An Experimental Investigation On Self-Compacting Concrete By Using M-Sand

Chaitanya Kamble[1], S.R. Suryawanshi[2]
[1]Dept of Civil Engineering
[2]Professor, Dept of Civil Engineering
[1, 2]Imperial College of Engineering & Research Pune,Maharashtra, India

Abstract- *In this thesis, an experimental investigation on self-compacting concrete by using M-sand is to be done. The materials to be used for the experiment are collected and the physical properties tests are done. Self-Compacting Concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction. In the work, an attempt has been made to make a comparative study on the fresh and hardened state properties of M40 grades of plain concrete mixes to self compacting concrete with 100% replacement of River sand by manufactured sand. This paper presents an Experimental Investigation on Strength aspects like Compressive, Flexural and Split Tensile Strength of Self-Compacting Concrete and Workability tests (slump, T50, L-box, and V-Funnel) are carried out. The methodology adopted is that 100% manufactured sand added with 0.5%, 1%, 1.5%, 2%, 2.5%, 3.% and 3.5% of naphthalene and Polycarboxylic Ether based super plasticizer is measured and compared. This research outcome is very beneficial and economical to the Community.*

Keywords- SCC, SF, M-Sand, PCE

I. INTRODUCTION

Concrete is a widely used construction material around the world, and its properties have been undergoing changes through technological advancement. Numerous types of concrete have been developed to enhance the different properties of concrete. So far, this development can be divided into four stages. The earliest is the traditional normal strength concrete which is composed of only four constituent materials, which are cement, water, fine and coarse aggregates. At the way to achieve the high compressive beginning, reducing the water cement ratio was the easiest way to achieve the high compressive strength. Thereafter the fifth ingredient a water reducing agent or super plasticizer was indispensable. The chemical admixture is said to be any material that is added in a small quantity (i.e., less than 5%) to the concrete mixture which enhances the properties of concrete in both the fresh and hardened state. But now a day the cost of sand has been increasing beyond imagination which is resulting in the increase in concrete cost. This is because demand for sand is more than its supply to overcome this problem the experiment on concrete by partial replacement of river sand by manufactured sand in self compacting concrete. We can reduce the cost of concrete and enhance the strength of concrete also M-sand can reduce ecological imbalance in nature

Advantages of Manufactured Sand (M-Sand)

- It is well graded in the required proportion.
- It does not contain organic and soluble compound that affects the setting time and properties of cement, thus the required strength of concrete can be maintained.
- It does not have the presence of impurities such as clay, dust and silt coatings, increase water requirement as in the case of river sand which impair bond between cement paste and aggregate. Thus, increased quality and durability of concrete.
- M-Sand is obtained from specific hard rock (granite) using the state-of-the-art International technology, thus the required property of sand is obtained.
- Modern and imported machines are used to produce M-Sand to ensure required grading zone for the sand

Properties of manufactured sand (M-sand)

- *higher strength of concrete*
- *Workability of concrete*
- *Less Construction Defects*
- *Economy*
- *Eco-Friendly*

II. RESEARCH AND LITERATURE REVIEW

This paper presents an experimental investigation on strength aspects like compressive, flexural and split tensile strength of self compacting concrete containing different mineral admixtures and workability tests for different mineral admixtures (slump, L-box, U-box and T50) are carried out. The methodology adopted is that mineral admixtures are replaced by 30%, 40% and 50% for Portland cement and performance is measured and compared. The influence of mineral admixtures on the workability, compressive strength, splitting tensile strength and flexural strength of self-compacting concrete was investigated. The mix proportion is obtained as per the guidelines given by European Federation of producers and contractors of special products for structure. The following inferences were made; optimum dosage of super plasticizer enhanced the29 flow property of the concrete. As a result, overall improvements in the flow and filling ability of the self-compacting concrete were observed. It is observed that when mineral admixtures used in self-compacting concrete, can reduce the amount of superplasticizer necessary to achieve a given fluidity. It should be noted that the effect of mineral admixtures on admixture requirements is significantly dependent on their particle size distribution as well as particle shape and surface characteristics. From this view point, a cost effective self-compacting concrete design can be obtained by incorporating reasonable amounts of silica fume, fly ash, and ground granulated blast furnace slag.

III. METHODOLOGY

3.1 Phase I

In this phase literatures of self-compacting concrete by using Msand related to various parameters are varying grades of concrete, properties related to with and without addition of admixtures studied. Preliminary studies were carried out to know about the physical properties of materials used in concrete. I have chosen the 100% replacement of manufactured sand by adding dosage of superplasticizer as 0.5%, 1%, 1.5%, 2%, 2.5%, 3% and 3.5% after the review of literature. The preliminary tests such as specific gravity, water absorption, fineness modulus etc. are carried out for the materials such as cement, fine aggregate(M-sand), coarse aggregate respectively. Assigning the material properties of specimen components to discuss with mix design grade of M40.An Experimental Investigation on Strength aspects like Compressive, Flexural and Split Tensile Strength of Self-Compacting Concrete and Workability tests (slump, L-box, U-box, V-Funnel, J-ring and T50) are carried out as per IS10262:2009 and EFNARC Feb2002. The flowchart in figure 3.1 describes the phase I methodology of this project.

3.2 *Phase II*

The methodology adopted is that Manufactured sand are replaced by 100% for river sand and performance is measured and compared with dosages of 21 superplasticizer as Ceraplast 300, Cera Hyperplast XR-W40 and Conplast SP400 based on Naphthalene and Polycarboxylic Ether has performing workability for 0.5%, 1%, 1.5%, 2%, 2.5%, 3% and 3.5% respectively adopted for giving SCC performance. Using the properties of the materials, the mix is designed for M40 grade concrete as per IS10262:2009. On fresh concrete, as per EFNARC 2002 selected the ranges of the (slump cone test, T50, L-box, and V-funnel) test. Finally these tests are carried out for each mix. Then the cube, cylinder and prism specimens are casted and tested after the curing of specimens to find out compressive strength, split tensile strength and flexural strength at the ages of 7th days, 14th days and 28th days as per the specific guidelines of EFNARC 2002.This references adopted only for self compacting concrete mix. Finally the casted specimens are tested and required strength has been satisfied.

3.3 Flowchart of Methodology

- Collection of literature
- Collection of material
- Mix proportion of concrete
- Testing of fresh concrete
- Test on properties of material on mix of 100% M-Sand+0.5% SP +10% SF
- And also taking test on same mix with increasing amount of 0.5% SP
- Casting of concrete cubes and curing for 28 days
- Test on concrete specimen
- Result and Discussion
- conclusion

IV. MATERIAL USED IN EXPERIMENT AND TEST CONDUCTED ON MATERIAL

4.1 Cement

Ordinary Portland cement is composed of calcium silicate sand, aluminate sand, and alumina ferrite. It is obtained by blending predetermined proportions lime stone clay and other materials in small quantities which is pulverized and heated at high temperature – around 1500˚C to produce clinker. The clinker is then ground with small quantities of gypsum to produce a fine powder called Ordinary Portland cement [OPC].Laboratory test were conducted on cement to determine specific gravity, consistency, initial and final setting time and fineness.

Table 4.1 Properties of cement

Description	Observation
Fineness	8%
Consistency	30%
Initial setting time	30 minutes
Final setting time	390 minutes
Specific gravity	3.15

4.2 Fine aggregate (Manufactured sand)

Manufactured sand confirming to IS: 383-1970 is used. Which is confirms to Zone II The physical properties of fine aggregate like specific gravity, bulk density, gradation and fineness modulus is tested in accordance with IS: 2386-1975.

Table 4.2 Grading zones of fine aggregate (M-sand)

IS sieve Designation	Percentage passing for grading zone			
	I	II	III	IV
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

Table 4.2.1 Properties of Manufactured sand

Description	Observation
Fineness Modulus	3.39
Specific gravity	2.68
Water absorption (%)	1.5
Moisture Content (%)	0.34
Loose bulk density(kg/m3)	1691.34
Compacted bulk density(kg/m3)	1771.71
Zone as per IS383:1970[9]	II

4.3 Coarse Aggregate

Crushed natural rock stone aggregate of nominal size up to 12.5 mm and aggregate passing 10 mm were used. The aggregates are proportioned by trial in the mixes. The physical properties of these coarse aggregates are listed in table4.4.The sieve analysis details of 12.5 mm coarse aggregate are showed as per IS 383-1970.

Table 4.3 Properties of Coarse Aggregate

Description	Observation
Fineness Modulus	3.36
Specific gravity	2.65
Water absorption (%)	0.3
Water absorption (%)	0.1

4.4 Silica fume

Silica fume is also known as micro silica. It is an ultra fine material with spherical particles less than 1 µm. In this project 10% of cement is replaced by silica fume. The property of silica fume to Portland cement concrete is to improve its properties like 26 compressive strength, bond strength absorption resistance. Silica fume reduces bleeding because the free water is consumed in wetting of the large surface area of the silica fume and hence the free water left in the mix for bleeding also decreases.

Table 4.4 Properties of Silica fume

Properties of Silica Fume	
Physical state	Micronized powder
Appearance	White colour powder
Colour	White
Specific gravity	2.3

4.5 CONPLAST SP 430[IS: 9103:1999, BS: 5075 Part 3]

Conplast SP 430 is an admixture of a new generation made from the Forsoc Company. Conplast SP 430 is free of chloride & low alkali. It is compatible with all types of cements. The chemical admixture added in the concrete deflocculates the cement particles and thus made use of the entrapped water to enhance the fluidity of the mix. By adding super plasticizers to the concrete mix, it is possible to obtain workable mixes even at water binder ratio of 0.3 and less. In the present investigation, a high range water reducing admixture of sulphonated naphthalene formaldehyde super plasticizers named CONPLAST SP 430 was used as a chemical admixture and the properties are given in Table 4.5

Table 4.5 Properties of Conplast SP 430

Properties of conplast SP 430	
Appearance	Brown liquid
liquid Specific gravity	1.20 at 20°C
Chloride content	Nil to BS 5075

4.6 *Ceraplast 300*

Ceraplast 300 is a high-grade superplasticizer based on Naphthalene, highly recommended for increased workability and high early and ultimate strengths of concrete. It disperses cement particles more rapidly in the concrete mix by reducing the surface tension of water and imparting repelling charges to the ions in solution. This makes the concrete highly workable and flowable even at lower water-cement ratios, resulting in increased strength.

Table 4.6 Properties of Ceraplast

Properties of Ceraplast	
Appearance	Brown liquid
Specific gravity	1.2 + .03

4.7 **Cerahyperplast XR-W40**

Cera Hyperplast XR-W40 is based on Polycarboxylic Ether with specifications ASTM C 494-03, BS 5075 and IS 9103 capable of reduction of water up to 25% is used as the chemical admixture.

Table 4.8 Properties of Cera Hyperplast XR-W40

Properties of Cera Hyperplast XR-W40	
Appearance	Light Brown liquid
Specific gravity	1.1-1.2
Chloride content	Nil

V. MIX DESIGN OF CONCRETE

5.1.Requirements of concrete mix design

The requirements which form the basis of selection and proportioning of mix ingredients are:

a) The minimum compressive strength required from structural consideration
b) The adequate workability necessary for full compaction with the compacting equipment available.
c) Maximum water-cement ratio and/or maximum cement content to give adequate durability for the particular site conditions
d) Maximum cement content to avoid shrinkage cracking due to temperature cycle in mass concrete.

5.2. Mix proportioning

For the present work SCC of grade M40 is adopted. The mix design of SCC is obtained as per standard procedure as out lined in IS: 10262-2009 was followed. Details of mix proportions obtained are given in Table 5.1 for SCC, M-Sand is replaced 100% for river sand , cement is replaced by 100% and added 10% of Silica fume constantly for giving bond strength, Superplasticizer is replaced by 0.5%, 1%, 1.5%,2%, 2.5%, 3%, and 3.5% respectively. These seven mixes are compared with the Normal SCC (100% cement with 100% M-sand) Super plasticizer is used to maintain the workability with constant Water/Binder ratio as obtained from the mix design. In this work M40 grade concrete was used and the mixture was prepared with the water cement ratio of 0.4. The concrete mix was designed as per IS 10262:2009 for M40 of control concrete. Unfortunately, perfect standard code book is not performed for generating self compacting concrete. So, some of specific guidelines provided to prove self compacting concrete thus the concrete mix ranges has been taken as per EFNARC Feb 2002. Typical detailed calculation of mix design as per standard procedure as out lined.

Table 5.1 Mix proportion for SCC in M40 grade

SN	Proportions	Mixture						
		Cement (kg)	M-Sand (kg)	CA (kg)	Silica fume (gram)	SP (%)	Water (litre)	W/C ratio
1	SCC (1:2.7:2.15)	390	1090	840	0	0	156	0.4
2	SCC1 (1:2.5:2.15)	390	997	840	351	0.5	156	0.4
3	SCC2 (1:2.59:2.46)	380	986	937	342	1	152	0.4
4	SCC3 (1:1.83:2.49)	393	722	979	354	1.5	197	0.5
5	SCC4 (1:2.92:2.5)	324	949	840	392	2	144	0.4
6	SCC5 (1:1.83:2.59)	393	722	1020	354	2.5	196	0.45
7	SCC6 (1:2.65:2.73)	342	909.5	937	308	3	144	0.4
8	SCC7 (1:2.8:2.74)	324	909.5	890	890	3.5	144	0.4

VI. TEST ON CONCRETE

6.1. Test on fresh concrete

The filling ability and stability of self-compacting concrete in the fresh state can be defined by four key characteristics. Each characteristic can be addressed by one or more test methods which are mentioned below.

TABLE 6.1 gives the acceptance criteria.

Characteristics	Preferred test methods
Flow ability	Slump flow test
Segregation	T50 flow test
Viscosity(assessed by rate of flow)	V-Funnel test
Passing ability	L-Box test

Table 6.2 Acceptance criteria

Test	Property	Range of values
Slump flow	Flow ability	650-800 mm
T50 flow	Segregation	2-5 sec
V- funnel	Viscosity	8-12 sec
L- box	Passing ability	0.8-1.0

6.2.Test on harden concrete

One of the purposes of testing hardened concrete is to confirm that the concrete used at site has developed the required strength. Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete works. Systematic testing of raw materials, fresh and hardened concrete are inseparable part of any quality control programme for concrete, which helps to achieve higher efficiency of the material used and greater assurance of the performance of the concrete with regard to both strength and durability.

- Compressive strength
- Split tensile strength
- Flexural strength

6.2.1 Specimen details

The specimens for controlled and replaced concrete were casted as per the below mentioned details.

a) Cubes of 100mmx100mmx100mm size
b) Cylinders of 100mm diax200mm height
c) Prism of 100mmx100mmx500mm size

VII. RESULT AND DISCUSSION

The proportioning of the quantity of cement, cementitious material like silica fume, and manufactured sand, coarse aggregate and chemical admixture as superplasticizer has been done by weight as per the mix design.In order to study the effect on fresh concrete properties, the SCC containing different proportion of silica fume with dosage of superplasticizer have been tested for slump flow, T50, V-funnel test, and L-box test.The results of various fresh properties tested by slump flow test (Filling ability), V-funnel test (Filling ability), L-box test (Passing ability) for various mix compositions in the present study conform to range given by EFNARC 2002 method standards which are given in following Table 7.1

Table 7.1 Fresh concrete properties

SN	Mix Designation	Slump flow 650-800mm	T50 (2- 5sec)	L-box (h2/h1)	V-Funnel (8-12sec)	Results
1	100% Msand	534	0.8	0.60	19	Failed
2	100%Msand+ 0.5%SP	520	0.65	0.52	14	Failed
3	100%Msand+ 10%SF+ 1%SP	520	0.8	0.58	16	Failed
4	100%Msand+ 10%SF+ 1.5% SP	560	0.6	0.76	18	Failed
5	100% Msand + 10% SF + 2% SP	654	4	0.88	12	Passed
6	100% Msand + 10% SF + 2.5% SP	580	0.7	0.66	13	Failed
7	100%Msand+ 10%SF+ 3%SP	660	3.2	0.82	11	Passed
8	100%Msand + 10%SF+ 3.5%SP	698	3.76	0.94	8.2	Passed

7.1.Fresh properties of SCC

7.1.1 Slump Flow Test Variation

In this workability test the slump range is appeared in SCC 4, SCC 6 and SCC 7 respectively. Based on seven trial mixes with and without chemical admixture has compared to normal SCC the slump range percentage has increased from 2.6% to 30%. Finally the ultimate values for slump find it from EFNARC (2002) guidelines for performing self compacting concrete.

- Adding 0.5%, 1%, 1.5% superplasticizer named as Conplast SP430 with 100% of manufactured sand and 10% of silica fume the slump range is not satisfied and the values is appeared at 2.6% and 4.8% respectively. •
- Adding 2% Ceraplast 300 based on Polycarboxylic ether and VMA with 100% of manufactured sand and 10% silica fume the slump range is appeared and it increased 22% respectively. •
- Adding 2.5% superplasticizer named as Ceraplast 300 without VMA the slump range is decreased 8.6% respectively. Thus this workability test is showed the slump value is not satisfied.
- Adding 3%, 3.5% superplasticizer named as Cera Hyperplast XR-W40 with 100% manufactured sand and 10% silica fume. The percentage of slump range has increased at 23% and 30% respectively.

7.1.2.T50 Flow time test variation

This T50 workability test provided for flowability. The no of values varies from trial 1 mixes to trial 7 mixes. The comparison of results is showed below:

- In the trial 1 mix shows the normal SCC value is increased when compared to SCC mixes.
- When the chemical admixture named as Ceraplast 300 is added in trial 2, trial 3, and trial 4 mixes showed performances for SCC. When compared to normal SCC the flow range is increased up to 25% respectively. •
- When the chemical admixture named as Cera Hyperplast XR-W40 is added in trial 5 mix shows the good performance for SCC. When compared to normal SCC the flow range is decreased. But the flow time is satisfied at 4% respectively and trial 6 mixes flow time is higher than trial 6 mixes at 12% .Hence, the flow range is not satisfied. •
- In trial 6 and trial 7 mixes shows the performance for SCC. The flow range is satisfied by increased 3% and 3.7% respectively.

7.1.3.V-Funnel Test Varition

The workability test for V-funnel test is obtained and it shows below:

- Mix SCC 1 and SCC 2 the value varies at higher range 26% and lower range 15%. Thus this workability test value is not obtained. •
- Mix SCC 3 and SCC 4 the value is decreased at 5.2% and let it increased at 36%.Thus this result shows the SCC 4 mix is satisfied. •
- Mix SCC 5, SCC 6 and SCC 7 the percentage was increased at 42% and 57%. Thus this result shows the filling ability test is satisfied.

7.1.4. L Box Test Variation

In this work shows the L-box values and it varies from higher range 56% to lower range 3.3% respectively.

- Finally eight mixes has obtained. But unfortunately the mixes were collapsed at the time of filling ability. Thus two mixes did not provided in L-box test.
- Other mixes are tested and the result of L-box test ranges varies comparing to normal SCC.
- From this work, the L-box values are satisfied in SCC 4, SCC 6 and SCC 7 mixes. Let it is increased in SCC 4 at 46%, then it is decreased in SCC 6 at 10% from SCC 4 i.e.) 46%. Finally SCC 7 mixes increased 56% respectively.

7.2. Mechanical Properties of SCC

7.2.1. Compressive Strength

This experimental work result was discussed and shows the results below:

- Mix normal SCC from the ages of 7th, 14th and 28th days the strength is increased at 40% respectively. •
- Mix 100% M-sand with 10% SF and 0.5% SP to solving the strength beware of SP the strength is reduced at 20% when comparing to Normal SCC the strength is not eligible. •
- Mix 100% M-sand, 10% SF with 1% SP and 1.5% SP the strength at 14th and 28th days required 21%. Thus the strength is not satisfied for M40 grade of concrete. •
- Mix 100% M-sand, 10% SF and 2% SP the strength at the ages of 14th days has increased 30%. Here, in this mixes due to failure of flowability range in 46 trial 1, trial 2 and trial 3 mixes. The name of superplasticizer is changed as well as the strength is increased at 30% in the age of 28th days. •
- Mix 100% M-sand, 10% SF and 2.5% SP shows the strength at ages of 28th days is decreased 5% were comparing to trail 4 mixes. •
- Mix 100% M-sand, 10% SF and 3%, 3.5% SP shows the best result in strength. It indicates the strength at the ages of 14th days and 28th days is increased 40% respectively. Thus the strength is satisfied in trial 6 and trial 7 mixes.

Compressive Strength N/mm²			
100% M-Sand	7 Days	14 Days	28 Days
SCC	22.3	32.4	44.8
SCC 1	13.3	24.6	34.3
SCC 2	19	253	35
SCC 3	16	20	28.6
SCC 4	27.3	32.4	45.3
SCC 5	21.9	24.8	33.6
SCC 6	28.6	38.6	48.2
SCC 7	29	44.2	52.1

7.2.2.Split Tensile Strength

This experimental work result was discussed and shows the results below:

- Let the mixes of Normal SCC. The split tensile strength is appeared at the ages of 28th days in 3.5% respectively.
- The mixes of SCC with SP at 0.5%, 1% and 1.5% at the ages of 7th and 28th day's strength are increased at 50%.Thus this percentage is not required in split tensile.
- The mixes of SCC with SP at 2% and 2.5% at the ages of 7th and 28th days strength are increased at 1.7% when compared to Normal SCC this strength is decreased.48
- The mixes of SCC with SP at 3% and 3.5% at the ages of 28th day's strength are at 5.2%. Let the strength is increased when compared to Normal SCC

Split Tensile Strength N/mm²		
100% M-Sand	7 Days	28 Days
SCC	2.68	3.45
SCC 1	1.54	1.58
SCC 2	1.71	1.90
SCC 3	1.26	1.47
SCC 4	2.96	4.05
SCC 5	1.59	2.65
SCC 6	2.54	3.81
SCC 7	2.86	4.30

7.2.3. Flexural Strength

This experimental work result was discussed and shows the results below:

- Let the mixes of Normal SCC. The Flexural strength is appeared at the ages of 28th days in 3.3% respectively. •
- The mixes of SCC with SP at 0.5%, 1% and 1.5% at the ages of 7th and 28th day's strength are increased at 4.4%.Thus this percentage is not required in flexural strength. •
- The mixes of SCC with SP at 2% and 2.5% at the ages of 7th and 28th days strength are increased at 3.8% when compared to Normal SCC this strength is increased. •
- The mixes of SCC with SP at 3% and 3.5% at the ages of 28th day's strength are at 3.3%. Let the strength is perfect when compared to Normal SCC.

Flexural Strength N/mm²			
100% M-Sand	7 Days	14 Days	28 Days
SCC	2.24	3.12	3.34
SCC 1	1.52	1.64	2.21
SCC 2	1.23	1.45	1.86
SCC 3	1.82	1.56	2.28
SCC 4	2.23	3.24	4.32
SCC 5	1.65	2.53	3.21
SCC 6	2.25	3.32	4.24
SCC 7	3.81	4.22	4.45

VIII. CONCLUSION

Based on the results of this experimental investigation, the following conclusions can be drawn: By laboratory test trials namely slump flow test, the values of w/c ratio was obtained as 0.4 with optimum dosage of SP as 0.5% to 3.5% and VMA as 2.3% by weight of cement respectively. For all mixes, the fresh properties tests were conducted and the obtained values were well within the specifications of EFNARC guidelines. Hence, it was concluded that SCC can be produced with chemical admixture with considerable replacement of cement. In the present work, 10% silica fume with 100% of manufactured sand was the optimum values in terms of strength and economy index. Thus the mix SCC at 100% M-sand got failed. So, the percentage of superplasticizer was increased as 0.5% to 3.5% and constantly 10% of silica fume was added to get strength of concrete. Finally in SCC 4, SCC 6 and SCC 7 got ultimate strength of all tests. Hence the target strength has been satisfied. By replacing the limited amount of cement content in SCC with the cementitious material like silica fume in fixed basis resulting mechanical properties increasing manner with respect to age of the concrete. The investigation reveals that, by utilizing the superplasticizer named Conplast SP 430, Ceraplast 300 and Cera Hyperplast XR-W40 as chemical admixture in SCC to get required fresh properties in economical way. From the experimental results, it can be concluded that the SCC has higher mechanical properties than control mix

REFERENCES

[1] Sheelan M. Hama and Nahla N. Hilal, "Fresh properties of self-compacting concrete with plastic waste as partial replacement of sand" International Journal of Sustainable Built Environment (2017) http://dx.doi.org/10.1016/j.ijsbe.2017.01.001.

[2] Arabi N.S. Alqadi , Kamal Nasharuddin Bin Mustapha ,Sivakumar Naganathan , Qahir N.S. Al-Kadi, "Development of self-compacting concrete using contrast constant factorial design" ,Journal of king saud university- Engineering Sciences(2013)25,105- 112.

[3] Brahim Safi, Mohammed Saidi, Abdel hakim Daoui , Ahmed Bellal , Ali Mechekak , Kamel Toumi, "The use of seashells as a fine aggregate (by sand substitution) in selfcompacting mortar (SCM)" ,Construction and Building Materials 78 (2015) 430–438.

[4] Jinrui Zhang, Xiaoping Ding, Qingxin Zhao, "Experimental and numerical investigation of scattering gravels on the surface bond strength of self-compacting concrete", Construction and Building Materials 145 (2017) 11–19.

[5] Mounir M. Kamal, Mohamed A. Safan, Zeinab A. Etman, Bsma M. Kasem, "Mechanical properties of self-compacted fiber concrete mix" HBRC Journal (2013), http://dx.doi.org/10.1016/j.hbrcj.2013.05.012.

[6] Mutiu A. Akinpelu, Samson O. Odeyemi, Oladipupo S. Olafusi, Fatimah Z. Muhammed, "Evaluation of splitting tensile and compressive strength relationship of self-compacting concrete", Journal of King Saud University – Engineering Sciences (2017), http://dx.doi.org/10.1016/j.jksues.2017.01.002.53

[7] Binu Sukumar, K. Nagamani, R. Srinivasa Raghavan, "Evaluation of strength at early ages of self-compacting concrete with high volume fly ash", Construction and Building Materials 22 (2008) 1394–1401.

[8] Bertil Persson, "Sulphate resistance of self-compacting concrete", Cement and Concrete Research 33 (2003) 1933–1938.9.

[9] Reza Bani Ardalan and Alireza Joshaghani, R. Douglas Hooton, "Workability retention and compressive strength of self-compacting concrete incorporating pumice powder and silica fume", Construction and Building Materials 134 (2017) 116–122. 10. Mohsen Tennich, Mongi Ben Ouezdou, Abderrazek Kallel, "Behavior of selfcompacting concrete made with marble and tile wastes exposed to external sulfate attack", Construction and Building Materials 135 (2017) 335–342.

[10] Praveen Kumar M, Punith Kumar, Ravikiran V, Yogesh J, “Experimental investigation of SCC using m-sand with lime stone as part replacement for cement”, International Research Journal of Engineering and Technology” [IRJET] Vol: 04 Issue: 06 / June-2017

[11] Wang Her Yung , Lin Chin Yung , Lee Hsien Hua, “A study of the durability properties of waste tire rubber applied to self-compacting concrete”, Construction and Building Materials, 41(2013) 665–672

[12] Farid Benmerioul, Abdelkadir Makani, Ahmed Tafraoui, Said Zaouai, “Valorization of the crushed dune sand in the formulation of self-compacting concrete”, Procedia Engineering 171(2017)672-678

[13] Mr. Sanjay raj A , Yogananda N, “Experimental investigation on Self-Curing SelfCompacting Concrete by Replacing Natural Sand by M-sand and Coarse aggregates By 54 Light Weight Aggregate for M-40 Grade Concrete”, International Journal of Scientific and Research Publications, Volume 4, Issue 8, August 2014 1 ISSN 2250-3153

[14] S.S. Vivek, G. Dhinakaran, “Fresh and hardened properties of binary blend high strength self compacting concrete”, Engineering Science and Technology, an International Journal 20 (2017) 1173–1179.

[15] P.A. Ganeshwaran1, Suji2, S. Deepashri, “Evaluation of Mechanical Properties of Self Compacting Concrete with Manufactured Sand and Fly Ash”, International Journal of Civil Engineering and Technology (IJCIET) Volume 3, Issue 2, July- December (2012), pp. 60-69.

[16] M. Benaicha, O. Jalbaud, X. Roguiez, A. Hafidi Alaoui, Y. Burtschell, “Prediction of Self-Compacting Concrete homogeneity by ultrasonic velocity”, Alexandria Engineering Journal (2015) 54, 1181–1191. 18. Gajendra Koli1, V. D. Gundakalle, “Properties of Self Compacting Concrete using GGBS and Manufactured Sand”, International Journal of Research and Scientific Innovation (IJRSI) |Volume III, Issue IX, September 2016|ISSN 2321–2705.

[17] IS: 12269-1987 ‘Specifications for 43-Grade Portland cement’, Bureau of Indian Standards, New Delhi, India.

[18] IS 516:1959. Methods of tests for strength of concrete, New Delhi, India: Bureau of Indian Standard.56

[19] IS: 10262 – 2009, Indian Standard Recommended Guidelines for Concrete Mix Design, B.I.S., and New Delhi.

[20] Shetty M.S., “Concrete Technology – Theory & Practice”, S.Chand & Company Ltd., 2002.

[21] IS: 383 – 1970, Indian Standard Specification for Coarse & Fine Aggregates from Natural Sources for Concrete, B.I.S., New Delhi.

[22] IS: 2386 – 1963 (Part I – VIII), Methods of Test for Aggregates for Concrete