Test Results |
|---|---|
| **Specific surface area ( $cm^2$/gm)** | **$20.12*10^3$** |
| **Bulk density(kg/$m^3$)** | **354** |
| **Specific gravity** | **2.16** |
| **color** | **Light grey** |

*Table 3: Chemical analysis of the used silica fume*

| Oxide | Content % | Limitation%* |
|---|---|---|
| **$SiO_2$** | 95 | 90 min |
| **C** | 0.5 | 1 max |
| **$Al_2O_3$** | 0.2 | 1 max |
| **$Fe_2O_3$** | 0.5 | 1.5 max |
| **CaO** | 0.4 | 1 max |
| **MgO** | 0.5 | 1.5 max |
| **$K_2O$** | 1.2 | 1.5 max |
| **$Na_2O$** | 0.3 | 0.5 max |
| **$SO_3$** | 0.3 | 0.2 max |
| **$H_2O$** | 0.85 | 0.8 max |
| **Cl** | 0.01 | 0.05 max |
| **PH fresh** | 6.0 | ±1max |

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* According to the tests carried out in Norway on the Egyptian product of silicafume.

**Table4: XRF analysis for the used flyash**

| Oxide | Content % | Limitation%* |
|---|---|---|
| $SiO_2$ | 61.30 | Min. 70% |
| $Al_2O_3$ | 29.40 | |
| $Fe_2O_3$ | 3.27 | |
| CaO | 1.21 | ……….. |
| MgO | 0.75 | ……….. |
| $K_2O$ | 1.20 | ……….. |
| $SO_3$ | 0.003 | Max. 3% |
| $TiO_2$ | 0.01 | ……….. |
| $Na_2O$ | 0.73 | Max. 1.5% |
| Cl | 0.04 | Max. 0.05% |
| LOI | 0.67 | Max. 6% |

* According to the requirementof ASTM C618 Class F [16].

**Table5:Physical properties of the used flyash**

| Property | Test Results |
|---|---|
| Specificsurface area ($cm^2/gm$) | 3950 |
| Bulk density($kg/m^3$) | 1250 |
| Specific gravity | 2.5 |
| color | Light grey |

**Table 6: Super plasticizer (ViscoCrete-3425) Technical Data**

| Property | TechnicalData |
|---|---|
| **Color** | brown liquid |
| **State** | Liquid solution |
| **Specific gravity** | 1.08 |
| **Chloride content** | Nil |
| **Compatibility with cement** | Allkinds of Portland cement |

## 3. SPECIMENS PREPARATION

The SCC was mixed in the laboratory mixer for a total time of 4 min. Table 7has shown the SCC mixtures proportions details. The micro rubber ash was used in SCC mixtures as an addition from cement weight at five levels: 5%, 10%, 15%, 20 and 25% by weight from cement. Since the micro rubber ash density is less than the cement, the overall volume of the micro rubber ash increased. The w/c ratio of the SCC (as measured by flow test) increased by increasing micro rubber ash addition level due to the high specific area of its fine particles which need more water to occur better workability. In the fresh state, the tests are slump flow, and slump flow time at T 50cm, V-funnel (Flow Time), L-box (Blocking Ratio), J-rang and GTM screen stability (segregation resistance).The compressive strength specimens were cubes measuring 150*150*150 mm. The flexural strength specimens were beams measuring 150*150*500 mm. Splitting

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tensile strength and Bond strength specimens were prismatic measuring 150*300 mm cylinders. The abrasion test samples were conducted on cubes measuring 70*70*70 mm. Three specimens of SCC were prepared for testing to obtain average values for each test condition. Each specimen was casted in two layers without compacted by any vibrating. After casting, the specimens should be left in casting room at for 24 h. in the next day, the specimens were dismantled and cured in the drinking water at 23 ± 2C$^{0}$ until the time of testing.

*Table 7: the mix proportions of the SCC*

| Mix ID | Cement | C.A | F.A | Silica fume | Fly ash | MRA | W/b | SP |
|---|---|---|---|---|---|---|---|---|
| | Kg/m$^3$ | Kg/m$^3$ | Kg/m$^3$ | Kg/m$^3$ | Kg/m$^3$ | Kg/m$^3$ | Kg/m$^3$ | Kg/m$^3$ |
| **mix control** | 450 | 840.28 | 700.24 | 67.50 | 67.50 | 0.0 | 200.00 | 11.5 |
| **5% MRA** | 450 | 840.28 | 700.24 | 56.25 | 56.25 | 22.50 | 201.20 | 11.5 |
| **10% MRA** | 450 | 840.28 | 700.24 | 45.00 | 45.00 | 45.00 | 203.70 | 11.5 |
| **15% MRA** | 450 | 840.28 | 700.24 | 33.75 | 33.75 | 67.50 | 204.75 | 11.5 |
| **20% MRA** | 450 | 840.28 | 700.24 | 22.50 | 22.50 | 90.00 | 205.81 | 11.5 |
| **25 % MRA** | 450 | 840.28 | 700.24 | 11.25 | 11.25 | 112.50 | 206.95 | 11.5 |

## 4. TEST PROCEDURES

The slump flow, slump flow time at T 50cm, J-rang, V-funnel (Flow Time), L-box (Blocking Ratio), and GTM screen stability (segregation resistance) of the fresh SCC was measured according to the ESS 360/2007 [19].The compressive strength, flexural strength tests, splitting tensile strength and then the Bond strength for hardened SCC mixtures were conducted according to ESS 1109/2002[15]. The compressive, flexural, splitting tensile and Bond strength for hardened SCC mixtures specimens were tested using a universal testing machine. The rate of loading of test specimen is 40kN/min. Abrasion resistance was measured according to the IS 9284 [22] on cube specimens of 70*70*70 mm by using abrasion test machine(Is standard is highly recommended for the abrasion of concrete paving applied on SCC samples to be an alternative of ASTM C779 [19] A major deal of researchers used this method and done reliable results [22].

## 5. FRESH PROPERTIES

The properties of fresh SCC mixes were repeated every 10 minutes after short re-mixing. From the test results shown in Tables 8, and Figs. 2a, 2b, 2c, 2d and 2ewas observed that, when the test age was 0 and 10 minutes, the slump flow, slump flow time at T 50cm, J-rang, V-funnel (Flow Time), L-box (Blocking Ratio) and GTM screen stability (segregation resistance), varied from 700mm to 770 mm, 2.5 sec. to 6.0 sec., 4.0 mm to 12.0 mm, 5.5 sec. to 12.0 sec., 0.82% to 0.99 % and 5.43% to 14.55% respectively, the results are shown in Figs. 4, 5, 7,8, and 9,respectively.All results are in acceptable range according to ESS 360/2007 [19],except the SCC mixtures containing the percentage 25% of the micro rubber ash in terms of slump flow time at T 50cm and J-rang. The addition of micro rubber ash by weight from cement in SCC, throughout the test period of fresh properties resulted a work able concrete that are acceptable to a considerable extent as indicated in Table 8.

*Table 8, the tests results of fresh properties of SCC*

| Mix ID | Slump flow (mm) | T50 cm (sec) | J-ring (mm) | V-funnel flow time (sec) | L- box (h2 / h1) (3rebars) | GTM Screen stability test (%) |
|---|---|---|---|---|---|---|
| **mix control** | **770** | **2.5** | **4.0** | **5.5** | **0.99** | **14.55** |
| **5% MRA** | **740** | **2.5** | **5.5** | **6.0** | **0.97** | **12.13** |

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| | | | | | | |
|---|---|---|---|---|---|---|
| 10% MRA | 710 | 4.0 | 7.0 | 7.5 | 0.92 | 9.75 |
| 15% MRA | 705 | 4.5 | 8.0 | 8.5 | 0.87 | 8.52 |
| 20% MRA | 705 | 5.0 | 9.5 | 10.0 | 0.85 | 7.85 |
| 25 % MRA | 700 | 6.0 | 12.0 | 12.0 | 0.82 | 5.43 |
| Range ESS 360/2007 [18] | 650-800 | 2-5 | 0-10 | 6-12 | 0.8-1 | 0-15 |


***Fig., 2. The fresh properties of SCC mixes (a) The slump flow, slump flow time at T 50cm, (b) V-funnel test (Flow Time), (c) J-rang test tests (d) L-box test (Blocking Ratio) and (e) GTM screen stability.***

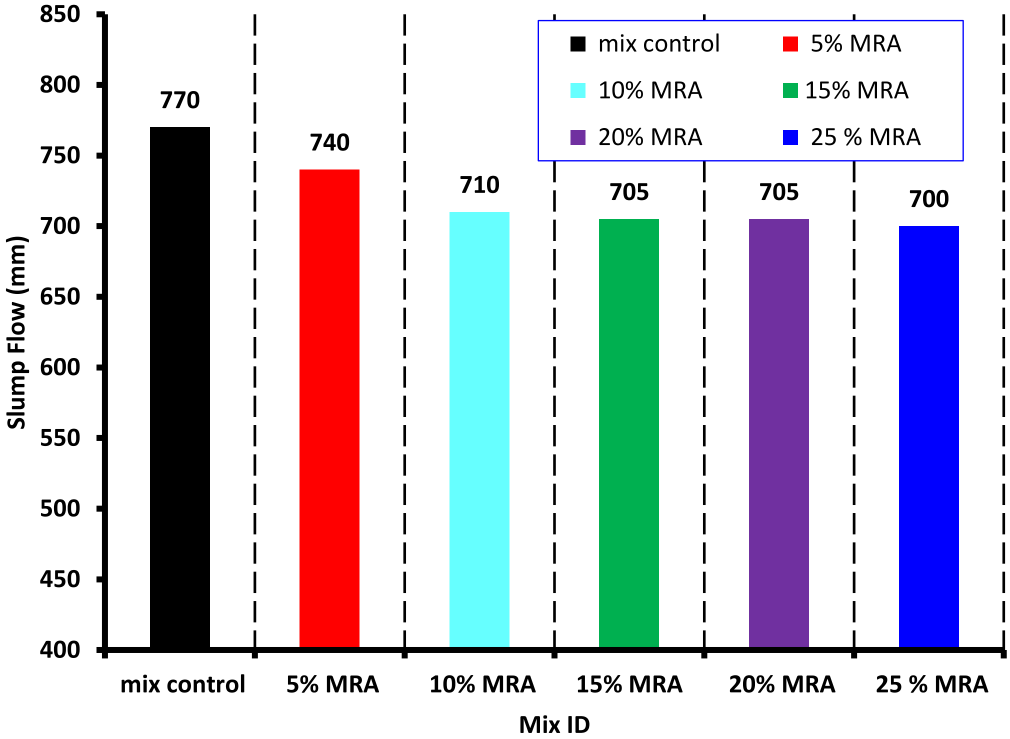


*Fig. 4.Slump flow results for all mixtures*

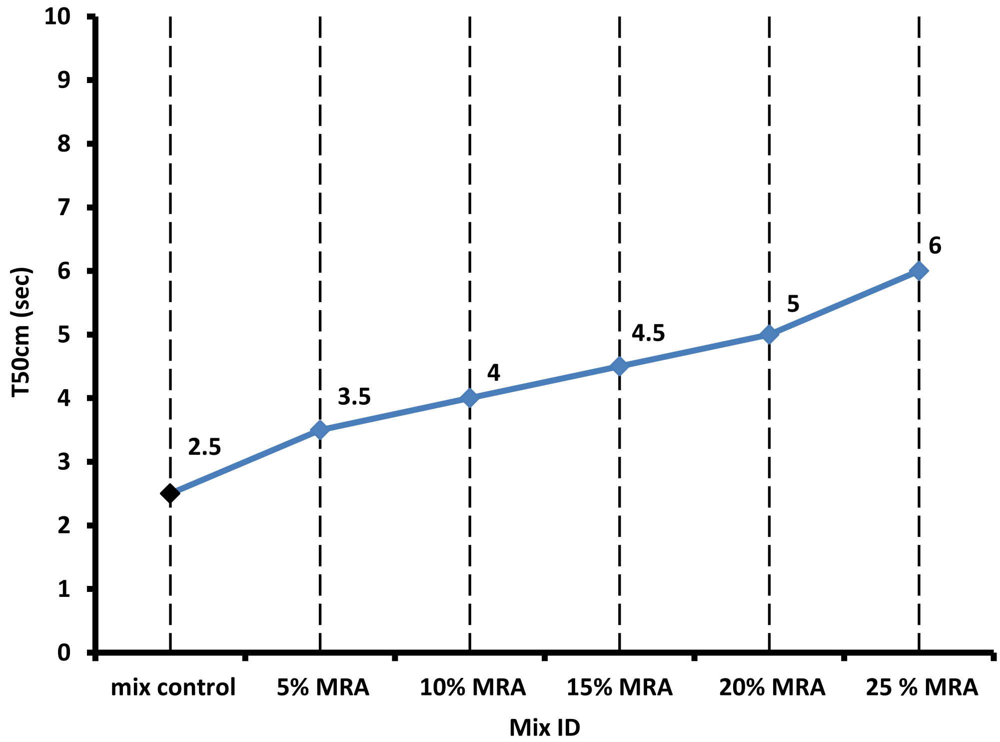


*Fig. 5. $T_{50}$ cm results for all mixtures*

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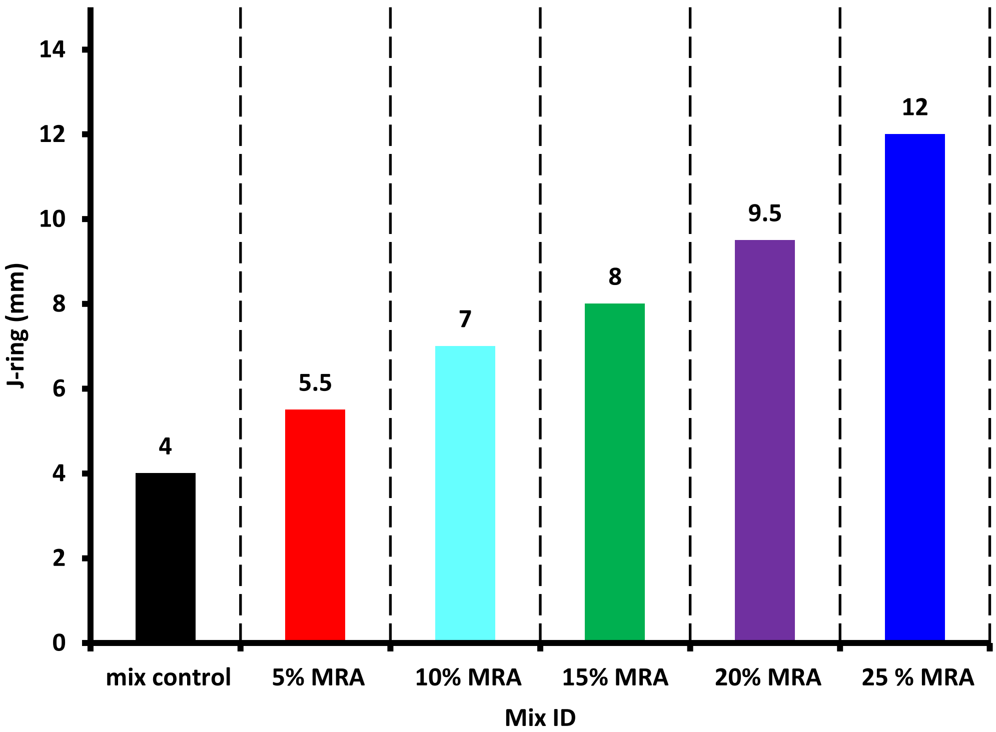


*Fig. 6. J-ring results for all mixtures*

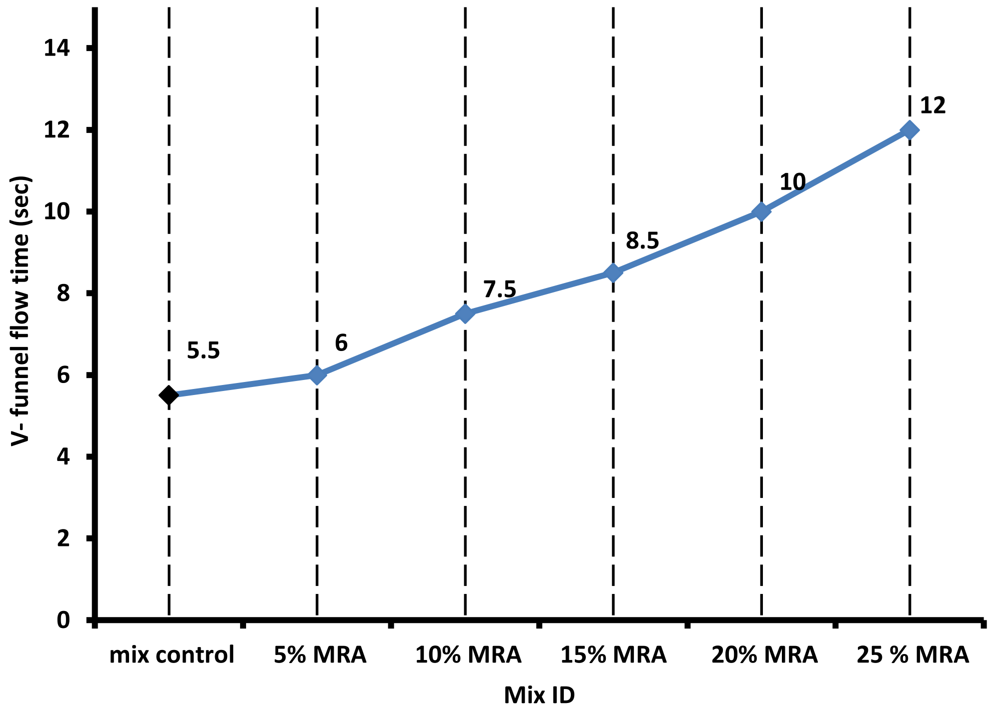


*Fig. 7. V- funnel flow time results for all mixtures*

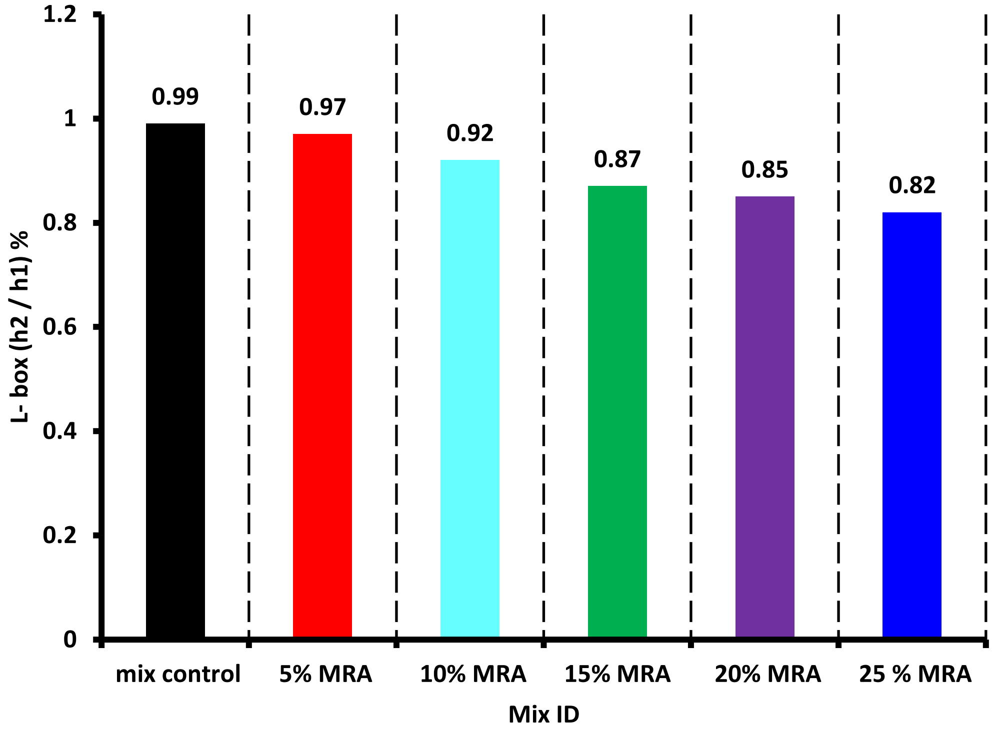


*Fig. 8. L- box results for all mixtures*

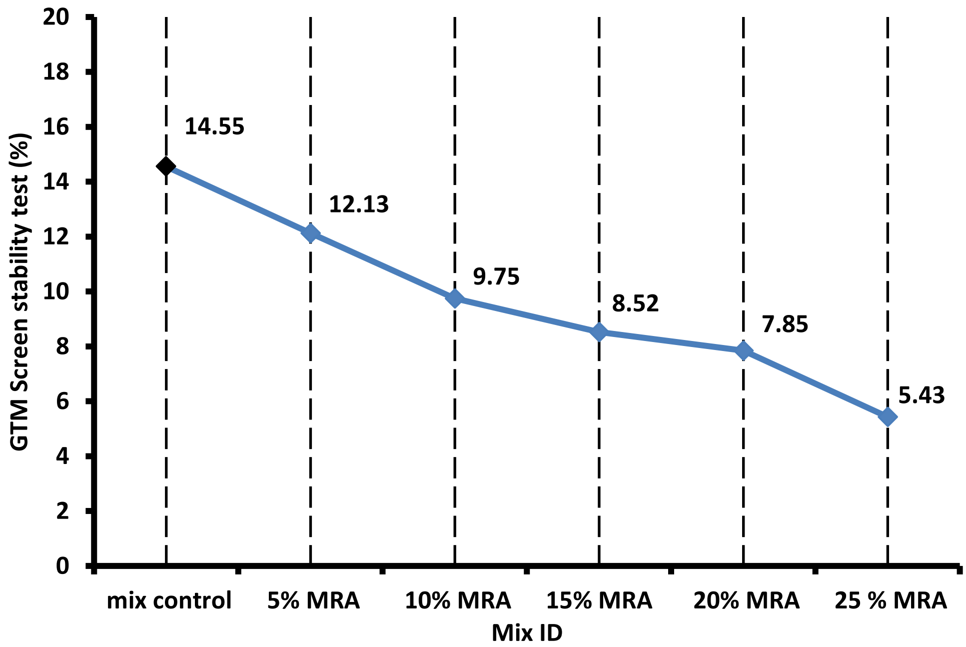


*Fig. 9. GTM Screen stability test results for all mixtures*

## 6. HARDENED PROPERTIES

### 6.1 Compressive strength

Table 9showsa reduction in the compressive strength during the curing duration (3, 7, 28, and 56 days) for hardened SCC containing 0%, 5%, 10%, 15%, 20% and 25% of MRA. The average rate of decreasing in the compressive strength was comparatively elevated between 3 and 7 days in proportions of 8.3%, 18.4%, 38.5%, 50.2% and 66.5%followed by a slower rate through the interval 7-28 days with the percentages decrease of 3.3%, 12.6%, 33.3%, 43.3% and 64.6%,respectively. Whereas, the percentage decrease in compressive strength of SCC specimens at 56 days were 2.5%, 12.0%, 31.0%, 42.2% and 63.1% at MRA content of 5%, 10%, 15%, 20% and 25%, respectively. Fig10 shows the growth of the compressive strength during different times of curing for SCC containing MRA. The rapid growth of the compressive strength of SCC containing different MRA addition percentage levels through the early time of 3 and 7 days indicates rapid hydration during this interval. even at a later time, but with a relatively slower rate. The growth of strength continued even at a later time, but with a relatively slower rate. Generally, the compressive strength of the mixtures decreased with increasing the percentage of MRA as shown in Fig. 11 and Fig.12.The decrease in compressive strength may be related to the physical effect where MRA behaves as voids in concrete mixtures. This is especially important in the interfacial transition zone part where MRA produces fewer bond with surrounding cement paste. Also, from these results, one can refer to the lower strength for MRA particles in SCC compared to CSH, SF, FA and aggregate, which act together as one hardened mass, while the rubber particles as non-homogeneous material with this mass, acts as pores in SCC mix that leads to decreasing the compressive strength, and to low strength of interfacial transition zone between rubber particles and paste mortar, the obtained results are found in agreement with the published literature [13-21].

*Table 9 Mechanical properties of MRASCC*

| Mix ID | Compressive Strength ($N/mm^2$) | | | | Tensile strength ($N/mm^2$) | Flexural strength ($N/mm^2$) | Bond strength ($N/mm^2$) |
|---|---|---|---|---|---|---|---|
| | 3 days | 7 days | 28 days | 56 days | 28 days | 28 days | 28 days |
| mix control | 34.6 | 69.3 | 85.6 | 87.4 | 7.65 | 12.12 | 7.32 |
| 5% MRA | 32.5 | 63.5 | 82.8 | 85.2 | 7.62 | 12.02 | 6.81 |
| 10% MRA | 33.8 | 56.5 | 74.8 | 76.9 | 7.15 | 11.92 | 6.12 |
| 15% MRA | 21.9 | 42.6 | 57.1 | 60.3 | 5.96 | 9.96 | 4.66 |
| 20% MRA | 18.9 | 34.5 | 48.5 | 50.5 | 5.39 | 8.69 | 3.72 |
| 25 % MRA | 14.5 | 23.2 | 30.3 | 32.2 | 4.18 | 5.55 | 2.29 |

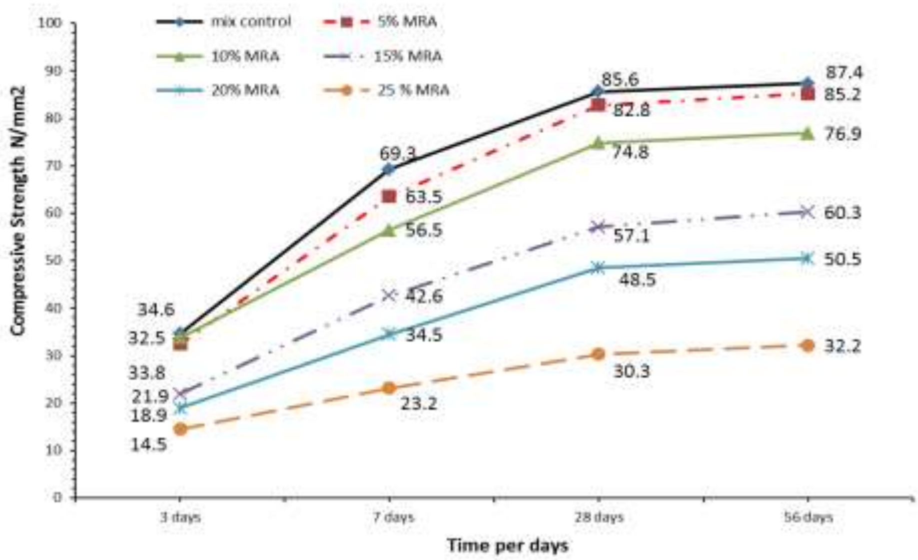


*Fig. 10 shows the effect of MRA as an addition from cement weight on the compressive strength of SCC*

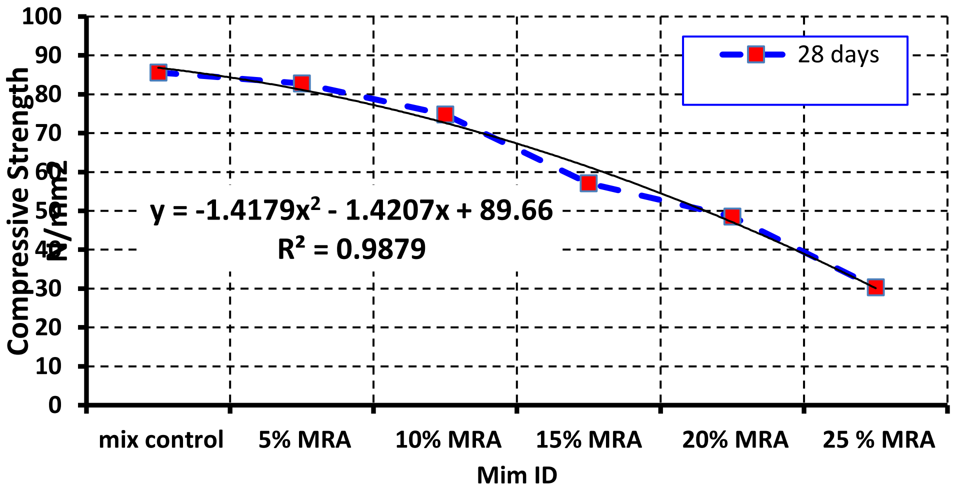


*Fig. 11 shows the effect of an additional level of MRA from cement weight on the compressive strength of SCC at 28 days.*

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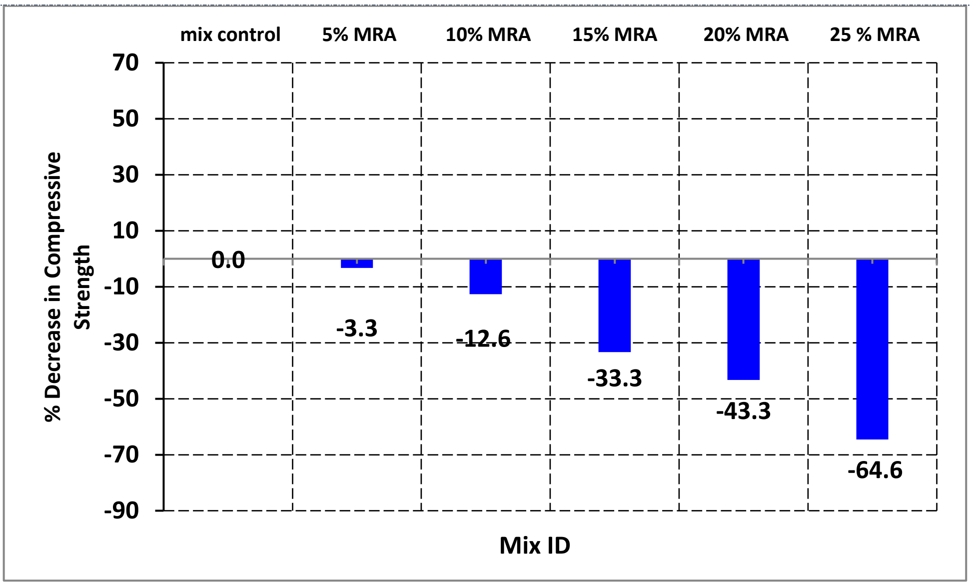


***Fig. 12shows the percent decrease in the compressive strength of SCC at 28 days for an additional level of MRA from cement weight.***

**6.2 Flexural strength**

Table 9 and Fig. 13shows the flexural strength test results at 28 days for SCC mixtures including MRA. Generally, it was noticed that increasing addition of MRA in the levels of5%, 10%, 15%, 20% and 25%increased the flexural strength from 14.51%, 15.93%, 17.44%, 17.91 and 18.31%, respectively compared with 14.16 for the control mix. The flexural strength results were computed as a percent from the compressive strength values (fcu).This enhancement in the flexural strength is associated with the shape of the microstructures of the MRA compared to SF and FA shapes, the obtained results stated in acceptance with the published literature [13].

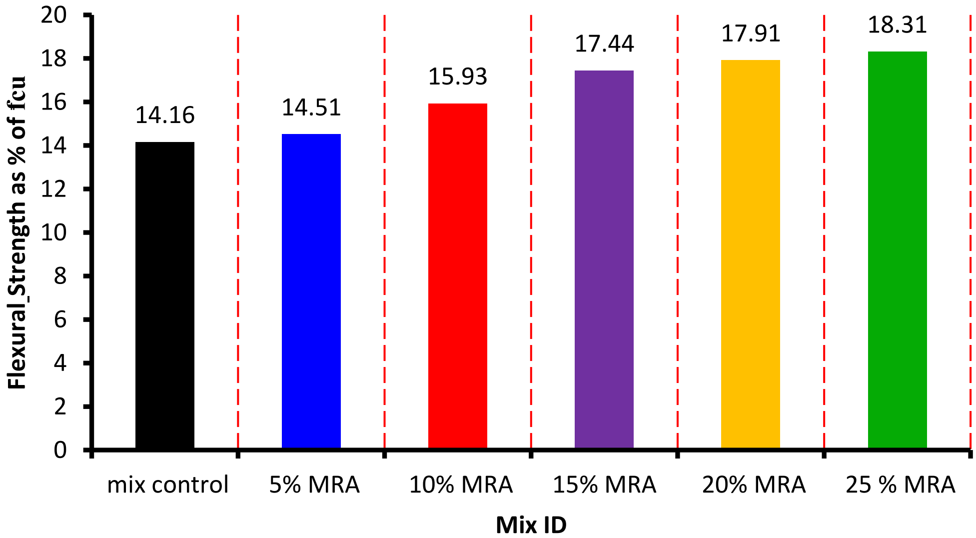

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***Fig. 13 shows the effect of MRA as an addition from cement weight on the flexural strength of SCC***

### 6.3 Tensile strength

The variance in splitting tensile strength has beennotedat 28 days for all SCC including MRA content.
The values of splitting tensile strength were ranging from 7.65 N/mm2 for SCC control mix to 7.62, 7.15, 5.96, 5.39 and 4.18 N/mm$^2$ for SCC containing 5%, 10%, 15%, 20% and 25% MRA, respectively stated in table 9, but the values for the splitting tensile strength increased in the percentages of 9.16%, 10.45%, 10.62%, 10.82% and 11.61% compared with values of compressive strength for SCC containing 5%, 10%, 15%, 20% and 25% MRA, respectively. Fig. 14 indicated that increasing MRA content yielded in the enhancement of splitting tensile strength as a percentage from compressive strength (fcu).Generally, the whole SCC has a little tensile strength (Approximately 10% from compressive strength) these results are conformable with the published literature [20].

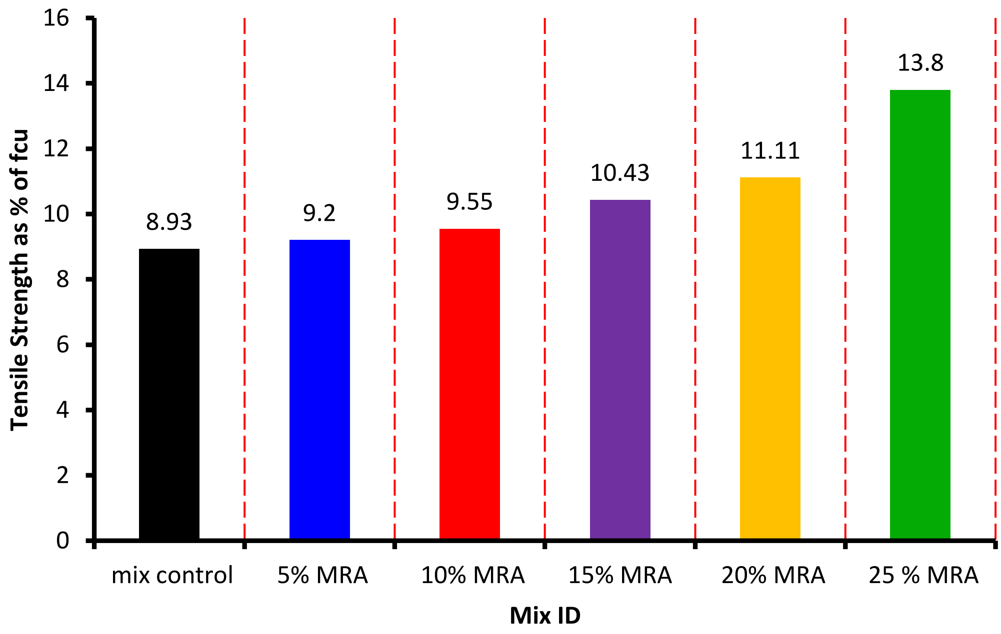


**Fig. 14 shows the effect of MRA as an addition from cement weight on the tensile strength of SCC**

### 6.4 Bond strength

The bond strength is the stress that works parallel with reinforcement baralong with the interface[20]. This occurred due to transition of axial force to the reinforcing from surrounding SCC by the development of tangential stress components along the contact surface. Eq. (1) was applied to calculate the bond strength from the test values of cylinder samples, including the 16 mm reinforcement bar to be imposed by axial tensile load. The obtained results stated in Table 9showedthe highest bond strength test value of 7.32 N/mm$^2$ for the control mixture and then decreased to the proportions of 6.81, 6.12, 4.66, 3.72 and 2.29 N/mm2with the increase of MRA content level of 5%, 10%, 15%, 20% and 25% at 28 days,respectively.Fig.15 shows the effectiveness of MRA on the bond strength. The decrease in the bond strength test results is due to weakness bonding surface around cement paste and MRA [21].

$$F_b = \frac{P}{\pi \times D \times L} \qquad \text{Eq.1}$$

Where:
P: is the ultimate load causing slipping of the reinforcing bar in N.
D: is the diameter of reinforcing bar in mm.
L: is the embedded length of the bar in concrete in mm.

ISSN: 2277-9655
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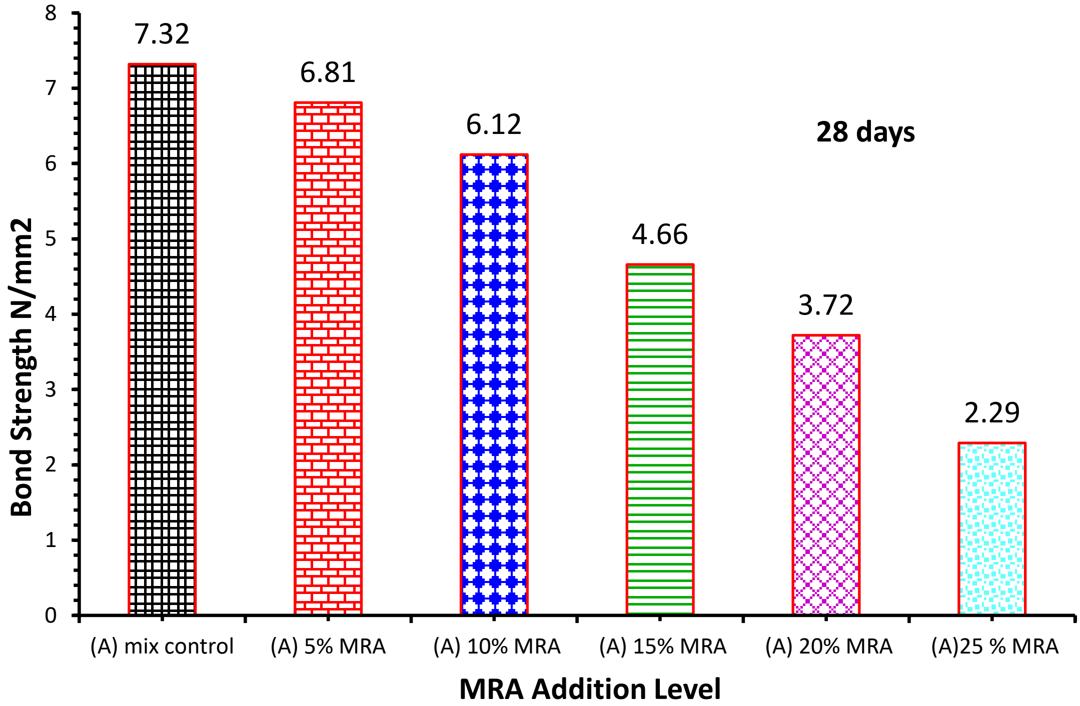


***Fig. 15 shows the effect of MRA as an addition from cement weight on the bond strength of SCC***

**6.5 Abrasion Resistance**

Abrasion can be defined as a behavior of construction elements against destructive effect due to skidding, rubbing, scraping, or sliding of the object on the surface of concrete, which results in an erosion of this surface.[22].The present study adopted an experimental program to examine the effect of using micro rubberash MRA as an addition by weight of cement on abrasion resistance of SCC surface. The abrasion test procedure is fulfilled according to the [IS: 9284] [24] where the specimen size of (70*70*70 mm) was prepared to be tested by abrasion test machines seen in Fig.16.It was noticed at 28 days that the weight loss values decreaseby2.03%, 1.62%, 1.45%, 1.22%, 1.02% and 0.95 % for the specimens containing MRA of 5%, 10%, 15%, 20%, and 25 %,respectively, compared with the control mix as stated in Table 8, Fig.17.and 18That means the abrasion resistance of SCC was better affected by increasing MRA content from 5% to 25%.Thisis a good characteristic for SCC that applied in the constructions imposed by heavy environment

or dynamic loads, rigid pavement, wear of vehicles traffic and, etc.[24]**,**where abrasion resistance is considered a significant feature of concrete to realize long-term durability for these types of construction. This may be related to the particles position of micro rubber ash present in the rubberized concrete lies beyond the smooth surface of concrete and they restricted the rubbing/ grinding the concrete surface by acting like a brush, and therefore can minimize the effect of abrasive on the surface of concrete, and hence the resistance of SCC to abrasion with higher amount of MRA improves gradually and remarkably.

ISSN: 2277-9655
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*Figure.16 abrasion test machine*

*Table 8 Abrasion test results of MRASCC*

| Mix ID | Abrasion Weigh loss % 28 days |
|---|---|
| mix control | 2.03 |
| 5% MRA | 1.62 |
| 10% MRA | 1.45 |
| 15% MRA | 1.22 |
| 20% MRA | 1.02 |
| 25 % MRA | 0.95 |

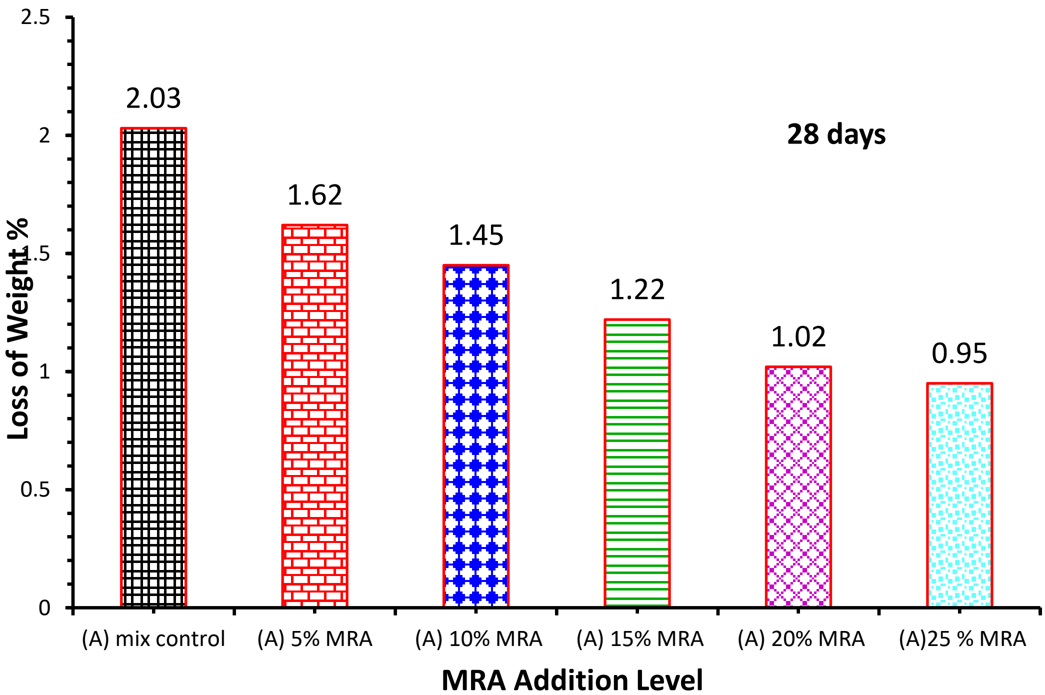


***Fig. 17 shows the effect of MRA as an addition from cement weight on the abrasion resistance of SCC.***

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

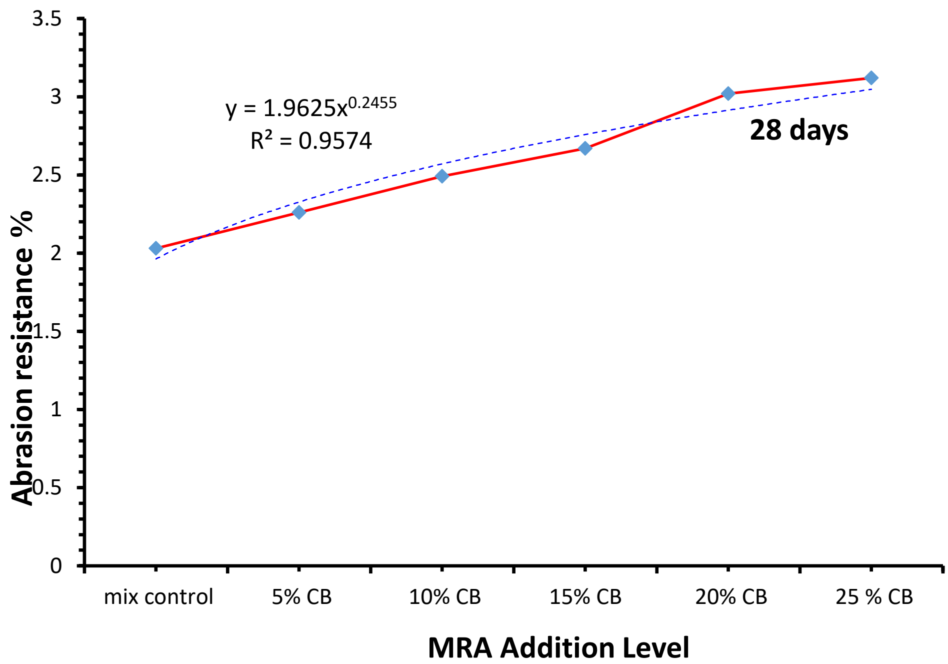


***Fig. 18 shows the increase in abrasion resistance of SCC effect with MRA as an addition from cement weight***

## 7. CONCLUSIONS

The conclusions have been done according the results obtained from the experimental tests as drawn below:

- The use of MRA approved a development of the SCC fresh properties, successfully within the acceptable limits by using up to 20% of MRA content.

- The compressive strength of SCRC having above 30 Mpa could be easily obtained with 25% of MRA.
- The strength test results indicated slight decrease in the compressive strength about 3.27 % at 28 days, for MRA content of 5%. Whereas, increasing the percentage of MRA content of 25%.in SCC mixtures showed a negative impact on the compressive strength about 64.6 % at 28 days, for MRA content of 25%.
- The addition of MRA to SCC enhances the flexural strength and splitting tensile strength even with using high percentages of MRA and help in maximizing the percentage of MRA in SCC mixtures.
- SCC abrasion resistance increases with the increase in the proportion of MRA. In turn, this is a good characteristic in the SCC used for rigid concrete pavement and the construction that subjected to dynamic loads. Also, the amount of loss in mass decreased by 53.0 % for the SCC containing MRA percentage of 25% as an addition for cement weight.

## 8. RECOMMENDATION

According to the results, it was concluded that 15% is the best percentage of Micro Rubber Ash to be used as addition by weight of cement. Since, it occurred the limits of fresh and hardened properties.

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