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COMPARISON OF THE PERFORMANCE OF SELF COMPACTING CONCRETE

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Abstract:

Self-Compacting Concrete Originally developed in Japan, SCC technology was made possible by the much earlier development of Superplasticisers for concrete. To compare the performance of SCC with Fly Ash 20%, Silica Fume 10%, Rice Husk Ash (5%, 10%, and 15%) as a partial replacement of cement, due to the high increase in construction which has brought a heavy demand for ingredients of concrete such as cement and sand, and these materials are becoming costly and scarce. The use of self-compacting concrete (SCC) is spreading worldwide because of its very attractive properties in the fresh state as well as after hardening. By using Super plasticizer (High Range Water Reducing Admixture) to increase the workability & admixture should bring about the required water reduction & fluidity but should also maintain the dispersing effect. The Using M40 grade of concrete with curing period of 7days, 14days and 28days.To Study the workability and mechanical properties of Self-Compacting Concrete & Compare to Conventional Self-Compacting Concrete. The laboratory testing included slump flow test, L-Box test, V-Funnel test, compressive strength test, and splitting tensile strength test.

Key Words: Self-Compacting Concrete, Silica Fume, Rice Husk Ash, Fly Ash, Super Plasticizer & Material Testing

1. Introduction:

Self-compacting Concrete (SCC) is first developed in Japan in the year of 1980's. A concrete that can able to flow and consolidate under its own weight, also it fill the complete formwork even in the presence of congested reinforcing bars and it maintain it properties without the any need of compaction, and it undergoes without any bleeding and segregation. In recent times, this concrete is used many countries for their need of applications and structural configurations. From the use of SCC offers some sustainable benefits in the construction industry like improves working environment and reduces the overall construction cost. This concrete can used, when there is lack of labour, and it helps to also achieve better surface finish. For this kind of innovation concretes requires high slump, which can be obtain from the addition use of super plasticizers. To avoid the segregation while adding super plasticizers in concrete, the sand content of 4 – 5% has to be increased. When the volume of coarse aggregate is excessive in the concrete, there is a chance of contact between coarse aggregate particles increases greatly, causing interlocking and there is possibility of blockage in concrete while passing through the reinforced bars. So, while designing SCC, the coarse aggregate is to restrict in the volume. This is increases the higher volume use of cement in concrete, which is increases cost of construction. So the cement can be replaced by some mineral admixtures like Silica fumes, Blast furnace slag, Fly ash etc. The usage of mineral admixtures in the production of SCC is not only gives the economical benefits; it can also reduce the heat of hydration (EFNARC guide lines 2002). In this mineral admixtures have some improving rheological properties, and also reduces the thermal cracking in the concrete by the reducing the overall heat of hydration, and it increase workability and durability of concrete. There is no standard mix proportion design for SCC, hence it work in this Nan Su et al. Compared with conventional concrete of similar mechanical properties, the material cost of SCC is more due to the relatively high demand of Cementation materials and chemical admixtures including high – range water reducing admixtures (HRWRA) and viscosity enhancing admixtures (VEA). Typically, the content in Cementation materials can vary between 450 and 525kg/m^3 for SCC. It can be filled of highly restricted areas and for repair works. Particular works requires low aggregate volume for the uniform flow among the restricted spacing without blocking and it ensures to fill all over the formwork without consolidation. By the proper way of increase high volume of finely ground powder materials is necessary to enhance cohesiveness and increase the paste of volume required for successful casting of SCC. The SCC essentially eliminates the need for vibration to consolidate the concrete. This results in an increase in productivity, a reduction in noise exposure and a finished product.

2. Literature Review:

Rajathi. A & Portchejian.G (2014) were described "Experimental study on Self Compacting Concrete using Glass powder" International Journal of Structural and Civil Engineering Research. The specimen was casted by M20 grade of concrete. They studied the effect of different proportion of Glass Powder (5%, 10% and 15%) in concrete. The flow value decreases by an average of 1.35%, 2.2% and 4.36 for glass powder replacements of 5%, 10% and 15% respectively. The V-funnel time is observed and increase by average of 6.21%, 15% and 22.54% for glass powder replacements of 5%, 10% and 15% respectively. The L-box was also observed to follow a decreasing trend with average of 1.5%, 3.2% and 5% for glass powder replacements of 5%, 10% and 15% respectively. The compressive strength decrease with even increase in the glass powder contents. The average reduction of compressive strength for the grade around 6%, 15% and 20% for replacements of glass powder of 5%, 10% and 15% respectively.

Pavi. B. H. V, Nandy. M, Krishnamoorthy. A, Sarkar. P. K & Pramukh Ganapathy. C (2014) were described “Experiment Study on Self-Compacting Concrete contained industrial by-products (GGBS & SF)” European Scientific Journal. The specimen were casted by M25 grade of concrete as per Nan Su et al method., which is specifies the usage of two powders in SCC with GGBS and SF with two different mixes. . The SCC mixes with GGBS and that has SF as powder material tested for fresh properties as per EFNARC guidelines, have satisfied the norms under the EFNARC. From this it can be finalized that achieving fresh SCC properties is possible by process of the Nan Su et al. method where these industrial by-products are used as powders. The GGBS based SCC has good Compressive strength, Split tensile strength and flexural Strength when compared to the SF based SCC. The low strength of SF based SCC is by the high amount of SF (50.19%) in the mix. From the optimum amount of GGBS content is 30% of the total powder content (Dinakar P et al. 2013), the experimental investigation proved to have considerable results for GGBS based SCC of grade M25 for 66.88% of total powder content. From literature review it can see that high volume GGBS content of 80% which can be used to achieve strength of 30MPa (Dinakar P et al. 2013). The strength of GGBS is gains that is based on mix may be attributed to a higher pozzolonic activity of GGBS as compared to SF.

Bouzoubaa.N & Lachemi.M (2001) were described “Self Compacting concrete Incorporating High-Volume of Class F Fly Ash: Preliminary Results” International Centre of Sustainable Development of Cement and Concrete. The specimens were casted by M35 grade of concrete. They studied the effect of different proportion of F Class Fly ash in 40%, 50% and 60% replacement of cement in concrete with water-cement ratio of 0.35 to 0.45. In this nine trials of SCC mixtures and with one conventional concrete were investigated in this study. The high-volume fly ash in self compacting concretes (except one) is having a slump flow range of 500 to 700 mm, a flow time from 3 to 7 seconds, a segregation index in the ranging from 1.9 to 14%, and bleeding water around 0.025 to 0.129 ml/cm^2 . The temperature rises in the self compacting concrete was around 5 to 10 °C lower than that of the normal concrete, and the setting times of the self-compacting concrete were 3 to 4 hours longer than those of the normal concrete. The self-compacting concrete develops compressive strengths in the ranging from 15 to 31 MPa, and it increases from 26 to 48 MPa, at 7 and 28 days, respectively. From the mix design cost, the economical self compacting concrete can be achieved in 28-days around 35Mpa compressive strength that was made with 50% replacement of cement by fly ash, and with a water-to-cementitious materials ratio of 0.45.

N R Gaywala & D B Raijiwala (2006) was done on “Self-Compacting Concrete: A Concrete of Next Decade” Journal of Engineering Research and Studies. The specimens were casted by M25 grade of concrete. They studied the effect of different proportion of Fly Ash (15%, 25%, 35%, 45%, and 55%) in concrete with using high performance super plasticizer of Glenium 784, with the dosage of 1% - 1.5%. From the result, the maximum compressive strength, split tensile strength, flexural strength & pull out strength for self-compacting concrete can be obtained by addition of 15% of fly ash in mix as compared to addition of 25%, 35%, 45% and 55% cement replacement by fly ash. SCC gives good durability properties as compared to the normal concrete. M25 grade of concrete (35% replacement of fly ash in concrete) compressive strength, tensile strength, flexural strength and withdraws strength result are nearer so in construction of heavily congested reinforcement structures and high rise buildings, this mix proportion can be considered.

Oladipupo S. Olafusi, Adekunle P. Adewuyi, Abiodun I. Otunla & Adewale O. Babalola (2015) were described “Evaluation of Fresh and Hardened Properties of Self-Compacting Concrete” Open Journal of Civil Engineering. The specimens were casted by M20 grade of concrete. Two types of SCC mixes were compared with a conventional concrete as control mix to study the plastic and compressive strength properties. The water cement ratio (w/c) for the conventional mix is 0.5, and it varied at 0.5 and 0.38 for the SCC mixes. Conplast SP430 Superplasticizers is used to maintain high workability. The tests are to be conducted for passing ability is determined by the L-box apparatus while their flowability and segregation resistance were tested by the V-funnel apparatus. The compressive strength test has been carried out as per ASTM C39 at 7,14,21,28 & 90days For the well designed SCC mix, the compressive strength at 28 days is in the range of 85% - 95% of conventional concrete, but it exhibited that the compressive strength is slowly increases at 90 days and beyond. Rheological properties of conventional and self-compacting concrete is seems like some different between in it.

Dhiyaneshwaran,S, Ramanathan.P, Baskar.I & Venkatasubramani, R. (2013) were described “Study on Durability Characteristics of Self-Compacting Concrete with Fly Ash” Jordan Journal of Civil Engineering. They studied the effect of different proportion of Fly Ash (10%, 20%, 30%, 40% and 50%) as per the EFNARC. The super plasticizer used was Glenium B233 and with the viscosity modifying agent using Glenium Stream 2. The experiments are carried out by assuming a water-powder ratio of 0.45.The workability test is determined by slump flow, T50, V-funnel, L-Box and U-Box test. The durability of concrete is tested by acid resistance, sulphate attack and saturated water absorption at the age of 28, 56 and 90 days. From the result, 30% replacement of fly ash, the fresh properties observed that is good to compare with 10%, 20%, 40% and 50% fly ash replacement. The dosage of VMA is to properly design as per the criterion of SCC. Otherwise the flowability may fall below 500mm slump, if the dosage is of VMA is more than desired. The local available VMA, if has small changes, then the substantial changes in SCC properties like, Flowing ability, passing ability, stability and segregation resistance. From the result of Mechanical properties (Compressive, split and flexural Strength) the 30% replacement of Fly ash is considerable for flowability, mechanical properties and also for durability study. The acid resistance of SCC with fly ash was higher, when it comes to compare with concrete mixes without fly ash at the age of 28, 56, and 90days. Saturated water absorption percentage can be decreases when the fly ash content is increases. For 30%replacement of fly ash, the lower water absorption level is a good. Compressive strength loss decrease when the increases fly ash in concrete.

Vivek, Bhavana. B, Prema Kumar. W. P, Prathap Kumar. M.T, (2015) were described “experimental investigation on properties of self-compacting and self-curing concrete with silica fume and light weight aggregates” international journal of engineering research & technology. The specimens were casted by m70 grade of concrete, 60 concrete cube and 60 concrete beams for determining the compressive strength and flexural strength. silica fumes 11% weight of cement and super plasticizer 1% weights of the silica fume+cement were used in all the test specimens. self-compacting concrete (scc) and self-compacting and self-curing concrete (scscc) is partially replacing with light weight aggregate (lwa) and super plasticizer (super absorbent polymer (sap)). all the concrete type VIZ., SCC AND SCSCC OF 0.15% AND 0.30% SAP, AND 10% AND 15% OF LWA. For all the concrete types, the compressive and the flexural strengths increase with age. SCSCC of 0.30% SAP gives the highest value for compressive strength at any age compared to others, the next best is SCC. SCSCC of 0.30% SAP has the highest value for flexural strength at all ages compared to the other types, the next best is SCSCC of 0.15% SAP. The compressive strength of SCSCC of 15% LWA at 28 days is considerably lower than the designed strength. Self-compacting and self-curing concretes with SAP (SCSCC of 0.15% and 0.30%) have better flexural strengths compared to self-compacting concretes (SCC) and self-compacting and self-curing concretes with LWA (SCSCC of 10% and 15%).

Junaid Ahmad, Raj Bandhu Dixit, Rahul Singh (2015) were described “To Study the Properties of Self Compacting Concrete Using Recycled Aggregate and Polypropylene Fiber” International Journal of Recent Research in Civil and Mechanical Engineering. The specimens were casted by M25 grade of concrete. They studied about the work demolished concrete in various % (I.e. 5%, 10%, 15%&20% of T.C.A) has been used as partial replacement of coarse aggregate and fly ash with 45% replacement of cement has been used. In this dissertation work 3 type of mix has been done to study the properties of SCC. Type 1-Nominal casting for SCC of M25 grade. Type 2-Casting of SCC with the partial replacement of coarse aggregate with demolish concrete in various percentage of (5%, 10%, 15% & 20%) in the nominal mix. Type 3- Casting of SCC with the addition of polypropylene fiber in various percentages of (0.1%, 0.15% & 0.20% by wt of cement) to the mix ,which is giving high strength while using demolish concrete. From the result, the SCC made with 45% of fly ash as the cement replacement gave considerable result after the 28 days of testing. Compressive strength for M25 grade of SCC was found to be 34.22MPa and modulus of rapture as 8.47. On the same mix proportion Total Coarse Aggregate was partially replaced by demolish concrete in different percentages (5%,10%,15% &20%) and it is found the best result for compressive strength and modulus of rupture for 10% demolish concrete i.e. 29.37 MPa and 6.20 respectively. On the above mix polypropylene fiber was added in various percentages to enhance the properties of SCC, 0.15% of weight of cement of polypropylene fiber should be added for best results in SCC. If increase the percentage of fibers more than 0.15%, which is to be detected that decrease in modulus of rupture.

Belal Alsubari, Payam Shafigh and Mohd Zamin Jumaat (2015) were described “Development of Self-Consolidating High Strength Concrete Incorporating Treated Palm Oil Fuel Ash” Open Access Materials ISSN 1996-1944. In this experiment study about the treatment and utilization of Palm oil fuel ash (POFA) in high volume of up to 50% by weight of cement in self-consolidating high strength concrete (SCHSC). POFA was treated via heat treatment to reduce the content of unburned carbon. Ordinary Portland cement (OPC) was substituted with 0%, 10%, 20%, 30%, and 50% treated POFA in SCHSC. The specimens were casted by M60 grade of concrete. Tests have been conducted on the fresh properties, such as filling ability, passing ability and segregation resistance, as well as compressive strength, drying shrinkage and acid attack resistance to check the effect of high volume treated POFA on SCHSC. From the result, the physical properties and the chemical compositions of POFA were gradually improved via heat treatment and the grinding process. Treated POFA can be utilized in higher percentage (up to 50%) with an improving the concrete properties compared to ground POFA. SCHSC is to treated POFA monitoring better fresh properties than the control mix. Incorporating treated POFA up to 50% cement replacement in SCHSCs showed higher compressive strength compared to concrete made with OPC at 28 days of water curing. The specimens containing treated POFA showed better resistance against hydrochloric acid solution compared to SCHSC only made with OPC.

T. Jeevetha, S. Krishnamoorthi & G. S. Rampradheep (2014) were described “Study on Strength Properties of Self-Compacting Concrete with Micro Silica” International Journal of Innovative Research in Science, Engineering and Technology. In this study the Self-Compacting Concrete mix proportions is based on EFNARC. Cement is replaced with various percentage of micro silica (5% and 10%). The fresh properties of workability tests are determined by Slump flow test, L-Box, V-funnel test. And also this study is about the performance of concrete mix with micro silica, super plasticizer and VMA is determined. From the several trial mixes of SCC were designed at varying the powder contents range between 500kg/m^3 to 600kg/m^3 as per EFNARC specification. From the workability results, it was seen that the workability is decreases with increase in percentage of micro silica. It exhibited that 5% replacement of micro silica (powder content of 530kg/m^3) in SCC gives a good workability and compressive strength. If further increases in micro silica in SCC is gradually decreases the compressive strength of concrete.

3. Material Study and Test Results:

General: The self-compacting considered here is prepared by the following ingredients ASTM Type II Portland cement, fine sand (approximately 150-500 μm), and Naphthalene super plasticizer 553.

Cement: Ordinary Portland Cement 53 grade cement can be used.

Fly Ash: SCC is produced with high quantity of powder or fine materials. In majority of cases SCC is used with Fly Ash. Where Class-F Fly ash normally produced burning anthracite or bituminous coal, usually has less than 5% CaO. Class F fly ash has pozzolanic properties only. This fly ash is pozzolanic in nature, and contains less than 20% lime (CaO).

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Silica Fume (SF): Silica fumes also referred to as micro silica or condensed silica fume, is another material that is used as a pozzolonic admixture. It is a product obtained from reduction of high purity quartz with coal in an electric furnace in the manufacture of silicon or ferrosilicon alloy. The use of silica fume in conjunction with super plasticizer has been the backbone of modern high performance concrete. For higher strengths, the use of silica fume is essential. Highly reactive pozzolan used to improve mortar and concrete.

Rice Husk Ash (RHA): Rice husk Ash, is obtained by burning rice husk in controlled manner without causing environmental pollution. Rice husk Ash exhibits high pozzolanic characteristics and contribute to high strength and high impermeability of concrete. Rice husk Ash essentially consist of amorphous silica (90%SiO_2).India produces about 122 million ton of paddy every year .Each ton of paddy producers about 40Kg of RHA.

Fine Aggregate: Fine aggregate should be properly graded to give minimum void ratio and be free from deleterious materials like clay, silt content and chloride contamination etc. It can be natural or manufactured. The grading must be uniform throughout the work. The moisture content or absorption characteristics must be closely monitored as quality of SCC will be sensitive to such changes. Particles smaller than 0.125mm (125µ) size are considered as fine which contribute to the powder content. Fine aggregates shall conform to the required of IS 383. The sand was washed and screened at site to remove deleterious materials and tested as per the procedure given in IS: 2386-1968 and the results were tabulated.

Coarse Aggregate: The coarse aggregate chosen for SCC is typically round in shape, is well graded, and smaller in maximum size than that used for conventional concrete typical conventional concrete could have a maximum aggregate size of 40 mm or more. In general, a rounded aggregate and smaller aggregate particles aid in the flow ability and deformability of the concrete as well as aiding in the prevention of segregation and deformability of the concrete as well as aiding in the prevention of segregation. Gradation is an important factor in choosing a coarse aggregate, especially in typical uses of SCC where reinforcement may be highly congested or the formwork has small dimensions. Gap – graded coarse aggregate promotes segregation to a greater degree than swell-graded coarse aggregate. As with conventional concrete construction, the maximum size of the coarse aggregate for SCC depends upon the type of construction. Typically, the maximum size of coarse aggregate used in SCC ranges from approximately 10 mm to 20 mm.

Chemical Admixture: Admixtures may be defined as the materials other than the basic ingredients of concrete i.e. cement, aggregates and water added to the concrete mix immediately before and during the mixing process to modify one or more specific properties of concrete in fresh and hardened state. Superplasticizer is an essential component of SCC to provide necessary workability. To improve the workability of self-compacting concrete we have to add some plasticizers (water reducers) as a chemical admixture. While naphthalene based superplasticizer are popularly used in conventional concrete, SCC is associated more with polycarboxylic ether based superplasticizer. These have been most recently developed, and are sometimes referred to as "new generation" super plasticizers. The difference in functional mechanism between these two types and general compatibility of the latter with major types of cement could be reasons for this trend. In my project, I am going to use polycarboxylic ether based super plasticizer Naphthalene Super Flow complying with ASTM C-494 type F.

Compressive Strength of Concrete: Compressive strength of concrete is defined as the load, which causes the failure of a standard specimen. (Ex 150 mm cube according to IS) divided by the area of cross section in uniaxial compression under a given rate of loading. The test of compressive strength should be made on 150mm size cubes. Place the cube in the compression-testing machine. The green button is pressed to start the electric motor. When the load is applied gradually, the piston is lifted up along with the lower plate and thus the specimen application of the load should be 300 KN per minute and can be controlled by load rate control knob. Ultimate load is noted for each specimen. The release valve is operated and the piston is allowed to go down. The values are tabulated and calculations are done.

Split Tensile Strength: A concrete cylinder of size 150mm dia×200mm height is subjected to the action of the compressive force along two opposite edges, by applying the force in this manner .The cylinder is subjected to compression near the loaded region and the length of the cylinder is subjected to uniform tensile stress.

Horizontal tensile stress=$2P/\pi DL$

Where, P=the compressive load on the cylinder.

L=length of the cylinder

D=dia of cylinder

4. Test Results:

Test Results for Workability

SCC- Trial mix details are explained below

Trail 1 = C+FA+CA+W + 0.4 % SP

Trail 2 = C+FA+CA+W + 0.9 % SP

Trail 3 = C+FA+CA+W + 1.2 % SP

The following table shows the SCC Trial mix Workability test results.

MIX	Slump Flow (mm)	L-Box Test (mm)	V-Funnel Test (sec)
Trail 1	520	0.6	1.25
Trail 2*	590	0.7	2
Trail 3	670	1	2.5

* Best Trail mix = SCC

SCC Mix = C+FA+CA+W+1.2% SP

The following table shows the comparison ofcompressive strength of Conventional Self-Compacting Concrete, and Mixing Self-Compacting Concrete.

Type	7 days (N/mm2	14 days (N/mm2)	28 days (N/mm2)
SCC	27.66	30.85	47.47
Mix-1	28.83	31.38	48.9
Mix-2	29.67	32.55	48.57
Mix-3	28.9	32.35	46.57

The Split Tensile Strength of Conventional Self-Compacting Concrete, and Mixing Self-Compacting Concrete.

Type	7 days (N/mm2	14 days (N/mm2)	28 days (N/mm2)
SCC	3.02	3.6	4.12
Mix-1	3.09	3.54	4.08
Mix-2	3.16	3.62	4.21
Mix-3	3.08	3.6	4.11

5. Conclusion:

To increase the stability of fresh concrete using increased amount of fine materials in the mixes. Some of the cement replacement material has positive effects on self- compacting concrete; mechanical and fresh properties. The amount of aggregates, binders and mixing water, as well as type and dosage of super plasticizer to be used are the major factors influencing the properties of SCC. Slump flow, V-funnel, L-flow, U-box and compressive strength, Split tensile strength tests were carried out to examine the performance of SCC. The maximum Expected compressive strength, Split tensile strength for self-compacting concrete can be obtained by addition of 20% of fly ash, 10% of Silica Fume & 10% Rice Husk Ash mix as compared to addition of 5% & 15% of cement replacement by Rice Husk Ash.

6. References:

1. Rajathi. A & Portchejian. G “Experimental study on Self Compacting Concrete using Glass powder”, International Journal of Structural and Civil Engineering Research, 2014.
2. Dhiyaneshwaran, S, Ramanathan. P, Baskar.I & Venkatasubramani. R “Study on Durability Characteristics of Self-Compacting Concrete with Fly Ash”, Jordan Journal of Civil Engineering,(2013).
3. T. Jeevetha, S. Krishnamoorthi & G. S. Rampradheep “Study on Strength Properties of Self-Compacting Concrete with Micro Silica” International Journal of Innovative Research in Science, Engineering and Technology, 2014.
4. Vivek, Bhavana. B, Prema Kumar. W. P, Prathap Kumar. M. T, “Experimental Investigation on Properties of Self-Compacting and Self-Curing Concrete with Silica Fume and Light Weight Aggregates” International Journal of Engineering Research & Technology, 2015.
5. Bouzoubaa. N & Lachemi. M “Self Compacting concrete Incorporating High-Volume of Class F Fly Ash: Preliminary Results” International Centre of Sustainable Development of Cement and Concrete, 2001.
6. Oladipupo S. Olafusi, Adekunle P. Adewuyi, Abiodun I. Otunla & Adewale O. Babalola “Evaluation of Fresh and Hardened Properties of Self-Compacting Concrete” Open Journal of Civil Engineering, 2015.
7. K. Sathish Kumar* and S. Dilli Babu “A Study on Performance of Self Compacting Concrete with Mineral Admixtures” Indian Journal of Science and Technology, 2015.
8. N R Gaywala& D B Raijiwala “Self-Compacting Concrete: A Concrete of Next Decade” Journal of Engineering Research and Studies, 2006.
9. Pavi. B. H. V, Nandy. M, Krishnamoorthy. A, Sarkar. P. K & Pramukh Ganapathy. C “Experiment Study on Self-Compacting Concrete contained industrial by-products” European Scientific Journal, 2014.
10. Nagamoto N. and Ozawa K. “Mixture proportions of self-compacting high performance concrete”, High-performance Concrete: Design and Materials and Advances in Concrete Technology.
11. Sumit Ahlawat, Utsav Jain, Shwetang Kundu “Design Mix - Self Compacting Concrete” International Journal of Engineering Science Invention Research & Development, 2015.
12. SanjeevGill,.RajivKumar“ Experiment Study on Workability of Concrete by various type of water cement ratio” International Journal of Latest Research In Engineering and Computing, 2015.
13. M. A. F. Arediwala M. A. Jamnu “Relation between Workability and compressive Strength of Self-Compacting Concrete.” International Journal of Advanced Engineering Research and Studies, 2012.
14. The European guidelines for self compacting concrete, 2005.
15. Belal Alsubari, Payam Shafigh and Mohd Zamin Jumaat “Development of Self-Consolidating High Strength Concrete Incorporating Treated Palm Oil Fuel Ash” Open Access Materials ISSN 1996-1944, 2015.
16. N. Kaarthik Krishna, S. Sandeep, K. M. Mini, “Study on Concrete with Partial Replacement of Cement by Rich Husk Ash”.