Self Compacting Concrete Using Recycled Bituminous Road Aggregates

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Abstract- *Self compacting concrete or self consolidating concrete has high potential application for congested reinforcement member with good workability. Self compacting concrete (SCC) is normally being used for construction of high rise buildings and industrial structures. This paper presents the methodology and test to be performed on self compacting concrete prepared by combination of natural coarse aggregate (NCA) and recycled bituminous road aggregate (RBRA). The study has to be conducted in order to find out the amount of percentage of coarse aggregate to be replaced by RBRA and also to find out the alteration in the fresh and hardened properties of self compacting concrete with such combinations. The study also help us to investigate, what will be the effect on self compacting concrete if some percentage of cement is replaced by fly ash. The overall aim is to find out the percentage to which replacement of NCA with RBRA can be raised in order to get concrete of desired strength without much alteration in its properties.*

Keywords- Natural coarse aggregates, Recycled bituminous road aggregates, Fresh properties, Harden properties.

I. INTRODUCTION

In construction industry concrete is one of the widely used materials, it is usually related with Portland cement as main ingredient in making concrete. The demand for concrete is increasing day by day in construction industry. Often admixtures and reinforcements are added in the mix to achieved the desired properties and finished products. Concrete is produced by mixing cement, sand, coarse aggregate and water to produce a material that can be molded into almost any shape. The aggregate in concrete comprises about 65 – 75% of total volume. Over time, cement forms a hard matrix like structure which binds all the material together to form a stone like material. With time many development took place in the field of concrete out of which self compacting concrete is one.

Various researches in the field of concrete have proved that proper material selection and mix design of concrete can provide good compaction without any need for vibration. This type of concrete is known as self compacting concrete and is widely used in precast and cast-in-place construction. Self compacting concrete has gained huge industrial interest since its introduction in Japan in1990. Due to its excellent flowing and segregation resistance property, self compacting concrete has been used for many different purposes which include construction of bridges, precast bridge members, pavement repairing works etc. As concrete technology gets matured in producing self compacting concrete its use will become more common. Use of self compacting concrete increases the speed of construction, provide a good quality concrete without segregation and loss of air, reduces cost of labour and energy and minimizes the environmental impacts.

In today's world where we are facing shortage of natural resources, its very problematic and difficult to obtain natural aggregates at reasonable cost. Meanwhile the increasing quantity of demolished bituminous material from road reconstruction and repairing projects is generally dumped in land and is completely waste. Hardly 10% of it is reused. Rest is just used as landfill and does not represents the suitable use of bituminous pavement material. Recycling of bituminous material didn't become a common practice until early 1970s. When bitumen binder prices sky rocketed as a result of Arab Oil Embargo. Scientist reacted to this situation by developing recycle method to reduce demand of bitumen binder and thereby reducing the cost of bitumen paving mixture. Many practices have been developed from that time and are still in use today and have become routine part of pavement construction and rehabilitation. Economical benefits involves reducing material cost from recycling the old aggregate with fresh aggregate. It is never been tested as a coarse aggregate in concrete. In recent researches it has been observed that part of coarse aggregate can be replaced by RBRA.

II. MATERIALS

Cement

Any cement with requirement according to the Indian standards is suitable for self compacting concrete. The choice of cement depends upon strength requirement, durability and minimum amount of fines required for the mix. However cement to be used need to have compatibility with the super plasticizers used.

Fly ash

Fly ash is available in two types as per the specification of IS : 3812-2000. Grade 1 with blains fineness greater than 320 m^2/kg and Grade 2 with blains fineness not greater than 250 m^2/kg. Fly ash contributes to the formation of excellent mortar, which helps in maintaining coarse aggregate in suspension . Fly ash produces concrete with dark grey colour characteristics. Normally both Grade 1 and Grade 2 fly ash can be used for preparation of self compacting concrete but most preferable is Grade 2 fly ash because of its fineness.

Fine Aggregate

Sand plays a crucial role in preparing self compacting concrete. Its help to fill the voids between the powder and coarse aggregate. That's why well graded sand from particle size point of view must be used in order to fill as much voids as possible. Sand with less than 150 micron may help in increasing cohesion and thereby resisting segregation. Instead of river sand, man made sand also called as Robo – sand can also be used in preparing self compacting concrete. Sand is available in 4 grades – Zone 1, Zone 2, Zone 3 and Zone 4. For preparing self compacting concrete Zone 1 or Zone 2 sand are mostly preferred.

Coarse Aggregate

Coarse aggregate are the major component which gives dimensional stability to the concrete. Among different properties of aggregate, the most important one for self compacting concrete are shape and gradation. It has been observed that lower cement content is achieved when rounded aggregate are used as compared to angular aggregates. Other than this rounded aggregate also provides better flow and less blocking potential for given water powder ratio as compared to angular aggregates. Flaky and elongated particles causes blockage problems in narrow and confined areas.

Recycle Bituminous Road Aggregates (RBRA)

After demolition of bituminous roads only 10-15% of these old aggregates are reused in constructing new roads and rest of the aggregates are wasted. Recycling these road aggregates with the aim to reduce natural aggregate usage and to reduce the cost is the main objective. Generally angular or natural aggregates are preferred for preparing self compacting concrete. Flaky and elongated particles caused blocking problem in narrow areas.

Super Plasticizers

Super plasticizers are very essential for improving flow characteristics and workability retention. Super plasticizers are available in three types in local market namely Melamine based super plasticizers, Naphthalene based super plasticizers and Poly-Carboxylated Ether based super plasticizers. Any of these super plasticizers can be used in preparing self compacting concrete. The main job of these super plasticizers is to improve the flow and cohesion of concrete, avoid excessive air entrainment in concrete and provide high workability of concrete.

III. EXPERIMENTS AND TESTS ON FRESH CONCRETE

Concrete is generally named as self compacting concrete only when it fulfills the three characteristics that is filling ability, passing ability and resistance to segregation.

Filling ability: The ability of the concrete to flow and fill all the spaces within the formwork, by its own weight.

Passing ability: The ability of the concrete to flow through narrow spaces without blocking and segregation.

Segregation resistance: The ability of the concrete to maintain its homogeneous composition during placing and transportation.

There are many test to characterize the self compacting concrete according to the above properties.

List of Test Methods On Fresh Properties Of Self Compacting Concrete

Method	Property
Slump-flow by Abrams cone	Filling Ability
T_{50cm}slumpflow	Filling Ability
J-ring	Passing Ability
V-funnel	Filling Ability
V-funnel at T5minutes	Segregation Resistance
L-Box	Passing Ability

Slump flow and T500 mm slump flow

Slump flow test is used to find the horizontal free flow of self compacting concrete without any obstruction. The results indicates the filling ability of self compacting concrete. The T500 time is used to measure the viscosity of self compacting concrete. The procedure for slump cone test is similar to the slump test conducted for the normal concrete. After filling the mould with fresh concrete, raise the mould vertically up with steady upward lift. As the cone is lifted start the stop watch and stop when the concrete flow reaches 500mm mark on the base plate. Wait for concrete flow to stop and then measure the largest diameter of circular spread of concrete (d1). Measure a second diameter of the circular spread of concrete at an angle perpendicular to d1 (d2). Slump flow is calculated using formula – Slump Flow = (d1 + d2) / 2.

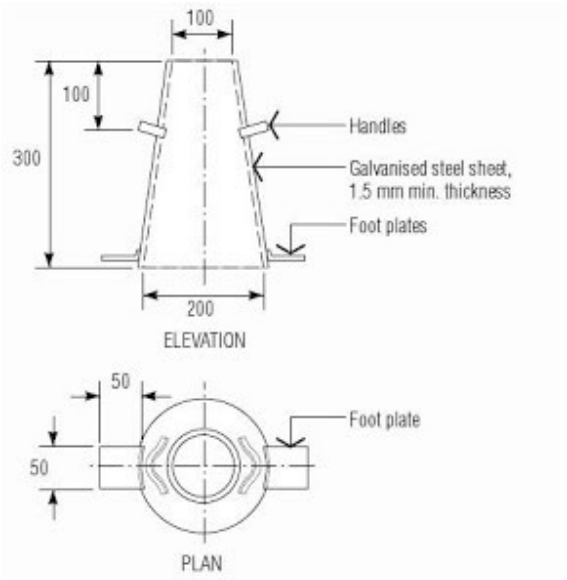

Fig.1. Abram's slump cone to determine horizontal flow

V – Funnel test

V – Funnel test is basically conducted to check the flow ability of concrete. The funnel is filled with about 12 litre of concrete and then the time taken for it to flow through the funnel is noted down. Generally a flow time of less than 6 second is recommended for concrete to be called as self compacting concrete. Another parameter known as T5is used to study the susceptibility of concrete to segregate. In this test the funnel is refilled and is left for 5 minutes and concrete is allowed to settle. After 5 minutes the knob is opened and time taked by the concrete to leave the funnel is noted down. The T5time should not be more than 3 seconds to that of V – Funnel time at zero minute.

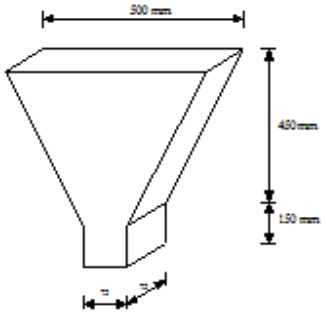

Fig.2. V – Funnel

J – Ring test

This test is basically done to determine the passing ability of self compacting concrete mixture. Fresh concrete is poured into a mould in shape of a frustum of a cone placed in the centre of a J – ring. When cone is lifted upward, the concrete is allowed to pass through the J – ring bars thus providing a measure of the filling ability and passing ability of concrete. After the concrete stops flowing, the difference in the height between the concrete inside and that just outside the J – ring is measured. This indicates the passing ability of the concrete. The combination of slump flow test and J – ring helps to find both the flowing ability and passing ability of the concrete.

Fig.3. J-Ring

L – Box test

L – box test is also one of the test used to determine the flow of concrete and also extent to which it is subjected to blocking by reinforcement. The fresh concrete of about 12.7 litres is filled in the vertical part of the L- box and is allowed to rest for about one minute. Then the slide gate is lifted and the concrete is allowed to flow into the horizontal part. On its way it has to pass through sets of vertical reinforcement bars. When the flow of concrete stops completely the height H1 and H2 are measured. The ratio H2 / H1 also called as blocking ratio is calculated and its value should be less than 0.8. Both passing ability and segregation resistance can be determined

by this test. If the concrete gets accumulated in front of the reinforcement bars the concrete is either blocked or segregated. Passing ability is generally displayed by coarse aggregate gathered between the reinforcement bars.

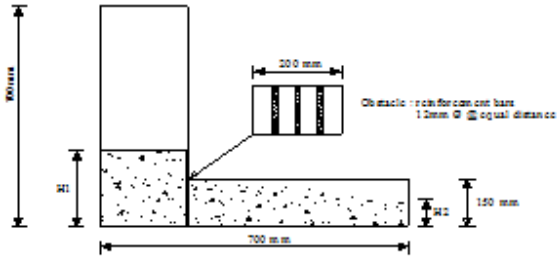

Fig.3. L. Box

IV. TESTS ON HARDEN CONCRETE

Strength of the concrete is one of the most important criteria based on which its use is defined. In order to be used anywhere in construction the self compacting concrete should have required design strength.

Compression Strength Test

Self compacting concrete should have high flow ability but should be enough cohesive to resist segregation. Higher compressive strength is achieved by lowering the water cement ratio. Compression test develops a complex system of stresses by inducing a tangential force between the end surfaces of the concrete specimen and the steel plates of the machines. The cube of size 150mm *150mm *150mm should be casted and curing should be done according to the required time. After curing, the cubes should be tested for compression load on compression testing machine. The rate of loading should be 140 kg / sq cm / min, and load is applied gradually over the cube until the specimen fails. The failed cube is removed and the strength of the cube is noted down.

Fig.5. ***Compression Testing Machine***

V. CONCLUSION

Above are the methods that can be used in determining the fresh properties and hardened properties of self compacting concrete. The result obtained from these tests and experiments will help us to fix the percentage of natural aggregates that can be replaced by recycled bituminous road aggregates (RBRA) without compromising the desired strength and properties of self compacting concrete. Recycling the waste road aggregates will also lead to sustainable development approach and will also help in reducing the overall cost of the project.

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