Experimental Investigations on Self Compacting Concrete With Partial Replacement of Fine Aggregrate Using Crumb Rubber

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Abstract- *Parallel to the need for protecting the environment and to preserve natural aggregate by using alternative materials which are recycled or waste materials. hence study on experimental investigations on self-compacting concrete with partial replacement of fine aggregate using crumb rubber becomes essential. his study Self Compacting Concrete mix design are prepared by using EFNARC (for M30 grade of concrete).Furthermore, this study examined the mechanical and durability properties of concrete by partially replacing the fine aggregate by varying weight percentages Crumb Rubber(CR) (0%, 5%, 10%, 15% & 20%) respectively. Tests were done for fresh concrete (i.e. Slump test & U-box) and for hard concrete (i.e. compressive strength, shear strength and Splitting Tensile strength test) for M30 Grade of concrete.*

I. INTRODUCTION

Self-Consolidating concrete (SCC), also referred to as self-compacting concrete with excellent deformability and segregation resistance, was first developed in Japan in 1986.The most popular mix design method used for the self-compacting concrete was introduced by professor Okamura. It is a special kind of concrete that can be used to fill the gaps of reinforcement and corners of moulds without any need of vibration and compaction during the pacing process.

Self-Consolidating Concrete are made using an innovative world renowned technology widely used in the vast field of construction. The increasingly extensive developments in the construction industry throughout the world along with the need for the application of concretes with such qualities as of the SCC, has lead to many studies on such type Of concrete.

This kind of concrete like he common vibrated concrete (CVC) is comprised of cement, aggregate, water and also chemical ad mineral admixtures. Chemical admixture are super plasticizer which usually affects the physical properties of concrete. Mineral admixture consists of pozzolanic powders, used as part of cement replacement. Fly ash (FA), Silica Fume (SF), Limestone powder (LP), Marble powder (MP) is such of these pozzolanic powders, used as part of cement replacement.

1.1: LITERATURE REVIEW

In this literature review the through study of research papers on partial replacement of fine aggregate with crumb rubber

Dr. B. Krishna Rao

In this investigation he did casting and testing of cubes, cylinders, and prisms for M20grade of concrete and added 5% and 10% of crumb rubber fibre by volume of concrete. There the specimens are tested for compression, split tensile and flexural strength. The test results were done and noted that due to addition of rubber fiber, strength of concrete decreases, but as observing ductility is improving. Hence it is used for medium grade of concrete. The various rubberised concrete mixes were designed in accordance with standard mix design mixes incorporating rubber fibre.

1.2 EXPERIMENTAL WORK

- The proposed work presents an experimental study of use of solid waste material (crumb rubber) in concrete by volume variation of crumb rubber.
- One of the important types of remains is waste tyres which have been classified as a part of Municipality soil waste (MSW), result from the increase of vehicle ownership and traffic volume within the Palestinian territories. This eventually well increase consumption of tyres over time.
- Current practices so that residents throw it randomly in different places such as valleys, road side, open area, and waste disposal in improper waste taking the means of open fire, and without consideration of risk on human health and environment.

- The purpose of this project is to investigate Self-compacting concrete with waste crump rubber. So this experiment will show us waste or recycled materials how can they use as an aggregate and results will be satisfied. And Self-compacting concrete's benefits for the future's construction industry. Then we investigate first stage of experiment which is waste and recycled materials.

1.3 METHODOLOGY

Crump rubber is a fine material with the gradation close to that of the sand is produced by mechanical shredding. In this study, size of crumb rubber were used 4.75 micron sieve as a partial substitute for sand (70%) in the production of test specimens (cubes and cylinders).

II. MATERIAL USED AND PROPERTIES

2.1 CRUMB RUBBER

It is the processing of the tire into fine granular or powdered particles using mechanical or cryogenic processes. The steel and fabric component of the tires are also removed during this process. Crumb rubber consists of particles ranging in size from 4.75 mm to less than 0.075 mm Crumb rubber used for the replacement of fine aggregate in concrete. Size of the Crumb rubber used is 24mesh.

Rubberized asphalt is the largest market for crumb rubber in the United States, consuming an estimated 220 millions pounds (100 kg), or approximately 12 millions tries annually. Crumb rubber is also used as ground cover under playground equipment, and as a surface material for running tracks and athletic fields.

Fig.1: Crumb rubber(Waste tyre rubber)

2.2 BENEFITS

When dealing with asphalt overlays, reflection cracks can arise and cause an unwanted crack pattern beneath the pavement. Rubber-modified asphalt uses stress absorbing membranes that reduce the reflective cracking because of its elastic properties. With fewer cracks, there are fewer repairs, so crumb rubber assists in reducing maintenance costs. The pavement has an increased lifespan because after multiple uses and exposure to different elements, regular asphalt loses elasticity over time. The use of the artificial rubber resists the formation of cracks and has an effect that keeps the asphalt in a better condition.

2.3 APPLICATION OF CRUMB RUBBER:

- Tens of millions of tires are discarded across the Middle East every year. Disposal of waste tires is a challenging task because tires have a long life and are non-biodegradable. The traditional method of waste tires management have been stockpiling or illegally dumping or land filling, all of which are short-term solution.
- Crump rubber is a term usually applied to recycled rubber from automotive and truck scrap tires. There are two major technologies for producing crumb rubber – ambient mechanical grinding and cryogenic grinding. Of the two processes cryogenic process is more expensive but it produces smoother and smaller crumbs.

Table 1: Composition of crumb rubber

COMPOSITION	PERCENTAGE
Recoverable rubber	71%
Steel	14%
Fiber	3%
Extraneous material	12%

2.4 SUPER PLASTICIZER

The super plasticizer used in the work is CONPLASTSP 430 is a Sulphonated naphthalene polymer, specific gravity 1.18.

III. EXPERIMENTALINVESTIGATION

In the present investigation, studies were carried out on the fresh and hardened properties of SCC for all the mixes. Experimental work consist casting cubes of size 150mm×150mm×150mm will cast to determine compressive strength, cylinders of size 150mm dia×300mm height will cast to determine split tensile strength.

3.1: RESULTS AND DISCUSSIONS

3.1.1: SPECIFIC GRAVITY OF SAND

Table 2: Observation table:

SL. NO.	W1 Kg	W2 Kg	W3 Kg	W4 Kg	W2-W1 Kg	(W4-W1)-(W3-W2) Kg	(W2-W1)/((W4-W1)-(W3-W2) Kg
1.	0.610	1.615	2.085	1.585	0.787	0.287	2.742
2.	0.625	1.342	2.040	1.585	0.717	0.262	2.736
3.	0.625	1.377	2.063	1.585	0.752	0.274	2.744
AVERAGE							2.741

W1 = Weight of empty pycnometer
W2 = Weight of pycnometer + sand
W3 = Weight of Pycnometer + sand + water
W4 = Weight of pycnometer + water

RESULT:

Specific gravity of sand sample is = 2.741.

3.1.2: SPECIFIC GRAVITY OF CRUMB RUBBER

Table 3: Observation table:

SL. NO.	W1 Kg	W2 Kg	W3 Kg	W4 Kg	W2-W1 Kg	(W4-W1)-(W3-W2) Kg	(W2-W1)/((W3-W2)) Kg
1.	0.610	0.695	1.505	1.480	0.085	0.06	1.42
2.	0.610	0.720	1.330	1.570	0.090	0.05	1.90
3.	0.610	0.740	1.350	1.590	0.078	0.04	1.62
AVERAGE							1.63

W1 = Weight of empty pycnometer
W2 = Weight of Pycnometer + crumb rubber
W3 = Weight of Pycnometer + crumb rubber + water
W4 = Weight of Pycnometer + water

RESULT:

Specific gravity of crumb rubber sample is = 1.63

3.1.3: FINENESS MODULUS OF GIVEN SAND SAMPLE

Table 4: Observation table:

Sieve no	Weight of sample	Weight of sand retained (gm)	Percentage of retention (%)	Cumulative of retention (%)
4.75 mm	20000 gm	0	0	0
2.36 mm		0.245	22.25	22.25
1.28 mm		1.425	70.75	83.00
600 µ		0.255	7.75	90.75
300 µ		0.130	6.50	97.25
250 µ		0.040	2.00	99.25
90 µ		0.010	0.50	99.75
Receiver		0.005	0.25	100
	TOTAL	2000	100	4.823

RESULT:

The fineness modulus of the sand sample = **4.8225**

3.1.4: BULK DENSITY OF SAND

Table 5: OBSERVATION AND TABULATION

TRIAL NO.	W1 in Kg	W2 in Kg	W2-W1 in Kg	Volume in Cu.m.	Bulk Density Kg/m³
1.	3.575	6.750	3.175	0.002	1697.86
2.	3.575	6.650	3.075	0.002	1673.92
3.	3.575	6.683	3.213	0.002	1694.61
AVERAGE					1688.79

W1 – Weight of empty cylinder
W2 – Weight of cylinder + sample
V = Volume of cylinder mould (internal)

RESULT:

Bulk density of given sand = **1680 Kg/m**

3.1.5: SPECIFIC GRAVITY TEST FOR COURSE AGGREGATE

W1 = Weight of container
W2 = Weight of container + coarse aggregate
W3 = Weight of container + Aggregate + Water
W4 = Weight of container + Water

RESULT:

The specific gravity of Coarse aggregate is = **2.596**

3.1.6: PH TEST

The pH value of given sample = **7.0**

3.1.7: CHLORIDE TEST ON WATER

table 6: Observation table:

SL.NO.	VOLUME OF SAMPLE TAKEN (ml)	OBSERVATION			CHLORIDES
		INITIAL BURETTE READING (ml)	FINAL BURETTE READING (ml)	AgNO3 SOLUTION USED (ml)	
Water	20	0	2.3	2.3	**57.09ppm**
Water	20	0	2.1		
Water	20	0	2.5		

RESULT:

The chloride content on the given water = **57.09 ppm**

3.2 FRESH PROPERTIES OF SCC AND THEIR REQUIREMENTS

A concrete mix can only be classified as SCC if the requirements for all the following three workability properties in fresh state are fulfilled (EFNARC, 2002): a) Filling ability: It is the property that characterizes the ability of the SCC of flowing into formwork and filling all space under its own weight, guaranteeing total covering of the reinforcement. b) Passing ability: It is the property that characterizes the ability of the SCC to pass between obstacles gaps between reinforcement, holes and narrow sections, without blocking. c) High resistance to segregation: it is the properly that characterizes the ability of the SCC to avoid the segregation of its components, such as the coarse aggregates. Such a property provides uniformity of the mixture during transport, placement and consolidation. Based on the EFNARC guidelines some of the available fresh property tests such as slump flow, V-funnel, L-box and U-box tests were conducted to evaluate the fresh properties. EFNARC specifications for SCC workability tests are tabulated below

Table 7: Requirements of SCC given by EFNARC guideline

WORKABILITY TEST	UNITS	EFNARC GUIDELINES
Slump flow (dia.)	mm	650-800
U-Box(h2-h1)	mm	0-30
L box(H2/H1)		0.8-1
V funnel (time of flow)	Sec	8-12

Fig.2: SLUMP TEST (Flow test),:T50

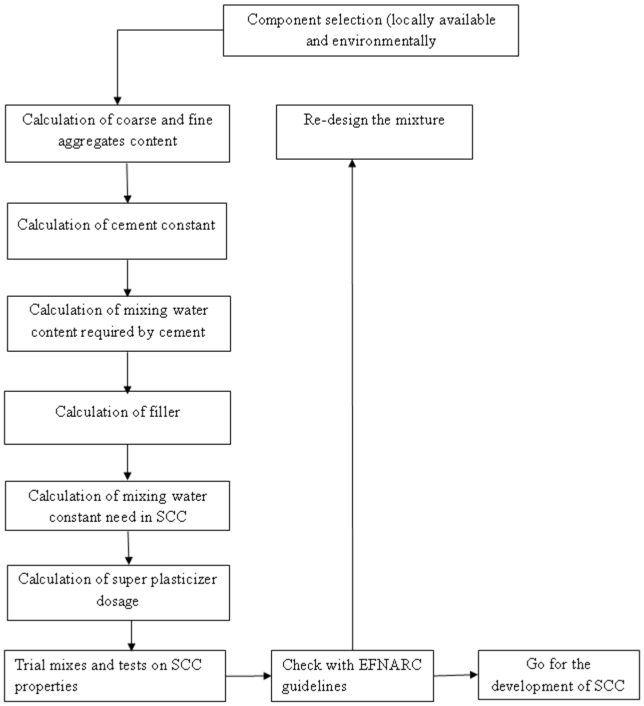
Result:

Slump flow diameter = 730 mm

IV. CONCRETE MIX DESIGN

The adoptable mix design of CC is 1:1.03:2.37 with W/C ratio of 0.375. The mix design of SCC is conducted in a trial basis. With 34 % increase in fine aggregate and 34 % decrease of coarse aggregate in CC mix with same W/C ratio and the addition of 0.4 % of super plasticizer satisfied EFNARC (The European Federation of Specialist Construction Chemicals and Concrete Systems) specifications of SCC mix [8,9]. SP increases the flowing, filling and passing ability of concrete. Four concrete mixes are prepared for both the CRC and SCRC with variation of rubber from 0 to 20%. Two sizes of rubber chips are used for this experiment i.e. 5 and 10 mm.

4.1: FLOW CHART FOR MIX DESIGN PROCEDURE



4.2 MIX DESIGN

Design specification

1. Characteristic Compressive strength (Required in study) at 28-days : 30Mpa
2. Max. size of aggregate: 12.5mm)
3. Degree of workability : up to 0.9(compaction factor)

Steps in the Mix Proportion:

1. Targeted mean strength for M30 grade concrete
fck*= fck + KS
fck* = 30+ 1.65 x 6.0= 39.9N/mm2
Where, Values for K = 1.65 and S=6.0
3. Selecting water % for 12.5mm max size aggregate and the sand lap-up to ZONE -II.
For W/C= 0.6, C.F-0.8, angular, sand lap-up to ZONE-11.
a) Water % per 1m³= 208/m³
b)Sand % total aggregate by absolute volume = 62%
c) C.F = 0.9
4. Determination of cement % = .38
Water=199.2l/m3 =
The cement content = 1 99 .4 kg/ m3
5. Determination of both aggregate contents for the max aggregate size of 12.5 mm, the amount of trapped air in the wet concrete is 3%, taking this in to concern and applying equations for the same.
V= [W/SW+C/SC+ FA/ (P*SFA)]*1/1000;
V= [W/SW+C/SC+CA/ ((1-p)*SCA)]*1/1000;

0.97= [199.24+ (524.31/3.01) FA/ (0.506*2.613)]*1/1000.
FA=788.77kg/m³
0.97= [199.24+ (524.31/3.01) +Ca/ ((1-0.506)*2.625)]*1/1000.
CA=773.06kg/m³.

Conversion to SCC test specimens:

The normal concrete are modified as per EFNARC specifications and different trail mixes are produced. By considering the fresh properties and harden properties of the mixes we finally conclude at the SCC mix proportion:

Cement = 524.31
Fine aggregate = 788.77
Coarse aggregate = 773.06
Total aggregate (T.A.) = 524.31+788.77+773.06 = 1561.83
Let's take 56% of T.A. as F.A. = 199.24 kg/m³
C.A. = 687.2 kg/m³

Table 7: The modified proportion is

CEMENT	SAND	C.A.	WATER
524.31kg	788.77 kg	773.06 kg	199.24
1	1.5	1.47	0.38

(55%) of Fly ash,
(40%) of GGBS ie.108 kg/m³
(1% addition) of silica fumes are used.ie 2.7 kg/m³
(62%) The fine aggregate/Total aggregate.

Table 8: The contents of cement, fly ash, GGBS, silica, fine and coarse aggregate, water

CEMENT	SAND	C.A.	WATER	FLY ASH	GGBS	MICRO SILICA	SP 430 DOSAGE	VMA DOSAGE
1	1.5	1.47	0.38	0.55	0.4	0.01	0.050	0.007

Table 9: description of mixes

SL NO.	MIXES	DESCRIPTION
1.	CM	Using 0% CR
2.	M1	Using 5% CR
3.	M2	Using 10% CR
4.	M3	Using 15% CR
5.	M4	Using 20 % CR

NOTES:
CM- CONTROL MIX
M1- CRUMB RUBBER MIX 1
M2- CRUMB RUBBER MIX 2

M3- CRUMB RUBBER MIX 3
M4- CRUMB RUBBER MIX 4

Table 10: WEIGHT OF CUBES
(FOR 28 DAYS OF CURING)
CONTROL MIX

SL.NO.	SIZES IN mm	WEIGHT IN gm
1.	150X150X150	9.260
2.	150X150X150	98.960
3.	150X150X150	9.100
AVERAGE		**9.107**

Table 11: ADDING 5% OF CRUMB RUBBER

SL.NO.	SIZES IN mm	WEIGHT IN gm
1	150X150X150	8.900
2	150X150X150	8.955
3	150X150X150	8.880
AVERAGE		**8.911**

Table 12: ADDING 10% OF CRUMB RUBBER

SL.NO.	SIZES IN mm	WEIGHT IN gm
1.	150X150X150	9.100
2.	150X150X150	8.990
3.	150X150X150	8.970
AVERAGE		**9.020**

Table 13: ADDING 15% OF CRUMB RUBBER

SL.NO.	SIZE IN mm	WEIGHT IN gm
1	150X150X150	8.850
2	150X150X150	8.960
3	150X150X150	9.050
AVERAGE		**8.953**

Table 14: ADDING 20% OF CRUMB RUBBER

SL.NO.	SIZES IN mm	WEIGHT IN mm
1	150X150X150	8.50
2	150X150X150	8.71
3	150X150X150	8.80
AVERAGE		**8.67**

V. HARDENED CONCRETE TEST

ThehardenedconcretetestisconductedforbothCCandSCCin7,28days.After casting the specimens (cube, cylinder) the curing has been done properly to achieve the target strength. Compressive strength, flexural strength and split tensile strength test were conducted to know the hardened properties of the specimens.

5.1 COMPRESSIVE STRENGTH

Compressive strength is compared with the results obtained from the conventional mix, It was observed that the increase in tensile strength gradually up to 10% replacement of fine aggregate by Crumb rubber and then decreased. The maximum Compressive strength 25.1 N/mm2 are obtained is shown in Fig 4.

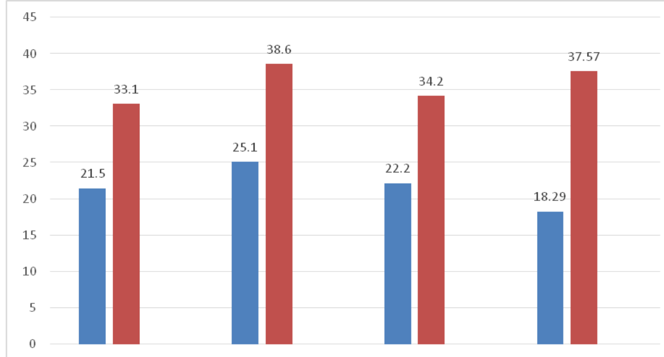


Fig.4: Compressive strength of cube at 7& 28 days

5.2 SPLIT TENSILE STRENGTH

Split tensile strength is compared with the results obtained from the conventional mix, It was observed that the increase in tensile strength gradually up to 5% replacement of fine aggregate by Crumb rubber and then decreased. The maximum split tensile strength 3.9N/mm2 are obtained is shown in Fig 6.

Fig.5: Split tensile strength.

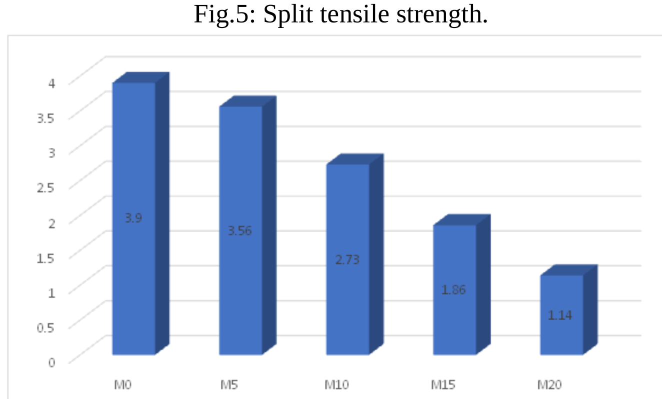


Fig.6: Split tensile strength of cylinder at 28 days

VI. CONCLUSION& REFERENCES

6.1 CONCLUSION

Based on the above studies, the following observations are made regarding to the strength properties of concrete on a partial replacement of fine aggregate by crumb rubber.

1. The maximum compressive strength was obtained as 25.1 N/mm2 at 10% use of crumb rubber in the concrete, which was (38.6 N/mm2) less than the conventional mix.
2. The maximum split tensile strength was obtained as 3.56 N/mm2 at 5% use of crumb rubber in the concrete, which was(3.9N/mm2) less than the conventional mix.
3. When rubber was used instead of aggregates in concrete it shows less compressive strength when compared with ordinary concrete. But it also shows some ductile behaviour before failure.
4. Rubberized concrete shows reduction in density of concrete when compared with control concrete specimen.
5. Concrete made of crumb rubber as fine aggregate shows much strength when compared with concrete made of chipped rubber as coarse aggregate.
6. No appreciable increment in the compressive strength of concrete density by using different percentage of rubber as fine aggregates in concrete.
7. It is recommended to use silica fume in rubberized concrete to increase its compressive strength.
8. It is recommended to use rubberized concrete small structures like road curbs and non-load bearing walls etc.

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