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Benefits of Partial Replacement of Aggregates by Foundry Sand and Waste Rubber in Self Compacting Concrete

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***Abstract*— Concrete manufacturing industry is the main largest consumer of the natural resources present in the world. Annually billion tons of raw materials, cement, sand and water are used in the manufacturing process of concrete. The over usage of natural resources creates imbalance in ecosystem. Therefore to reduce the usage of natural resources, alternative products are used. In present days only few amount of waste tyres are disposed due to the increase of wide usage of tyres for other recycling purposes. The rubber of old tyres is used for new tyres, agriculture, derived fuel, sports applications, and modified asphalt application and in civil engineering applications. The rubber is used as the modified asphalt process is widely recognized and there are so many future scopes for the incorporation of tyres into asphalt. This technology is used in various construction fields. The success rate of this technology is high in the construction of roads in the last 45 years. This rubber asphalt is produced in the one of the processes of recycled tyre rubber modified bitumen. The process is named as "wet process". For some various quality problems, rubber asphalt is used in spite of some drawbacks. In most of the conditions, rubber asphalt is used in the pavement of roads. But due to the improper information, less support to local policies, lack of proper training, the existing technologies are struggling to adopt. In the present study, the main aim is to find out the usage of waste tyre rubber and foundry sand in manufacturing of concrete. And finally support the technology and help for wide usage in construction field. In this project, self-compacting concrete is used as concrete type. It can be placed and compacted under its own weight without vibration effects. This investigation calculates the strength and durability properties of Self-compacting concrete in which natural sand was partially replaced with waste foundry sand. Here there is an improvement in resistance of concrete against sulphate attack and rapid chloride permeability.**

***Keywords:* Recycled Tyre Rubber, Foundry Sand and Rubber Modified Bitumen.**

I. INTRODUCTION

Self-compacting concrete is defined as an innovative concrete which does not require vibration for the purpose of placing and compaction. It can be placed and compacted by its own without any effect of vibration. It was first produced by Japanese in 1987. It reduces the labour and vibration is done to achieve consolidation. Workability and hardened properties are the main properties of self-compacting concrete. It also named as the best revolutionary development in concrete construction for several years. By considering several factors, it has proven that the self-compacting concrete has many beneficiary effects in the construction field. Following factors are mentioned below.

- Reduced noise levels, absence of vibration
- Easier placing
- Greater freedom in design
- Reduction in site manpower
- Faster construction
- Thinner concrete sections
- Safer working environment
- Improved durability
- Better surface finishes

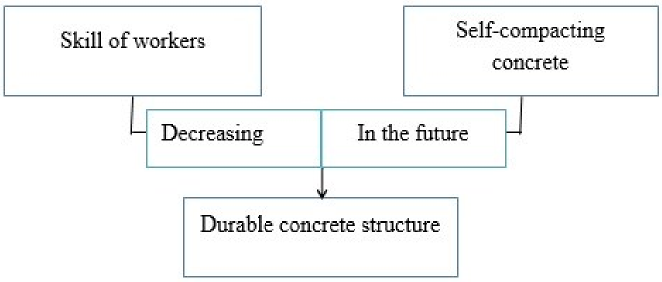

Figure 1: Methodology of self-compacting concrete

There is huge amount of foundry sand and red mud created due to industrialization. Aluminium is used in the manufacturing of red mud which is also termed as industrial wastes and causes threat to environment. It reduces the cost of construction to make concrete structure more durable. In this study following points are evaluated.

1. Study the properties of red mud.
2. Cement is replaced with different percentages of foundry sand.
3. Study the properties of foundry sand.
4. Study the comparativeness.
5. Preparing concrete by blending or by replacing the cement by red mud.

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The foundry sand is dumped for the filling the areas. But it converts agriculture areas into barren area as there is no space for the waste other than land filling. It causes big threat and it is in balance the eco system of the environment. Concrete became cost effective and eco-friendly.

The new technology in the material science is developing rapidly. There are several researches are carried out to increase the strength and performance of concrete. The use of concrete in architectural configurations is growing and the reinforced steel bars which are placed closely have made it essential to produce concrete that provides suitable and proper filling ability, adequate durability and good performance. In recent days, a study was carried out throughout the world to increase the performance of concrete in terms of durability and strength.

Self-compacting concrete is generally a concrete which has the capacity of flowing in to the formwork to fill completely and uniformly by its own weight without vibration and segregation during placing. As there is no standard self-compacting concrete, it has to be designed for the particular constructions. But the basic properties of self-compacting concrete may be proportioned for any type of concrete structure. The properties of self-compacting concrete are plastic viscosity, flow ability, resistance to segregation and deformation. Following performance requirements are considered for establishing an appropriate mixture proportion of self-compacting concrete.

1. Shape
2. Dimensions
3. Construction conditions
4. Reinforcement density

The conditions include placing, transporting, finishing and curing. Capacity is the basic requirements of self-compacting concrete without vibration in fresh state. For the normal concrete structures strength and durability should be established.

Following are the requirements to meet the concrete performance.

A. Power type
B. Viscosity agent type
C. Combination type

A. Power type

By reducing the water-powder ratio, it gives the required self-compact ability and gives resistance against segregation. The required deformation is obtained by super plasticizer and air entraining.

B. Viscosity agent type

By using viscosity modifying admixture, it gives self-compaction and segregation resistance. As in the above process we use air entraining admixtures and super plasticizers.

C. Combination type

In this type, we use both water powder ratio and viscosity modifying admixture to reduce the quality fluctuations of fresh concrete and gradation.

II. LITERATURE REVIEW

Uysal and Sumer R.,et al(28).,in (2011) carried out a numerical and experimental study on properties such as elastic modulus, creep, strength and shrinkage of self-compacting concrete and these properties of normal mix. This study contains eight mix proportions with water to binder ratio varies between 0.22 and 0.80.Half of the mixes were self-compacting concrete and remaining are normal compacting concrete. In 2001, some researchers proposed a mix design method for self-compacting concrete. Here we use U-box, V-funnel, slump flow, L-flow and compressive strength tests to determine the performance of self-compacting concrete. This process is easier, simpler for implementation and less time consumption, and saves cost.

Okamura and Ouchi, et al (26). In 2004 carriedan experimental investigation to determine the performance of self-compacting concrete (SCC) which is prepared by using fly ash. In this experiment, we can determine the mechanical properties such as drying shrinkage and compressive strength.

Table 2.1 Chemical composition of fly ash

Oxides	Percentages
SiO_2+Al_2O_3+ Fe_2O_2	70 min
SiO_2	35 min
Reactive silica	20 min
MgO	05 max
SO_3	03 max
Na_2O	1.5 max
Total chlorides	0.05 max

Yung et al(21)., in (2013) carried out an experimental study on the concept of self-compacting concrete and replacement of waste tyre rubber and foundry sand with sand by conducting various tests as mentioned above.

Khayat K.F.,et al(23)., in (1999) performed an investigation on the self-compacting concrete which is defined as it can be placed and compacted by its own without any effect of vibration. It was first produced by Japanese in 1987.It reduces the labor and done vibration itself to achieve consolidation. Workability and hardened properties are the main properties of self-compacting concrete. It also named as the best revolutionary development in concrete construction for several years.

They also mentioned few advantages with self-compacting concrete that improves the manufacturing process of concrete. Some of the following are mentioned as Energy consumption is decreased, Easier placement of concrete, Man power is also reduced, total time of concreting is reduced, in this process we can achieve faster and more efficient placement of concrete, During placement of concrete, no need of vibration and Even in the congested reinforcement, high bond is obtained between reinforcement and concrete.

Parra et al(27)., in (2011) conducting various investigations which were carried out on cement content in self-compacting concrete which is replaced by various percentages of limestone powder and the hardened and fresh properties of concrete were studied. Limestone can efficiently use as a mineral additive in self-compacting concrete. The compressive strength after the age of 7 and 28 day increased with increase in the limestone content up to 20%.With 20% replacement of cement with limestone powder improves the compressive strength at 28 days. But beyond that percent tends to reduce in the compressive strength of concrete. With the addition of limestone, the hardened properties such as split tensile strength, flexural strength, compressive strength and modulus of elasticity improve.

Paris. Bonen D.A et al(6)., in (1993) By replacing 10% waste foundry sand which is immersed in magnesium sulphate solution gives more compressive strength than standard mix value .But when the percentage of replacement is increased from 15%, the compressive strength tends to decrease when compared with the compressive strength of concrete mix cured in water. Concrete of M30 grade mix which is replaced by 15% of waste foundry sand is observed an increase in compressive strength. Up to 15% replacement provides maximum compressive strength, but beyond that limit strength will be decreased.

III. EXPERIMENTAL TESTS AND RESULTS

A. Materials

The materials used for SCC are selected from those by the conventional concrete industry. Typical materials used for this project work are coarse aggregate, rubber , fine aggregate, foundry sand, cement, mineral admixtures (fly ash), and chemical admixtures (super – plasticizer, viscosity – modifying agents). SCC can be designed and constructed using a broad range of normal concreting materials, and that this is essential for SCC to gain popularity.

B. Experimental Tests

It is important to appreciate that none of the test methods for SCC has yet been standardized and the test described are not yet perfected or definitive. The methods presented here test procedures are descriptions rather than fully detailed procedures. They are mainly ad-hoc methods, which have been devised specifically for SCC.

Existing rheological test procedures have not been considered here, through the relationship between the results of these tests and the rheological characteristics of concrete is likely to figure out highly in future work, including standardization work. Many of the comments made come from the experience of the partners in the EU-funded research project on SCC.A further EU project on test methods is about to far dessert .In considering these tests, there are number of points which should be taken in to account.

- One principal difficulty in devising such tests is that they have to assess three distinct, though related, properties of fresh SCC-its filling ability (flow ability), its passing ability (free from blocking at reinforcement), and its resistance to segregation (stability). No single test so far devised can measure all three properties.
- There is no clear relation between test results and performance on site.
- There is little precise data, therefore no clear guidance on compliance a limits.
- Duplicate tests are advised.
- The test methods and values are started for maximum aggregate size of up to 20 mm; different test values and for different equipment dimensions may be appropriate for other aggregate sizes.
- Different test values may be appropriate for concrete being placed in vertical and horizontal elements.
- Similarly different test values may be appropriate for different reinforcement densities.

C. SCC Test Procedure:

The replacement levels of waste foundry sand with fine aggregate by weight is mentioned in the table. The w/p ratio varies between0.48-0.38.To calculate proportions of fresh concrete by using V-funnel, U-box and L-box. These tests are performed to evaluate properties of hardened concrete compressive strength test, sulphate resistance, rapid chloride permeability tests and splitting tensile strength.

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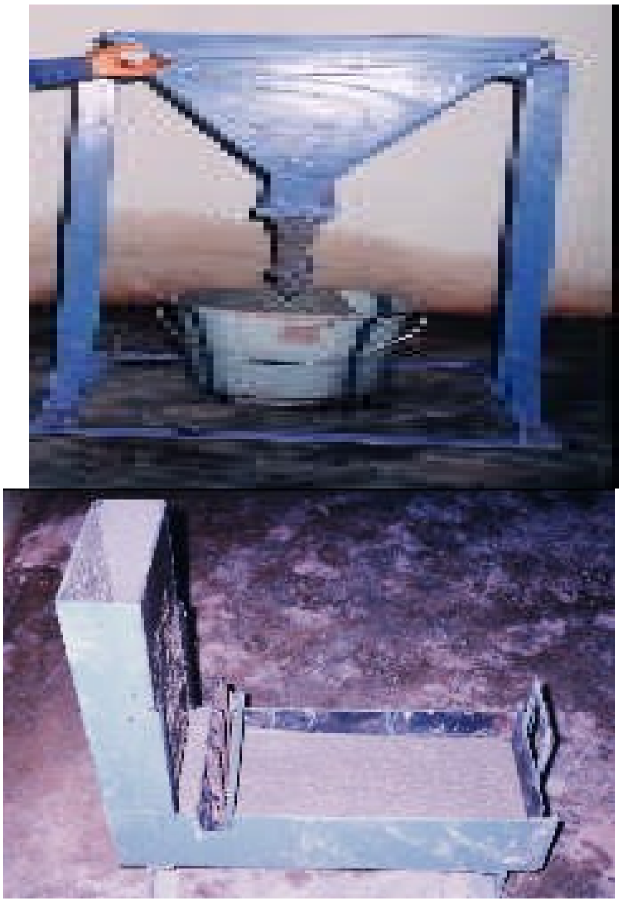

Figure 1 all test procedures

D. Slump Flow Test

The slump test is used to measure the horizontal free flow without abstractions of self-compacting concrete. For the ability of filling of the concrete, the diameter of the concrete circle is measured.

Apparatus

1. Trowel
2. Scoop
3. ruler
4. Stop watch

Procedure

- Minimum 6 litre of concrete is used in the test.
- The base plate and inside of slump cone are get moisture.
- Base plate is placed on the level stable ground and hold firmly.
- Fill the cone with scoop and remove the additional concrete from around the base of the cone.
- The cone was raised vertically and allows the concrete to flow freely.
- Record the time taken to reach 500mm spread circle for concrete by using stopwatch.
- Calculate the final diameter in two perpendicular directions of the concrete and calculate the average of two diameters

Figure 4.2 Slump test

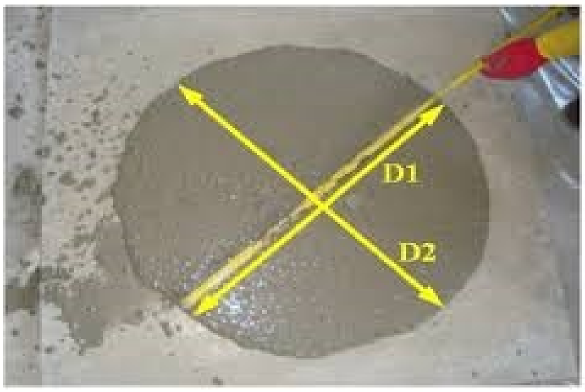

Figure 4.3 Slump measured diameters

Table 4.1 Slump flow test results

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Percentage of foundry waste sand	Slump flow (mm)	Time in (sec) T_{50}
0	670	4.8
1	670	4.8
2	650	4.8
3	640	4.8
4	720	4.2
5	670	5.2
6	620	9.6
7	670	4.8
8	520	14.1

L-Box Test:

The test is used to assess the flow of the concrete. The experiment consists of an L-shaped rectangular section box with a horizontal and vertical section which is divided by a movable gate.

The concrete is filled in the vertical section of the apparatus and flow into the horizontal section after the gate lifted. The height of the concrete at the end of horizontal section after the flow has stopped is defined as a proportion of remaining in vertical section. It defines the slope of the concrete at rest.

Apparatus

1. Trowel
2. Scoop
3. L box of a stiff non absorbing material
4. Stop watch

Figure 4.4 L-box test

Table 4.2 L - box test results

Percentage of foundry sand	Height H_1	Height H_2	Blocking ratio H_2/H_1	Time 200 mm (T_{20}) (sec)	Time 400 mm (T_{40}) (sec)
0	80	65	0.813	9.23	15.9
1	75	66	0.87	6.30	10.5
2	81	75	0.95	3.84	6.6
3	70	61	0.88	4.60	8.8
4	71	60	0.83	5.29	9.4
5	75	54	0.76	5.54	11.2
6	85	49	0.68	6.29	13.5
7	83	33	0.40	7.29	15.7
8	95	14.8	0.17	9.41	25.4

U-Box Test:

U-box test method is also known as box shaped test. This test is used to measure the ability of filling of self-compacting concrete. It consist a vessel parted by a middle wall into two divisions. Between the two sections an operating sliding gate is provided. Reinforced steel bars with diameter of 1.3 cm are installed at the gate with centre to centre spacing 5cm.It provides spacing of 3.5 cm between the bars. The concrete of

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20 litres is filled in left hand section and then the gate lifted; concrete flows upward into the other section.

Apparatus

1. Trowel
2. Scoop
3. U box of a stiff non absorbing material
4. Stop watch

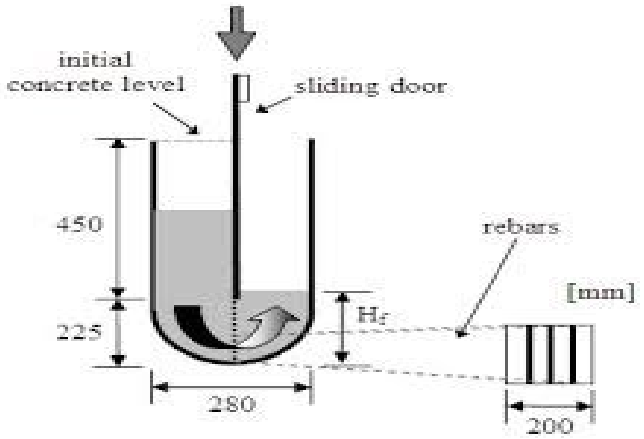

Figure 4.5 U-box test

V- Funnel Test:

The V-funnel test is used to determine the ability of filling of the concrete with aggregate size of 2 cm. The concrete of 12 litres is filled in the funnel and measure the time taken for it to flow through the apparatus measured. Again fill the funnel with concrete and leave it for 5 minutes to settle down. After the segregation, the flow time will increase significantly.

Apparatus

1. Trowel
2. Scoop
3. V funnel
4. Stop watch
5. Bucket

Figure 4.6 V- funnel test

Table 4.3 V- funnel test results

Percentage of foundry waste sand	Flow time (sec)
0	8
1	8
2	9
3	9
4	10
5	10
6	10
7	11
8	11

Table 4.4 Acceptance criteria for SCC (As per EFNARC Guidelines)

S. No	Method	Unit	Typical range of values	
			Minimum	Maximum
1.	Slump flow test	mm	650	800
2.	T_{50}cm slump flow	Sec	2	5

3.	V-funnel test	Sec	6	12
4.	V-funnel at T_5minutes	Sec	6	15
5.	L-Box test	H_2/H_1	.8	1.0
6.	U-Box test	(H_2-H_1)mm	0	30

Table 4.5 Overall results of flow test

Description	L-box value(mm)	Slump flow (mm)	v-funnel time(sec)
SCC I	0.81	670	8
SCRC I	0.87	670	8
SFRSCRC I	0.95	650	9
SCC II	0.88	640	9
SCRCII	0.83	720	10
SFRSCRC II	0.76	670	10
SCC III	0.68	620	10
SCRC III	0.40	670	11
SFRSCRC III	0.17	520	11

IV. CONCLUSION

By replacing fine aggregates with waste foundry sand, compressive strength of concrete mix is increases. This compressive strength is suitable for structural uses. Concrete of M30 grade mix which is replaced by 15% and 10% of waste foundry sand is observed an increase in compressive strength, split tensile strength. Up to 15% replacement provides maximum compressive strength, but beyond that limit strength will be decreased. With the increase of age of concrete, compressive strength also increased. We find higher compressive strength which replaced with waste foundry sand when compared with the concrete mix with no replacement.

In split tensile strength test, there is an increase in the strength for the concrete replaced with waste foundry sand at various percentages.

By replacing 10% waste foundry sand which is immersed in magnesium sulphate solution gives more compressive strength than standard mix value .But when the percentage of replacement is increased from 15%, the compressive strength tends to decrease when compared with the compressive strength of concrete mix cured in water. If the specimen is subjected to the process of wetting for long duration leads to strength loss. The project work carried out for extent needs. With the increase of waste foundry sand content, there is an increase of chloride permeability resistance.

The resistance is a decrease with the increase in waste foundry sand of 15% indicates denser concrete. This effect works up to 15% replacement. At 20%, there is slight increase but less than control mix. Replacement of chipped rubber with coarse aggregate provides decrease in the density of concrete strength compared to control mix. But there is an increase in ductility before the failure of the specimen.

Concrete mix which replaced with crumb rubber shows considerable increment when compared with the concrete which replaced with chipped rubber to sand. The resistance is a decrease with the increase in waste foundry sand of 20% indicates denser concrete. This effect works up to 20% replacement. At 20%, there is slight increase but less than control mix. If the specimen is subjected to the process of wetting for long duration leads to strength loss. The investigation carried out for extent needs.

V. FUTURE SCOPE

The following are the future scope for the self-compacting concrete.

The impact of addition of foundry sand on the characteristics of durability more than three admixtures of self-compacting concrete. Less than three admixtures with foundry sand are contains in the effect of high temperature on the properties of self-compacting concrete. More than two admixtures are contains in the effect of addition on the shrinkage and creep properties of self-compacting concrete to reduce the problems of environmental attack, there are lot of mineral admixtures which are the wastage of the industry.

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