International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 9 Issue 4 ǁ 2021 ǁ PP. 65-73

Effect of Recycled Coarse Aggregate on Fresh Properties Of Self Compating Concrete

Sushmita Sinha[1] Mrs. Shraddha sharma[2]
[1]*Student, M.Tech Structural Engineering, Bhilai Institute of Technology Durg (C.G.) India*
[2]*Associate professor, Department of Civil Engineering Durg (C.G.) India*

Abstract: *This paper gives you view to study the properties by using Recycled concrete aggregate as partial replacement for natural coarse aggregate on the properties of Self Compacting Concrete (SSC) in fresh state with different proportions. SCC is a type of concrete which have a very good deformability and segregation resistance, was first developed at Japan in 1980. SSC is able to flow under its own weight and can completely fill the formwork even within congested reinforcement. Studied on the usage of recycled concrete aggregate obtained from stamp out concrete for making of SCC, and additionally emphasizing its ecological value. In experiment, three types of concrete mix were made, where the percentage of substitution of coarse aggregate by recycled aggregate was 0%, 25% and 50% is varied. Determined the influence of different proportion on the performance of concrete made with coarse recycled aggregate from stamp out concrete. The properties analysed in fresh state using slump flow test, J-ring, v-funnel, L-shape apparatus. This review paper explains the utilization of Recycled concrete aggregate in properties of Self Compacting Concrete. SCC is type of concrete with very high level of homogeneity; minimize the concrete void spaces and have uniform concrete strength and also provides the superior level of finishing and durability of structure. SCC also achieves all same engineering properties and durability as the traditional vibrated concrete we use on construction. The use of SCC has gained extensive acceptance in recent years.*

Keyword: Self compacting concrete (SSC), Recycled coarse aggregate (RCA), Fresh properties, Coarse Aggregate (RA), Durability.

Date of Submission: 20-03-2021 Date of acceptance: 04-04-2021

I. INTRODUCTION

Reinforced concrete is one of the most extensively used materials in different types of material. The demand increasing day by day for reinforced concrete structures in the modern society to meet the needs of new developments due to increasing population and new ambitious structural design ideas, the reinforcement in concrete structures is becoming more dense and congregate. The massive and dense reinforcement can raise problems of pouring and compacting the concrete during placing. The concrete must be able to pass the dense rebar arrangement without obstructing or segregating. The design of such type of concrete is very challenging because it have poor placement quality and the lack of good vibratory compaction can lead to the inclusion of voids and loss of long term durability of concrete structures. This has been a concern for engineers for many years due to such type of problem.

SCC has favourable characteristics such as high fluidity, good segregation resistance and the distinctive self compactability without any need for vibration during the placing process and so noiseless construction. The unique characteristics of SCC are a rapid rate of concrete placement which take very less time. SCC offers a very high level of homogeneity; minimizes the void ratio between concrete and have uniform concrete strength and also it provides the superior level of durability and finishing of structure. Self compacting concrete also achieves same type of properties and durability as traditional vibrated concrete. During the last decade, concrete technology has made an extensive use advance through the introduction of self-compacting concrete (SCC). Self-compacting or self-consolidating concrete is a new generation of high-performance concrete. Recycled aggregates (RA) are produced from the re-processing of mineral waste materials, construction and demolition waste are largest source. In general, the quality of Recycled aggregate is almost near to those of natural aggregates we use. The density of the natural aggregate is higher than recycled aggregates and natural aggregate have a lesser water absorption value compared to recycled aggregates. By proper mix design we can obtain the desired qualities for concrete made with Recycled aggregate.

1.1 Self-compacting concrete definition

The British Standard (BS EN 206-9, 2010) defines "SCC is the concrete that is able to flow and compact under its own weight, fill the formwork with its reinforcement, ducts, boxouts etc., whilst maintaining homogeneity".

Other researchers (Ozawa et al., 1989; Bartos and Marrs, 1999; Khayat, 1999) have defined SCC in almost the same terms as a highly flow-able concrete that should meet the following requirements:

- **Flow-ability**: SCC should flow under its own weight and fill all parts of formwork without any external aid Or vibration.

- **Passing ability**: SCC should pass through heavy reinforcing steel bars.

- **Segregation resistance:** SCC should maintain its homogeneity without any migration or separation of its large components (aggregates or/and fibres).

1.2 Fresh state properties of self-compacting concrete

Deformability (flow and filling ability)

Deformability refers to the ability of SCC mix to deform and undergo changes in shape with completely filling all areas and corners of the formwork horizontally and vertically while maintaining its homogeneity. The deformability of SCC is characterized by the concrete's fluidity and cohesion, and mainly assessed using the slump flow test described later.

Kennedy (1940) proposed the 'Excess Paste Theory' as a way to explain the mechanism governing the workability of concrete. Kennedy states that there must be enough paste to cover the surface area of the aggregates, and that the excess paste serves to minimize the friction among the aggregates and give better flow-ability. Without the paste layer, too much friction would be generated between the aggregates resulting in extremely limited below workability.

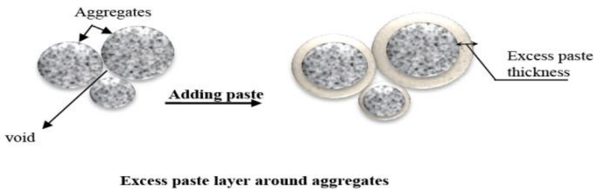


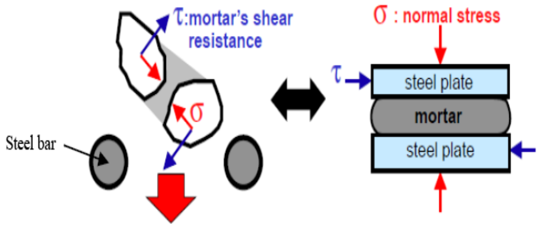
Fig-1: The formation of cement paste layers around aggregate

Passing ability

Passing ability refers to the ability of SCC mix to pass through congested reinforcement without blocking, whilst maintaining good suspension of coarse particles in the matrix, thus avoiding arching near obstacles and blockage during flow. The J-ring and L-box tests are the most common methods used to assess this property.

The probability of blocking increases when the volume fraction of large aggregates and/or fibers increases. The size of aggregates, their shapes and their volume fraction influence the passing ability of SCC, moreover, the presence of fibres especially long and hooked or crimped ends make self-compacting fiber reinforced concrete (SCFRC) more difficult to pass through reinforcement.

Okamura and Ouchi (1999) reported that the potential of collision and contacts between particles increases as the distance between particles decreases; which therefore results in an increase in the internal stresses when concrete is deformed, particularly near obstacles causing blockage. Research shows that the energy required for flowing is consumed by the increase of internal stresses. Limiting the coarse aggregate content whose energy consumption is high can effectively reduce the risk of blockage. Figure shows how normal stress can be generated due to the approach of coarse aggregate particles near obstacles.



Normal stress generated in mortar due to approaching coarse aggregate particles (After: Okamura and Ouchi, 1999)

Fig-2: Normal stress generated in mortar due to approaching Coarse aggregate

Highly viscous paste also prevents localized increases in internal stress due to the approach of coarse aggregate particles (Okamura and Ouchi, 1999) and therefore increases the passing ability of SCC. Roussel et al. (2009) state that highly fluid SCC could be more prone to have its coarsest particles blocked in highly reinforced zones, which is related to the instability of the material, and to the increases in the local volume fraction of coarse aggregates near an obstacle as shown in Figure in this case, the material is too fluid to carry its own particles during the flow.

Blocking can be also increased as the gaps between steel bars are reduced. The spacing between bars is typically recommended to be 3 times the maximum aggregate size (EFNRC, 2005). For fibre-reinforced concrete, the bars should be placed 1 to 3 times the maximum fibre length (Koehler and Fowler, 2003).

Segregation resistance (homogeneity/cohesiveness)

Segregation resistance refers to the ability to retain the coarse components of the mix and the fibres in suspension in order to maintain a homogeneous material. Stability is largely dependent on the cohesiveness and the viscosity of the concrete mixture which can be increased by reducing the free water content and increasing the amount of fines (Khayat et al., 1999).

Segregation resistance is largely controlled by viscosity; therefore ensuring a high viscosity can prevent a concrete mix from segregation and/or bleeding. Bleeding is a special case of segregation in which water moves upwards by capillary action and separates from the mix. Some bleeding is normal for concrete, but excessive bleeding can lead to a decrease in strength, high porosity, and poor durability particularly at the surface (Douglas, 2004).

Two basic methods can ensure adequate stability; the first approach is based on the Japanese method. It uses a super-plasticizer (SP), low water/cement ratio, high powder content, mineral admixtures, and low aggregate content. The second approach is based on incorporating a viscosity-modifying admixture (VMA), low or moderate powder content and super-plasticiser (Bonen, 2004).

1.3 RECYCLED CONCRETE AGGREGATE

Recycled concrete aggregate (RCA) is a construction material, which is being used in the Canadian construction industry more frequently than it was in the past. The environmental benefits associated with RCA use, such as reduced landfilling and natural aggregate (NA) quarrying, have been identified by industry and government agencies. This has resulted in some incentives to use RCA in construction applications. Some properties of RCA are variable and as a result the material is often used as a structural fill, which is a low risk application. The use of RCA in this application is beneficial from an overall sustainability perspective but may not represent the most efficient use of the material. Efficient use of a material means getting the most benefit possible out of that material in a given application. The initial step in efficient material use is evaluating how a material affects its potential applications. In the its use in concrete as a coarse aggregate.case of RCA, this includes RCA is made up of both aggregate and cement mortar from its original application. Its make-up results in absorption capacities, which are higher than NA. Its high absorption capacity indicates that RCA can retain a relatively large proportion of water. Internal curing of concrete is the practice of intentionally entraining reservoirs of water within concrete. This water is drawn into the cement at a beneficial point in the cement hydration process. This water allows for a more complete hydration reaction, less desiccation, a less permeable concrete pore system, and less susceptibility to the negative effects of poor curing. The potential for RCA to act as an internal curing agent was evaluated in this research.

II. LITERATURE REVIEW

Khayat, 1999 – Main quality of self compacting concrete is Stability and flow-ability are. That we can achieve by limiting the coarse aggregate content, the reducing water-powder ratio and maximum aggregate size together with using super-plasticizers (SP) (Okamura et al., 1998). At the time transportation and placement of SCC the increased flow-ability may cause bleeding and segregation which can be overcome by enhancing the viscosity of concrete mix, this is usually supplied by using a high volume fraction of paste, by limiting the maximum aggregate size or by using viscosity modifying admixtures (VMA).

Lewis et al., 2003; Domone and Illston, 2010 - The most common recycled concrete material used are ground granulated blast furnace (GGBS), micro-silica or silica fume (SF) and pulverised fuel ash or fly ash (FA). All CRMs have common features like; their particle size is smaller or the same as Portland cement particle and they become involved in the hydration reactions mainly because their ability to exhibit pozzolanic behaviour. By themselves, pozzolans which contain silica (SiO2) in a reactive form, have little or no cementitious value. However, in a finely divided form and in the presence of moisture they will chemically react with calcium hydroxide at ordinary temperatures to form cementitious compounds.

Uysal and Sumer, 2011; Boukendakdjia et al., 2012; Dinakar et al., 2013 - Ground granulated blast-furnace slag is a by-product from the blast-furnaces used to make iron. It has been used in many countries around the world by achieving many technical benefits in construction industries.

Russel, 1997 - Adding Ground granulated blast furnace to self-compacting concrete offers many advantages related to increasing its workability, compactibility and retaining it for a longer time, while protecting cement against both sulphate and chloride attack. Because GGBS has 10% lower density than Portland cement, replacing an equal mass of cement by GGBS will result in a larger paste volume, which substantially increases the flow-ability and segregation resistance.

Oner and Akyuz, 2007 - In their experiments on 32 different mixtures of SCC containing ground granulated blast furnace, indicated that increase in GGBS content, decreases water-to-binder ratio for the same workability and thus GGBS has a positive effect on the workability. They proved further that the strength gain is better when we use more steady concrete than GGBS made with only cement with the same binder content. Although it give lower strength at starting but as we increases curing period, the strength increase was higher for the GGBS concretes. The reason is that the slow pozzolanic reaction and that the formation of calcium hydroxide requires time.

Siddique and Khan, 2011 - Silica fume performs roles in concrete for two purpose, for Pore-size refinement and matrix densification: The presence of silica fume in the Portland cement concrete mixes causes considerable reduction in the volume of large pores at all ages. It basically acts as filler due to its fineness and because of which it fits into the spaces between grains.

Duval and Kadri, 1998 - The influence of micro-silica on the workability and compressive strength of concretes. He was found that if micro-silica increased the compressive strength at most by 25%, but the workability of concretes was best when its content was between 4%

and 8%. However, Duval and Kadri (1998) found out that if micro-silica exceeds 15% of the cementitious material, both compressive and tensile strengths are reduced.

III. MATERIALS AND EXPERIMENT

3.1 Materials

Cement: 53 grade Ultratech cement is used for all proportions SSC mixes. Specific gravity for cement is 3.12. Fineness modulus is 1%.

Fine Aggregate (FA): From IS sieve 4.74 passed is used. It is obtained from locally existing river sand, Specific gravity 2.54, Fineness modulus is 2.405, and water absorption is 0.806%.

Coarse Aggregate (CA): Coarse aggregate of 12.5mm down size is used. Specific gravity 2.75, Fineness modulus 7.84, water absorption 0.65%.

Recycled coarse aggregate (RCA): Construction dumped material at site is used. RCA is also 12.5mm down size is used. Specific gravity 2.56, Fineness modulus 8.09, water absorption 0.8%.

Superplasticizer (S.P): polycorboxylate based supeplasticizer is used. Quantity is 2% of cement material.

Viscosity modifying agent (VMA): VMA is added in a small dose of 0.3 per cent by weight of the binder content.

Fly ash: Specific gravity 2.1.

3.2 Mix design

Nan Su is the name of a scientist who initially introduced the mix design on SSC, based on that I collected the all required materials for experimental work and tested accordingly with many trial. Tests are conducted on fresh properties of SSC Slump flow, J-ring, V-funnel, L-box. Water cement ratio is 0.55. SSC is design for M25.

Table – 1: Mix proportions
Volume ratio of fine aggregate to total aggregate is 54%.

	Cement (kg)	FA (Kg)	CA (Kg)	RCA (Kg)	Flyash (Kg)	Water (Kg)	S.P.	VMA
RC0	300	895.1	604.6	-	167.5	240.4	9.35	0.72
RC25	300	895.1	453.45	151.15	167.5	240.4	9.35	0.72
RC50	300	895.1	302.3	302.3	167.5	240.4	9.35	0.72

3.3 Experiment

Flow ability using Slump flow test

The slump test with its simple and rapid procedure is used to evaluate the deformability of SCC in the absence of obstacles. This test measures two different aspects; the filling ability by measuring the horizontal flow diameter SF and the viscosity of mix by measuring the time needed for SCC to reach 500 mm flow (t500). The segregation resistance in this test can be detected visually. Because of its simplicity, the slump test can be done either on site or in the laboratory with inverted or upright Abram’s cone.

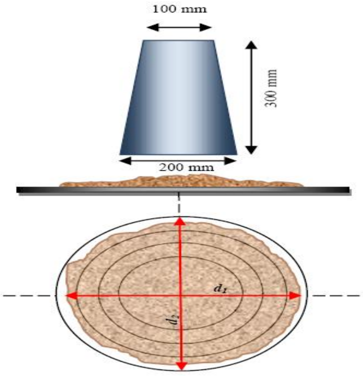


Figure Slump test apparatus with upright cone

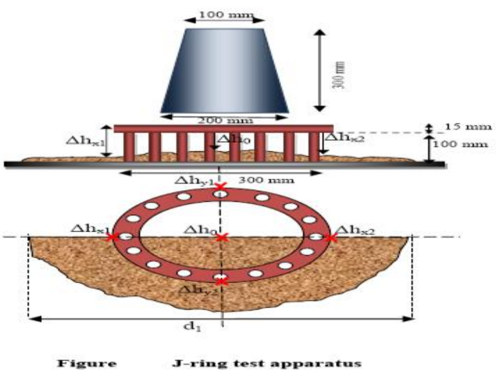
Fig-3: Slump test apparatus

The cone is placed on a non-absorbing levelled flat steel surface with a plane area of at least 900 mm x 900 mm, filled with SCC, and lifted in 2 to 4 sec to a height of 15 to 30 mm; SCC flows out under the influence of gravity. Two horizontal perpendicular diameters d1 and d2 as illustrated in Figure 2.24 are recorded and the average flow spread diameter SF is calculated using Equation

$$SF = \frac{(d_1 + d_2)}{2}$$

Passing ability by J-ring test-

J-ring is a test used in conjunction with a slump test to assess the passing ability of SCC with or without fibres through gaps in the obstacles, e.g. reinforcement. For this test, the slump test apparatus is used with an open steel rectangular section ring with 16 steel rods (ϕ16 mm) and 100 mm height, as shown in the Figure. The gap between the bars is 42 mm. Wider gaps can be used when fibres are introduced to the mix which should be 1-3 times the maximum length of fibres used (Tviksta, 2000).



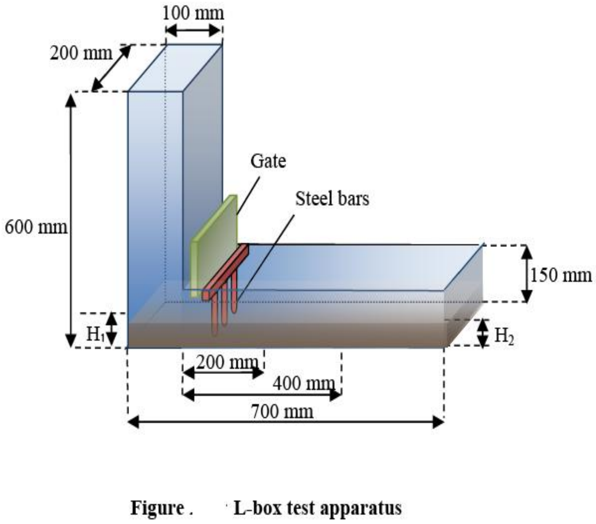
Fig–4: J ring apparatus

After filling the cone with concrete without using any vibration or rodding, the cone is lifted perpendicular to the steel base plate allowing the concrete to flow freely. The time needed for the flow to reach 500 mm diameter is recorded as t500J, and the flow allowed to stop before recording the remaining measurements.

L-box test

The L-box test is used to assess the filling and passing ability of SCC, or in other words the ability of concrete to pass though reinforced bars without blocking or segregation. After filling the vertical column of the L-box, the gate is lifted to allow SCC to flow into the horizontal part after passing through the rebar obstructions. Two measurements are taken, (H1, H2) heights of concrete at the beginning and end of the horizontal section, respectively. The ratio H2/H1 represents the filling ability, and typically, this value should be 0.8~1, while the passing ability can be detected visually by inspecting the area around the rebar.

In L-box, 2 or 3 smooth steel bars with 12 mm diameter can be used to represent light or dense reinforcement with distance between them 59 and 41 mm, respectively.



Fig–5: L box test apparatus

The passing ability ratio *PL* should be calculated:

$$PL = \frac{H_2}{H_1}$$

H_1 is the mean depth of concrete in the vertical section of the box
H_2 is the mean depth of concrete at the end of the horizontal section of the box.
T200 and T400 are also recorded which represent the time of SCC to reach 200 mm and 400 mm

V-funnel test

The V- Funnel test is used to determine the filling ability (flowability) of the concrete with a maximum size of aggregate 20 mm size. The funnel is filled with about 12 litre of concrete. Find the time taken for it to flow down. After this the funnel can be filled with concrete and left for 5 minutes to settle. If the concrete shows segregation then the flow time will increase significantly.

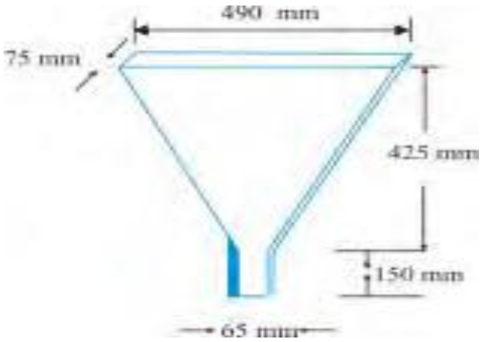


Figure-6: V-Funnel Test Equipment

About 12 litre of concrete is needed for the test. Set the V-funnel on firm ground. Moisten inside of the funnel. Keep the trap door open to remove any surplus water. Close the trap door and place a bucket underneath. Fill the apparatus completely with concrete No compaction or tamping is done. Strike off the concrete level. Open within 10 seconds the trap door and record the time taken for the concrete to flow down. Record the time for emptying. This can be judged when the light is seen when viewed from top. The whole test is to be performed within 5 min.

IV. RESULT

Table -2: Fresh properties of different proportion of Recycled aggregate

Mixture designation	Slump flow value (mm)	J-ring	L-box	V-funnel
RC0	687	2	0.94	7
RC25	661	4	0.84	10
RC50	650	5	0.76	13
Recommended value by EFNARC	600-800	0-10	0.8-1	6-12

Chart-1: Slump value

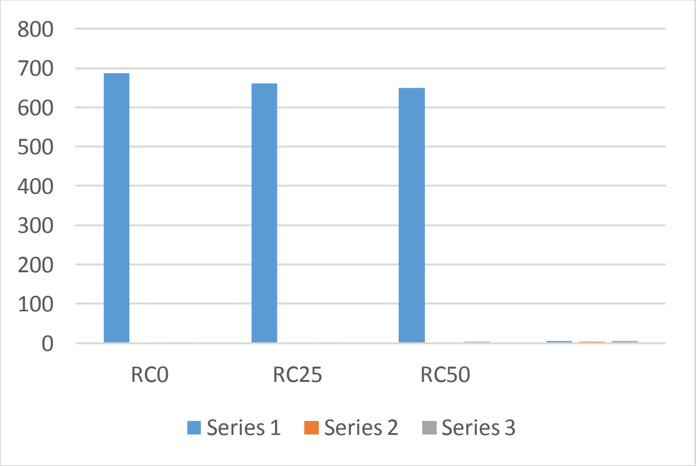


Chart-2: J-ring

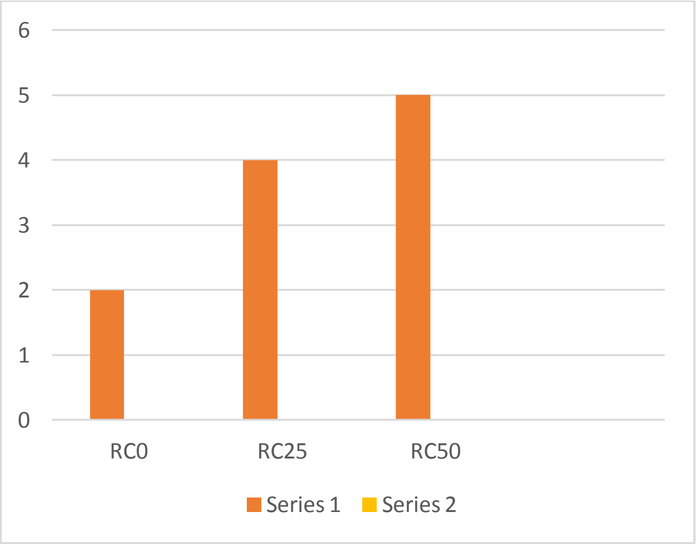


Chart-3: L-box

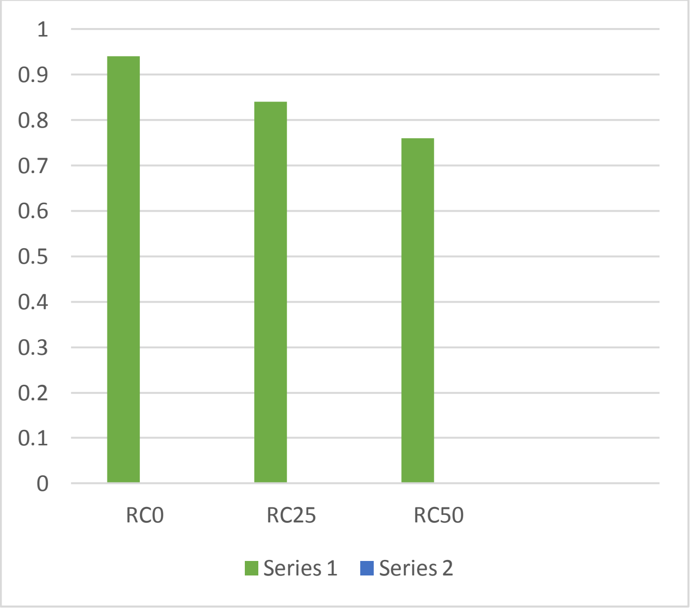
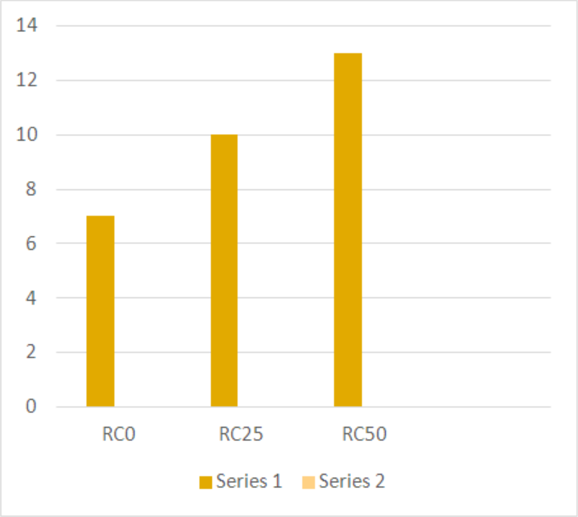


Chart-4: V-funnel



V. CONCLUSIONS

SCC has favourable characteristics such as high fluidity, good segregation resistance and the distinctive self compactibility without any need for vibration during the placing process and so noiseless construction. The unique characteristics of SCC are a rapid rate of concrete placement with very less time. SCC offers a very high level of homogeneity; minimize the concrete void spaces and have uniform concrete strength and also provides the superior level of finishing and durability of structure. SCC also achieves same engineering properties and durability as traditional vibrated concrete. The use of SCC has gained a wider acceptance in recent years. Recycled aggregates (RA) are produced from the re-processing of mineral waste materials, with the largest source being the construction and demolition waste. In general, the quality of RA is inferior to those of natural aggregates. The density of the RA is lower than natural aggregates and RA have a greater water absorption value compared to natural aggregates. As a result proper mix design is required for obtaining the desired qualities for concrete made with RA. As per above study following are the conclusion-

1. It is possible to attain an SCC with recycled aggregates. SCC was produced with this C&DW as aggregate within the proportions recommended by EHE-08 of 20% substitution and above 50% and 100% with minimal loss in the properties. The SP content needs to be increased as RCA content increases, so CC concrete contains 0.8% of the weight cement, Mix 20 contains 1%, Mix 50 contains 1.2%, and Mix 100 contains 1.35%.
2. The development of self-compacting concrete mixes may be a complicating method requiring the resolution of conflicting demands of flow-ability and non-segregation which may can be achieved by increasing the paste content and decreasing the massive aggregate volume. Self-compacting normal, high-strength and ultra-high-performance concrete mixes without fibres may be designed to satisfy only the flow-ability and cohesiveness (i.e. resistance to segregation) criteria using the slump cone flow test. The resistance to segregation was checked visually only.

3. The plastic viscosity of SCC mixes with and without fibres so developed is accurately estimated using a micromechanical procedure based on the measured viscosity of the cement paste and the mix proportions.

4. The main emphasis of this paper was to investigate the possibility of incorporating waste into the construction industry, more specifically, into concrete manufacturing. The aim was to establish if RA can serve as a more sustainable option to concrete production. Having found indications that RA can be used as concrete component, this thesis at-tempted to explain why the usage of RA in Finland remains embarrassingly low.

5. There is a significant potential for growth of recycled aggregate as an appropriate and green solution for sustainable development in construction industry.

6. Self compacting concrete made with recycled aggregates have achieved in all the mixes and satisfied the fresh state properties required for SCC as per EFNARC specification.

REFERENCES

[1]. Mas, B.; Cladera, A.; Del Olmo, T.; Pitarch, F. Influence of the Amount of Mixed Recycled Aggregates on the Properties of Concrete for Non-Structural Use. Constr. Build. Mater. 2012, 27, 612–622. [CrossRef]

[2]. Etxeberria, M.; Vázquez, E.; Marí, A.; Barra, M. Influence of Amount of Recycled Coarse Aggregates and Production Process on Properties of Recycled Aggregate Concrete. Cem. Concr. Res. 2007, 37, 735–742. [CrossRef]

[3]. Rodríguez-Robles, D.; García-González, J.; Juan-Valdés, A.; Morán-del Pozo, J.M.; Guerra-Romero, M.I. Effect of Mixed Recycled Aggregates on Mechanical Properties of Recycled Concrete. Mag. Concr. Res. 2015, 67, 247–256.

[4]. Güneyisi, E.; Gesoglu, M.; Algın, Z.; Yazıcı, H. Effect of Surface Treatment Methods on the Properties of Self-Compacting Concrete with Recycled Aggregates. Constr. Build. Mater. 2014, 64, 172–183. [CrossRef]

[5]. Herbudiman, B.; Saptaji, A.M. Self-Compacting Concrete with Recycled Traditional Roof Tile Powder. Procedia Eng. 2013, 54, 805–816. [CrossRef]

[6]. González-Taboada, I.; González-Fonteboa, B.; Eiras-López, J.; Rojo-López, G. Tools for the Study of Self- Compacting Recycled Concrete Fresh Behaviour: Workability and Rheology. J. Clean. Prod. 2017, 156, 1–18.

[7]. EFNARC (2005), The European guidelines for self compacting concrete; May 2005, pp. 1-63.53. EFNARC. Specification and Guidelines for Self-Compacting Concrete. Rep. EFNARC **2002**, 44, 32.

[8]. Davies N, Jokiniemi E. Dictionary of Architecture and Building Construction. Bur-lington, MA, USA: Architectural Press; 2008.

[9]. Francis AA. Non-Isothermal Crystallization Kinetics of a Blast Furnace Slag. Jour-nal of the American Ceramic Society 2015:88(7);1859–1863.

[10]. Gavilan R, Bernold L. Source Evaluation of Solid Waste in Building Construction. Journal of Construction Engineering and Management 1994;120(3):536-552.

[11]. Crow JM. The Concrete Conundrum. Chemistry World. March 2008, pp.62-66.

[12]. Edward GN. Concrete Construction Engineering Handbook. 2nd ed. USA: Taylor & Francis Group; 2009.

[13]. Haberta G, Bouzidib Y, Chena C, Jullienc A. Development of a depletion indicator for natural resources used in concrete. Resources, Conservation and Recycling 2010:54(6);364-376.

[14]. UEPG - European Aggregates Association. Annual Review 2014-2015. Belgium: Publisher unknown; 2015.

[15]. Domone P, Illson J. Construction Materials: Their nature and behaviour. 4th ed. USA and Canada: Spon Press; 2010.

[16]. William HL, Lawrence JD, Janet S S. Aggregate and the Environment. Alexan-dria, VA, USA: American Geological Institute; 2005.