IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727, Volume 21, Issue 4, Ser. II (Jul - Aug 2019), PP 22-31
www.iosrjournals.org

An Experimental Study on Strength Properties of Normal Compacting Concrete & Self Compacting Concrete

R. Durga Prasad[1], R. Aneesh[2]
[1]M.tech student Roll no- 17961D8707, Lenora Engineering College, Rampa chodavaram, E.G.Dist, AP, India.
[2] Assistant Professor, Department of Civil Engineering, Lenora Engineering College,Rampachodavaram, E.G.Dist, AP, India.
**Corresponding Author: R. Durga Prasad*

Abstract: *Self-Compacting Concrete (SCC), which flows under its own weight and does not require any external vibration for compaction, has revolutionized concrete placement. SCC, was first introduced in the late 1980's by Japanese researchers, is highly workable concrete that can flow under its own weight through restricted sections without segregation and bleeding. Such concrete should have a relatively low yield value to ensure high flow ability, a moderate viscosity to resist segregation and bleeding, and must maintain its homogeneity during transportation, placing and curing to ensure adequate structural performance and long term durability. The successful development of SCC must ensure a good balance between deformability and stability. Researchers have set some guidelines for mixture proportioning of SCC, which include i) reducing the volume ratio of aggregate to cementations material; (ii) increasing the paste volume and water-cement ratio (w/c); (iii) carefully controlling the maximum coarse aggregate particle size and total volume; and (iv) using various viscosity modifying admixtures (VMA).*

Date of Submission: 29-07-2019 Date of acceptance: 12-08-2019

I. Introduction

Self-compacting concrete (SCC) has been described as "the most revolutionary development in concrete construction for several decades". Originally developed to offset a growing shortage of skilled labor, it has proved beneficial economical because of a number of factors, including:

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

Originally developed in Japan, SCC technology was made possible by the much earlier development of super plasticizers for concrete. SCC has now been taken up with enthusiasm across Europe, for both site and precast concrete work. Practical application has been accompanied by much research into the physical and mechanical characteristics of SCC and the wide range of knowledge generated has been shifted and combined in this guideline document. The EFNARC (European Federation of National Associations Representing for Concrete) Specification defines specific requirements for the SCC material, its composition and its application.

The development of Self Compacting Concrete (SCC) is considered as the most sought development in construction industry due to its numerous inherited benefits. In India, this technology is yet to realize its full potential. Central Road Research Institute (CRRI) New Delhi, has been working on SCC technology since the year 2000 and carried out significant research work on various aspects of SCC starting from selection of suitable ingredients including super plasticizer, viscosity modifying agent, mineral admixtures, mix proportion optimization, evaluation of the characteristic properties at fresh stage and hardened properties such as compressive strength, split tensile strength, flexural strength, and Young's modulus of elasticity.

"No vibration" is necessary for SCC which can flow around obstructions, encapsulate the reinforcement and fill up the space completely under self-weight. The salient advantages are; ensure through compaction employing unskilled labour, minimize repair of finished surface, ensure good finished surface, reduced manpower for casting and finishing, increase in speed of construction and reduces requirements of coarse aggregates and minimizes electrical and mechanical energy. Development of SCC is not nascent in stage now. IRC: 112 also recommend use of SCC in concrete bridges and the same is under draft stage to be put in rigid pavement and cell fill pavement by IRC. Studies on SCC and cell fill pavement (which requires SCC also) is largely being undertaken by PL Bongirwar Advisor L&T and Prof BB Pandey, IIT Khargpur. However, it has been tried in the field on many projects in India now. As a safe guard against separation of water, use of a viscosity modifying agent is usually essential to minimize shrinkage due to high powder content in SCC besides additional requirements of fines passing 125 micron. There are typical mixes of SCC similar to conventional concrete where risk of cracking due to shrinkage and thermal stresses could be reduced. Addition of fly ash and other siliceous mineral admixtures such as silica fume, ground granulated slag in conventional concrete in addition to chemical admixtures, make sustainable 'SCC'. There are many organization/academic institutions/cement companies (CRRI, NCB, SERC, CBRI, L&T, ACC, Ultra-Tech, Ambuja Cements in India who are working hard in the laboratory and field for the advancement and use of SCC in structures to minimize carbon emission and making cost effective construction product. There is a need to formulate IRC/BIS specifications/ guidelines for the use of SCC in respective structures based on the experience/data gained in India. Guidelines are published by Hampshire, UK (EFNARC-2002)/contract documents on use of SCC in Nuclear Structures. For more details on mix design, materials required, and its different applications reference of June Issue (No. 6 2004) of Indian Concrete Journal may be made. The paper reviews some of the R&D activities carried out in India and abroad. A constant strive to improve performance and acceleration of productivity led to the development of self-compacting concrete (SCC). Traditionally placed concrete mix is compacted with the help of external energy inputs with vibrators, tamping or similar actions. On the other hand, SCC mix has special performance attributes of self-compaction/consolidation under the action of gravity.

II. Literature Review

A detailed review of literature on different aspects of the Self Compacting Concrete (SCC) will be presented in detail in this chapter. The development of SCC, materials used to produce SCC, the test methods for the self compacting properties under the fresh and hardened state are discussed. An account of the literature available on fibre reinforcement and the behaviour of wall panels is further provided in this chapter.

Ever since the invention of self-flowing and self-consolidating concrete in late 1980s so as to overcome the difficulties of normal cement concrete that can tend to cause honeycombs in spite of careful compaction process through vibration of fresh concrete in designed moulds, the SCC has made steady inroads into critical constructions. The ease with which the SCC has taken the form into congested embedment has made several researchers dwell more on expanding the applications in pre-cast and site situations with increased use of structural elements, with the addition of fibres forming FRSCC. The fibres are mostly confined to steel and glass. But newly developed FRSCC does not have complete properties and hence required further research to obtain the necessary properties of both fresh and hardened states of concrete that makes it possible to assess the strength of the composite.

Kuroiwa [1993], Developed a new type of concrete with materials normally used in conventional concrete, that is, cement, aggregates, water and admixtures. The chemical admixtures were used to improve the deformability and viscosity properties of the concrete. The newly developed concrete was named super-workable concrete. This has shown considerable resistance to segregation and deformability. It also filled heavily reinforced formworks completely without the use of any vibrators. The laboratory tests showed that the super-workable concrete has superior fresh and hardened state properties with improved durability. Because of this, this concrete was considered to be suitable for structures having heavy reinforcement areas and used in the construction of twenty-storied buildings.

Okamura et al. (1995), Developed a new concrete that flows and gets compacted at every place of the formwork by its own weight. In 1986, they started research on this project which was later called Self Compacting Concrete. This research work was started on the suggestions of professor Kokubu of Kobe University, Japan. He was one of the major advisors of Professor Hajime Okamura [1995]. They thought of developing this new concrete as anti washout concrete which was already in use. The anti washout underwater concrete is used for underwater concreting without any segregation by adding a large viscosity modifying agent which prevents the particles of cement from dispersing into the surrounding water. However, it was observed that this anti washout concrete was not applicable for open air structures for two reasons: first, non elimination of entrapped air bubbles due to higher viscosity; and second, difficulty in compaction in the areas of confined reinforcing bars. They found that for achievement of the self compactability, usage of Super Plasticizer was indispensable. With the addition of Super Plasticizer, the paste flows with a little decrease in viscosity. The water/cement ratio can be between 0.4 and 0.6. The self-compactability of the concrete is largely affected by the material characteristics and mix proportions. Okamura limited the content of coarse aggregate to 60% of the solid volume and the content of fine aggregate to 40% to achieve self-compactibility.

Khayat K. H (1999) Studied the behaviour of Viscosity Enhancing Admixtures (VEA) used in cement-based materials. He has concluded that by suitably adjusting the combinations of VEA and High Range Water Reducing (HRWR) agents, a fluid without wash out resistant can be produced. This will enhance properties of underwater cast grouts, mortars, and concretes, and reduces the turbidity, and increases the pH values of surrounding waters.

Victor C. Li, H.J.Kong, Yin-Wen Chan(1999) The authors present a self-compacting Engineered Cementitious Composite (ECC) developed by optimizing the micromechanical parameters that control composite properties in the hardened state, and the processing parameters, that control the rheological properties in the fresh state. In the development concept of self-compacting ECC, micromechanics is adopted to properly select the matrix, fibre, and interface properties in order to exhibit strain hardening and multiple cracking behaviour in the composites. With the selected ingredient materials, the selfcompactibility of ECC is then realized by the controlled rheological properties of fresh matrix, including deformability and flow rate. Selfcompactibility is a result of adopting an optimal combination of a super plasticizer and a viscosity agent. According to the measurements of slump flow and the self-placing test result, what the ECC developed in this study is proved to be self-compacting. Flexural tests demonstrate that the mechanical performance of self-compacting ECC is insensitive to the extremely applied consolidation during placing. This result confirms the effectiveness of the self-compatibility in maintaining the quality of structural elements.

Paul Ramsburg and Robert E. Neal (2000) Their research was focused on the development of SCC mixes making use of a natural pozzolona to enhance the SCC properties at Rotondo Precast. The calcined shale produced by the Lehigh Cement Company was used as natural pozzolona under a trade name XPM. The calcined shale characteristics improved the cohesion of the concrete mix with a better control of segregation, avoiding the necessity of a viscosity modifying agent. In addition, it is found that the total cementitious material content needed in the concrete was found to be less than the cement content required for the conventional SCC mixes. A natural pozzolona of 30% was found to be optimum for eliminating segregation and sufficient early age strengths.

Nan Su, Kung-Chung Hsu and His-Wen Chai (2001) Authors proposed a simple mix design procedure for SCC and their main focus was to fill voids of loosely filled aggregate with binder paste. They introduced a factor called Packing Factor (PF) for aggregate. It is the ratio of mass of aggregates in tightly packed state to the one in loosely packed state. The procedure totally depends upon the Packing Factor (PF). A higher value of PF indicates the larger aggregate content, which requires less binder and will have less flow ability. It was concluded that the packing factor determines the aggregate content and influence the properties like flow ability, self-consolidating ability and strength. In his mix design, the volume of FA to mortar was in the order of 54 – 60% and found that PF value will be the controlling factor for the U – box text.

Ho.D et al. (2002) studied the usage of quarry dust in SCC applications. Rheological studies on pastes and SCC mixes were made and compared with SCC mixes with limestone powder. It was observed that quarry dust can be used in SCC production, but requires higher super plasticizer dosages.

M. Sonebi and P.J.M. Bartos (2002) This paper shows results of an investigation of fresh properties of self-compacting concrete, such as, filling ability (measured by slump flow) and flow time (measured by orimet) and plastic fresh settlement measured in a column. The results of SCC were compared to a control mix. The compressive strength and splitting tensile strength of SCC were measured. The effects of water/powder ratio, slump and nature of the sand on fresh settlement were also evaluated. Keeping the volume of coarse aggregate and the dosage of Super Plasticizer constant, it was concluded that the settlement of fresh self-compacting concrete increased with the increase in water/powder ratio and the nature of sand influenced the maximum settlement.

Hajime Okamura and Masahiro Ouchi (2003) The authors report that self-compacting concrete was first developed in 1988 to achieve durable concrete structures and since then, various investigations have been carried out and this type of concrete has been used in practical structures in Japan, in order to shorten the construction period by large-scale constructions, such as, the anchorages of Akashin-Kaikyo (Akashi Straits) Bridge opened in April 1988, and a suspension bridge with the longest span in the world (1,991 meters) is a typical example (Kashima 1999). It is further reported that, SCC was used for the wall of a large LNG tank belonging to the Osaka Gas Company and the adoption of SCC in this project resulted in : (i) Decrease of the construction period of the structure from 22 months to 18 months (ii) Reduction of the number of concrete workers from 150 to 50 (iii) Decrease of the number of lots from 14 to 10 as the height of one lot of concrete was increased. The authors noted that when self-compacting concrete becomes so widely used that it is seen as the “Standard Concrete” rather than a “Special Concrete”, it will have succeeded in creating durable and reliable concrete structures that require very little maintenance work.

R.Sri Ravindrarajah, D.Siladyi and B. Adamopoulos (2003) This paper reports an investigation into the development of selfcompacting concrete with reduced segregation potential. The selfcompacting concrete mix having satisfied the criterion recognized by the differential height method is modified in many ways to increase the fine particle content by replacing partially the fine and coarse aggregates by low-calcium fly ash. It is reported that the systematic experimental approach showed that partial replacement of coarse and fine aggregate could produce self-compacting concrete with low segregation potential as assessed by the V-Funnel test. It further reports the results of bleeding test and strength development with age and concludes that fly ash could be used successfully in producing self-compacting highstrength concrete with reduced segregation potential.

Amit Mittal, Kaisare M.B and Shetty R.G (2004) Self compacting concrete is suitable for the concreting congested reinforcement structures or where the access is difficult for concreting. The authors in their topic "Use of SCC in a pump house at TAPP 3 & 4 Tarapur", explained in brief the methodology adopted for the design and testing of SCC mixes and the methods adopted for concreting walls and structures housing a condenser cooling water pump at Tarapur Atomic power project 3 & 4 (TAPP).

III. Materials And Their Tests

3.1 CEMENT

The cement selected is as per the IS 12269(1987). The preliminary material test conducted to check the properties of cement are:

1. Fineness of cement
2. Normal consistency of cement
3. Initial and final setting times of cement
4. Specific gravity of cement

3.1.1 Fineness of cement:

Fineness of cement is property of cement that indicates particle size of cement and specific surface are and indirectly effect heat of hydration.

Limits: The percentage residue should not exceed 10%.

Result: Fineness of given sample of cement = 91%

3.1.2 Normal consistency of cement:

The standard consistency of a cement paste is defined as that consistency which will permit the vicat plunger to penetrate to a point 5 to 7mm from the bottom of the vicat mould.

Result: Normal consistency for the given sample of cement = 30%

3.1.3 Initial and final setting times of cement:

Initial setting time duration is required to delay the process of hydration or hardening. Final setting time is the time when the paste completely loses its plasticity. It is the time taken for the cement paste or cement concrete to harden sufficiently and attain the shape of the mould in which it is cast.

Result:

Initial setting time for this given sample of cement = 32 min

Finial setting time for this given sample of cement = 8 hours 30 min

1.1.3 Specific gravity of cement:

To determine the specific gravity is normally defined as the ratio between the weight of a given volume of material and weight of an equal volume of water. To determine the specific gravity of cement, kerosene which does not recent with cement is used.

Result: Specific gravity of cement = 3.14

3.2 Aggregates:

The aggregates used are conforming to IS 383. Like the fine aggregates material testing is done for coarse aggregate also:

1. Fineness modulus of fine and coarse aggregates
2. Specific gravity of fine and coarse aggregates
3. Bulk density of fine and coarse aggregates

3.2.1 Fineness modulus of fine and coarse aggregates:

Fineness modulus of coarse aggregates represents the average size of the particles in the coarse aggregate by an index number. It is calculated by performing sieve analysis with standard sieves. The cumulative percentage retained on each sieve is added and subtracted by 100 gives the value of fine aggregate.

Result:

The fineness modulus of given fine aggregate = 3.725

The fineness modulus of given coarse aggregate = 7.692

3.2.2 Specific gravity of fine and coarse aggregate:

The ratio of the density of a substance to the density of a reference substance: equivalently, it is the ratio of the mass of a substance to the mass of a reference substance for the same given volume.

Result:

Specific gravity of fine aggregates = 2.808

Specific gravity of coarse aggregates = 2.735

3.3 Admixtures:

The most important admixtures are the Super plasticizers (high range water reducers), used with a water reduction greater than 20 %.The use of a Viscosity Modifying Admixture (VMA) gives more possibilities of controlling segregation when the amount of powder is limited. This admixture helps to provide very good homogeneity and reduces the tendency to segregation.

IV. Tests & Test Results

4.1 Normal Compacting Concrete Tests:

4.1.1 Workability tests on NCC:

1. Slump cone test
2. Compaction factor

4.2 TESTS FOR SELF-COMPACTING CONCRETE:

SCC differs from conventional concrete in that its fresh properties are vital in determining whether or not it can be placed satisfactorily. The various aspects of workability which control its Filling ability, its passing ability and its Segregation resistance all need to be carefully controlled to ensure that its ability to be placed remains acceptable.

4.2.1 Workability:

The level of fluidity of the SCC is governed chiefly by the dosing of the Super plasticizer. However overdosing may lead to the risk of segregation and blockage. Consequently the characteristics of the fresh SCC need to be carefully controlled using preferably two of the different types of test.

4.2.1.1 SLUMP FLOW TEST:

The slump flow is used to assess the horizontal free flow of SCC in the absence of obstructions. It was first developed in Japan for use in assessment of underwater concrete. The test method is based on the test method for determining the slump. The diameter of the concrete circle is a measure for the filling ability of the concrete.

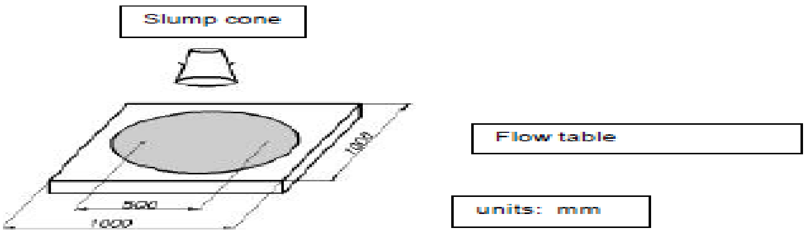

Figure 4.4 Slimp Flow Table for SSC

Table 4.1 Test Results

	Slump			$T_{50\ Cm}$
M40	680 mm	670 mm	680mm	2 s
M50	680 mm	680 mm	670 mm	3 s

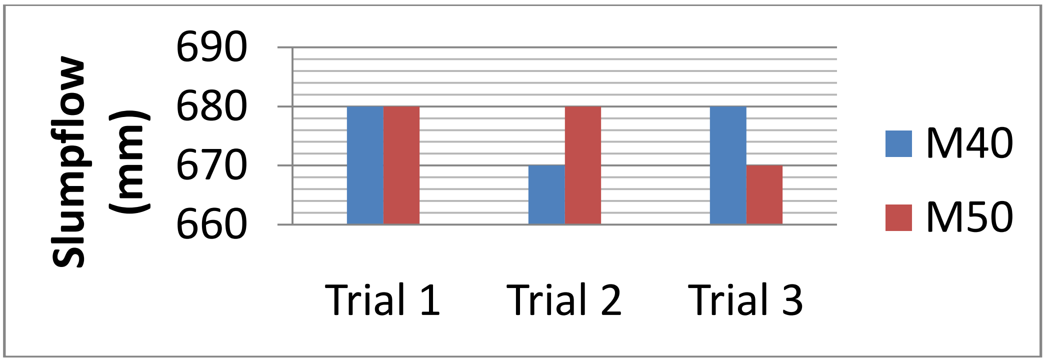

Figure 4.5 with reference to Table 4.1

4.2.1.2 J RING TEST

The principle of the J-Ring test may be Japanese, but no references are known. The J-Ring test itself has been developed at the University of Paisley. The test is used to determine the passing ability of the concrete. The equipment consists of a rectangular section (30mm x 25mm) open steel ring, drilled vertically with holes to accept threaded sections of reinforcement bar. These sections of bar can be of different diameters and spaced at different intervals: in accordance with normal reinforcement considerations, 3x the maximum aggregate size might be appropriate. The diameter of the ring of vertical bars is 300mm, and the height 100 mm. The J-Ring can be used in conjunction with the Slump flow, the Orient test, or eventually even the V-funnel. These combinations test the flowing ability ***and*** (the contribution of the J-Ring) the passing ability of the concrete. The orient time and/or slump flow spread are measured as usual to assess flow characteristics. The J-Ring bars can principally be set at any spacing to impose a more or less severe test of the passing ability of the concrete. After the test, the difference in height between the concrete inside and that just outside the J-Ring is measured. This is an indication of passing ability, or the degree to which the passage of concrete through the bars is restricted.

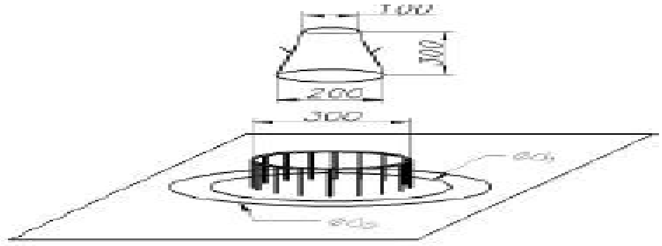

Figure 4.6: The J Ring used in conjunction with the Slump flow

Table 4.2: J-Ring Properties

	Height Difference				Average
M40	2mm	6mm	2mm	2mm	3mm
M50	2mm	3mm	2mm	1mm	2mm

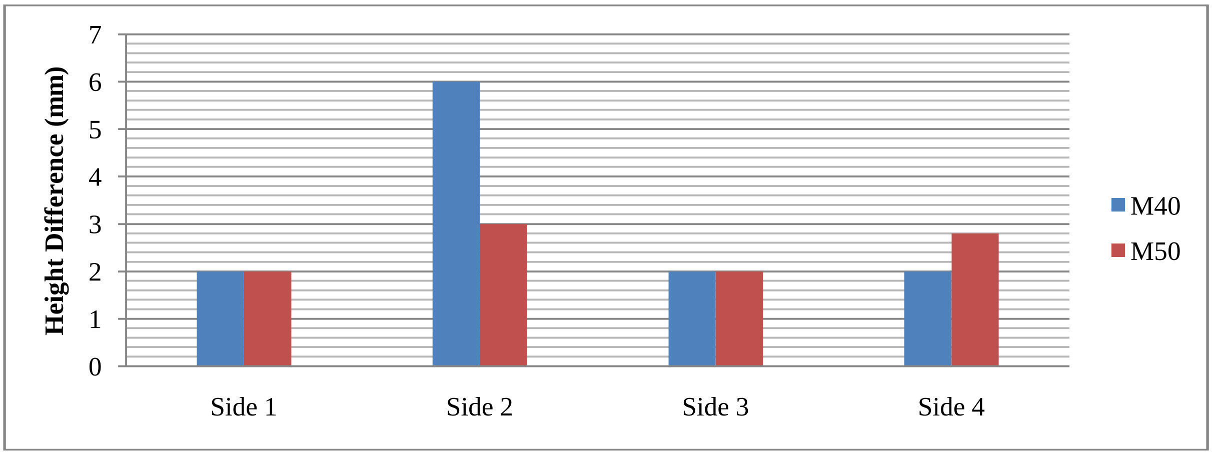

Figure 4.7 with reference to Table 4.2

4.2.1.3 L BOX TEST METHOD

This test, based on a Japanese design for underwater concrete, has been described by Petersons. The test assesses the flow of the concrete, and also the extent to which it is subject to blocking by reinforcement. The apparatus is shown in figure. The apparatus consists of a rectangular-section box in the shape of an 'L', with a vertical and horizontal section, separated by a moveable gate, in front of which vertical lengths of reinforcement bar are fitted. The vertical section is filled with concrete, then the gate lifted to let the concrete flow into the horizontal section. When the flow has stopped, the height of the concrete at the end of the horizontal section is expressed as a proportion of that remaining in the vertical section (H_2/H_1in the diagram). It indicates the *slope* of the concrete when at rest. This is an indication passing ability, or the degree to which the passage of concrete through the bars is restricted. The horizontal section of the box can be marked at 200 mm and 400 mm from the gate and the times taken to reach these points measured. These are known as the T20 and T40 times and are an indication for the filling ability. The sections of bar can be of different diameters and spaced at different intervals: in accordance with normal reinforcement considerations, 3x the maximum aggregate size might be appropriate. The bars can principally be set at any spacing to impose a more or less severe test of the passing ability of the concrete.

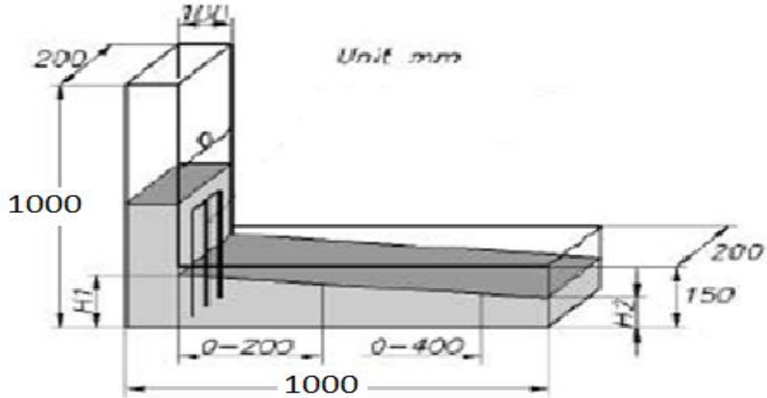

Figure 4.8 L-Box Test

Table 4.3 L-Box Test Properties

	H_1		H_2		H_2/H_1	T_{20}	T_{40}
M40	12mm	12mm	11mm	11mm	0.92	3 s	5 s
M50	9mm	9mm	11mm	11mm	0.82	3 s	7 s

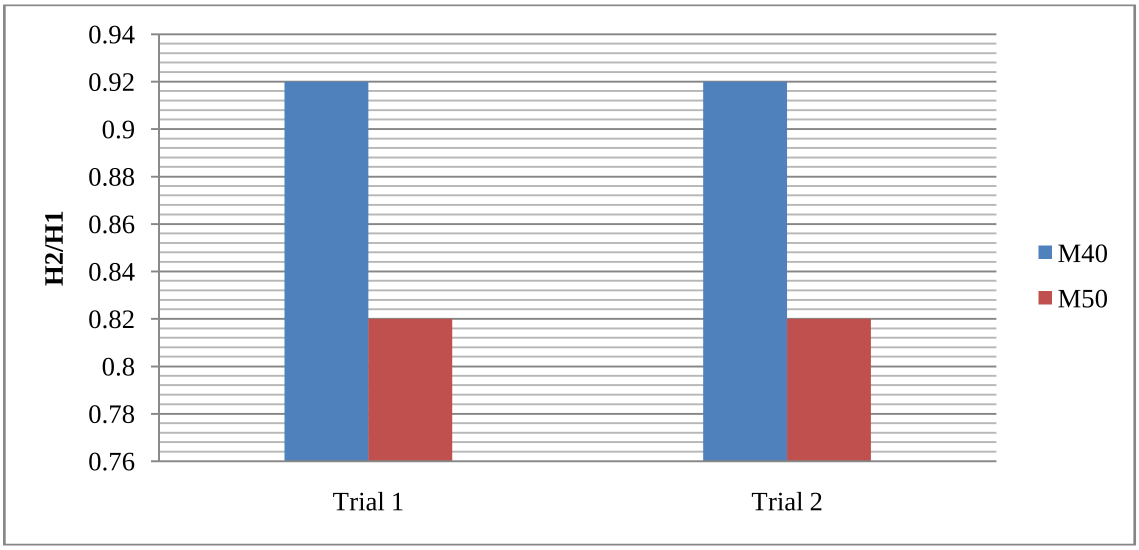

Figure 4.9 with reference to Table 4.3

4.2.1.4 U BOX TEST METHOD

The test was developed by the Technology Research Centre of the Taisei Corporation in Japan. Sometimes the apparatus is called a "box-shaped" test. The test is used to measure the filling ability of self-compacting concrete. The apparatus consists of a vessel that is divided by a middle wall into two compartments, shown by R1 and R2 in Fig. An opening with a sliding gate is fitted between the two sections. Reinforcing bars with nominal diameters of 13 mm are installed at the gate with center-to-center spacing of 50 mm. This creates a clear spacing of 35 mm between the bars. The left hand section is filled with about 20 liters of concrete then the gate lifted and concrete flows *upwards* into the other section. The height of the concrete in both sections is measured.

Note: An alternative design of box to this, but built on the same principle is recommended by the Japan Society of Civil Engineers.

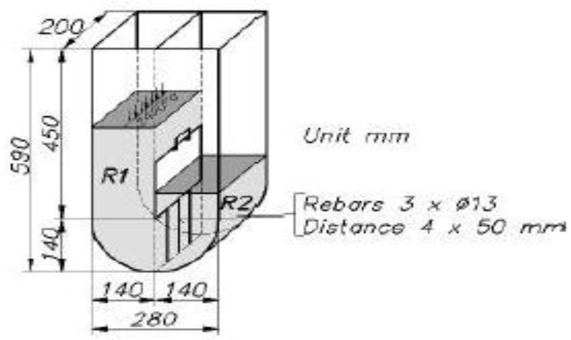

Figure 4.10 U-Box Test

Table 4.4 U-Box Test Properties

	H_1		H_2		H_1 - H_2
M40	46 mm	46 mm	18 mm	18 mm	28 mm
M50	45 mm	45 mm	24 mm	24 mm	21 mm

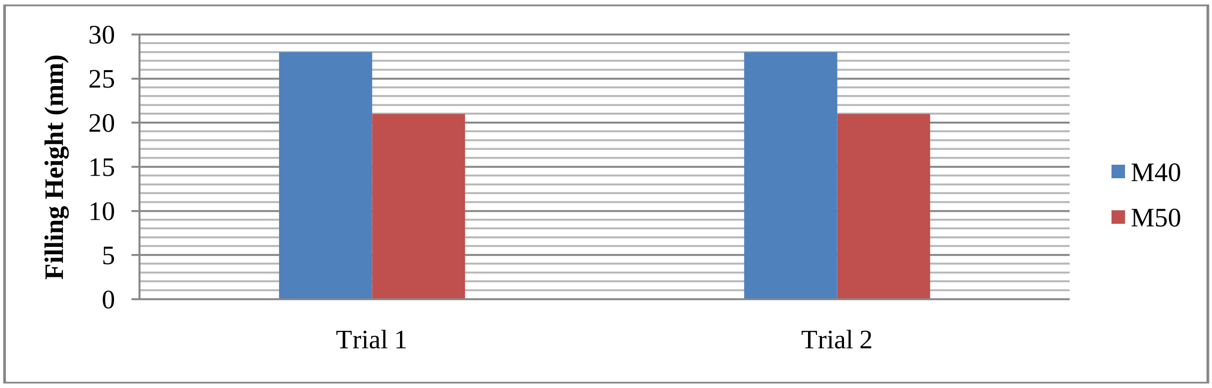

Figure 4.11 with reference to Table 4.4

4.2.2 Observations of Workability

Table 4.5 Workability Details of Mix 40 SCC

S.NO	Workability Tests	Values	Range
1	Slump-flow	676.67	650-800
2	J-Ring	3	0-10
3	L-Box	0.92	0.8-1
4	U-Box	28	0-30

Table 4.6 Workability Details of Mix 50 SCC

S.NO	Workability Tests	Values	Range
1	Slump flow	676.67	650-800
2	J-Ring	2	0-10
3	L-Box	0.82	0.8-1
4	U-Box	21	0-30

4.3 Segregation resistance:

Due to the high fluidity of SCC, the risk of segregation and blocking is very high. Preventing segregation is therefore an important feature of the control regime. The tendency to segregation can be reduced by the use of a sufficient amount of fines (< 0,125 mm), or using a Viscosity Modifying Admixture (VMA).

4.4 Open time:

The time during which the SCC maintains its desired rheological properties is very important to obtain good results in the concrete placing. This time can be adjusted by choosing the right type of super plasticizers or the combined use of retarding admixtures. Different admixtures have different effects on open time, and they can be used according to the type of cement and the timing of the transport and placing of the SCC.

Table 4.7 Compressive Strength results of NCC M40 and SCC M40

S.No	Test 1 N/mm2			Test2 N/mm2			Test3 N/mm2			Average N/mm2		
	7 days	7 days	7 days	21 days	21 days	21 days	28 days	28 days	28 days	7 days	21 days	28 days
M40 SCC	33.5	37.1	39.14	40.7	44.5	46.5	51.54	48.1	46.7	36.58	43.9	48.78
M40 SCC	30.6	28.8	30.9	38.3	43.62	41.2	43.5	45.2	48.13	30.1	41.04	45.61

Table 4.8 Compressive Strength results of NCC M50 and SCC M50

s.No	Test 1 N/mm^2			Test 2 N/mm^2			Test 3 N/mm^2				Average N/mm^2		
	7 days	7 days	7 days	21 days	21 days	21 days	28 days	28 days	28 days	28 days	7 days	21 days	28 days
M50 SCC	41.54		38.14	45.18	52.69	48.24	67.16	57.2	61.54	67.35	41.62	56.03	62.03
M50 NCC	34.25		32.8	42.54	48.56	50.89	58.05	58.42	54.36	62.27	36.53	52.51	58.35

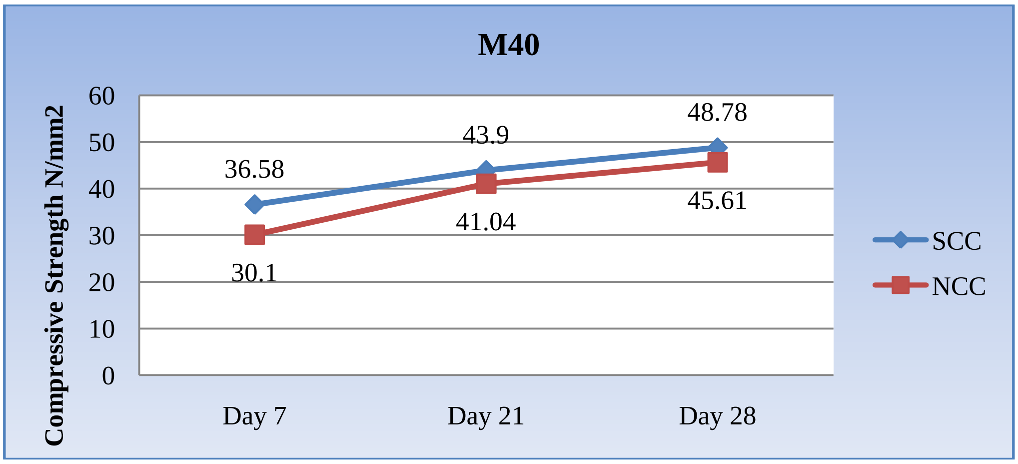

Figure 4.12 with reference to Table 4.1

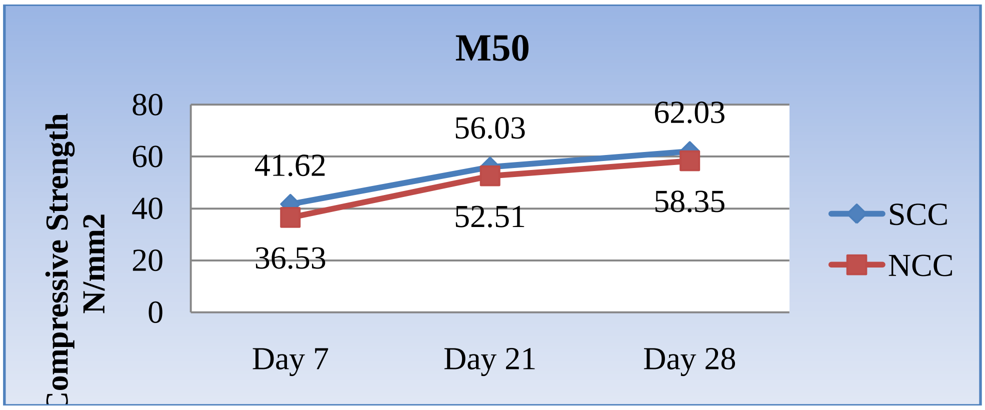

Figure 4.13 with reference to Table 4.2

V. Conclusions

- With 35% replacement of cement with fly ash in M40 SCC, the difference in compressive strength of NCC & SCC on the 7th day is 6.48 N/mm^2 which is higher and on the 21st day is 2.86 N/mm^2 which is of slight difference and on the 28th day is 3.17 N/mm^2 and is also of slight difference.
- With 20% replacement of cement with fly ash in M50 SCC, the difference in compressive strength of NCC & SCC on the 7th day is 5.09 N/mm^2 which is higher and on the 21st day is 3.52 N/mm^2 which is of slight difference and on the 28th day is 3.68 N/mm^2 and is also of slight difference.

References

[1]. Japan Society of Civil Engineers, 'Recommendations for Design and Construction of Antiwashout Underwater Concrete', Concrete library of JSCE, 19 (1992) 89 p.
[2]. Petersson, Ö., Billberg, P., Van, B.K., 'A model for self-compacting Concrete', Proceedings of International RILEM Conference on 'Production Methods and Workability of Concrete', edited by P.J.M. Bartos, et al. (Chapman & Hall/E & FN Spon) (Paisley, 1996) 483-490.
[3]. Bartos, P.J.M., 'An appraisal of the Orimet Test as a Method for On-site Assessment of Fresh SCC Concrete', Proceedings of International Workshop on Self-Compacting Concrete, (Japan, August 1998) 121-135.
[4]. Haykawa, M., 'Development and Application of Super Workable Concrete', Proceedings of International RILEM Workshop on 'Special Concretes - Workability and Mixing', edited by Prof. P.J.M. Bartos, (Paisley, 1993) 183-190.
[5]. Ozawa, K., Sakata, N., Okamura, H., 'Evaluation of Self-Compactibility of Fresh Concrete Using the Funnel Test', Concrete Library of JSCE, (25) (June 1995) 59-75.
[6]. Rooney, M., Bartos, P.M.J., 'Development of the settlement column segregation test for fresh selfcompacting concrete (SCC)', to appear in the second international symposium on SCC, Tokyo, Japan (2001).
[7]. Brite-EuRam programme: BE96-3801/BRPR-CT96-0366, 'Rational production and improved working environment through using self-compacting concrete'.
[8]. Henderson N A, Baldwin N J R, McKibbins L D, Winsor D S, & Shanghavi H B, 'Concrete technology for foundation applications', CIRIA Report C569: 2002
[9]. Hajime Okamura,"Self-compacting high performance concrete", Concrete International, 19(1997) 55-54.
[10]. Yahia A, M.Tanimura, A. Shimabukuro, Y Shimoyoma, "Effect of rheological parameters on self compactability of concrete containing various mineral admixtures in : A, skerendal, o.peterson(Eds.)", proceedings of first RILEM International Symposium On SCC, Stockholm, September,(1999) 523-535.
[11]. Kazumasa Ozawa, "Development of high performance concrete based on the durability of concrete structures", EASEC-2, (1989 455-450.
[12]. Mustafa Sahmaranet et al., "Transport and mechanical properties of self-consolidating concrete with high volume fly ash" Science Direct Cement And Concrete Composites 31(2009) 99-106.
[13]. D.W.S.Ho, A.M.M Sheinn, C.C Ng and C.T Tam, "The use of quarry dust for SCC applications" Cement And Concrete Research, 32(2002) 505-511.
[14]. Prajapathi Krishna paletal, "Development and properties of self-compacting concrete mixed with fly ash" Research Journal of Engineering Sciences, 1 (3) Sep (2012) 11-14.
[15]. P.Ramanathan et al., "Performance of self-compacting concrete containing different mineral admixtures" KSCE Journal of Civil Engineering, 17(2) (2013) 456-472.
[16]. K Turk et.al, 9th International Congress on Advances in Civil Engineering, 27-30 September (2010) 1-3.
[17]. MD NOR ATAN, HANIZAM AWANG, "The compressive and flexure strengths of self-compacting concrete using Raw Rice Husk Ash". Journal of Engineering Science and Technology. 6 (6) (2011) 720-732.
[18]. Okamura, "Self-compacting high performance concrete", Concrete Institute 19(7) 50- 54.
[19]. Jagadish Vengala and R .V Ranganath, "Mixture proportioning procedure for Selfcompacting concrete", The Indian concrete Journal, August (2004) 13-21.
[20]. Nan su, Kung-Chung Hsu, His-Wen Chai, "A simple mix designmethod for Selfcompacting concrete", Cement and concrete Research, 31, (2001) 1799-1807.

R. Durga Prasad, "An Experimental Study On Strength Properties Of Normal Compacting Concrete & Self Compacting Concrete. " IOSR Journal of Computer Engineering (IOSR-JCE) 14.4 (2019): 22-31.