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To Study Performance of Self-Compacting Concrete: A Review

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Abstract: Concrete is one of the versatile construction materials which are used worldwide. Self-Compacting Concrete is a type of concrete which is capable of flowing into the form work uniformly, without segregation and bleeding, better finishes, easier placement, thinner concrete sections, no vibration, safer working environment without any application of vibration. Due to many advantages like faster construction, reduction in site for thinner concrete sections, improved durability, suitability for congested reinforcement; this concrete becomes popular in civil engineering construction. Self-Compacting Concrete (SCC) is a flowing concrete mixture that is able to consolidate under its own weight, without the need for vibration. The highly fluid nature of SCC makes it ideal for placing in difficult conditions and in sections with congested reinforcement. Mixture proportions for SCC differ from those of ordinary concrete, in that the former has more powder content and less coarse aggregate. Fresh state properties of SCC like flow property, filling property, passing ability and segregation resistances of the mixes were checked by conducting inverted slump flow test, T500mm flow, V-shaped funnel test, V-shaped funnel test at T5min test, L-Box test method, U-Box test method were carried out according to EFNARC guidelines. Self-consolidating Concrete or Self Compacting High-Performance Concrete. It is very fluid and can pass around abstructions and fill all the nooks and corners without the risk of either mortar or other ingredients of concrete separating out, at the same time there are no entrapped air or rock pockets. This type of concrete mixture does not require any compaction and is saves time, labour and energy.

Keywords: SCC, Cement Concrete, Chemicals Admixtures.

I. INTRODUCTION

Self-Compacting concrete (SCC) Firstly introduced in 1986 by Prof. Okamura (Kochi University), Japan. It is a greatest technological advancement and the most revolutionary development in concrete technology over the years, at least from 1980 till date. SCC can flow under its own weight and does not require external vibration to undergo compaction. It is used in the construction where it is hard to use vibrators for consolidation of concrete. Filling and passing ability, segregation resistance are the properties of self-compacting concrete. SCC possess superior flow ability in its fresh state that performs self-compaction and material consolidation without segregation issues. Addition of super plasticizer is necessary to this concrete to increase the flow of concrete in some cases VMA may also be used to maintain homogeneity of the concrete. SCC also acts as environment friendly concrete by reducing the noise pollution and safety of labours at site and surroundings is maintained.

In India the power stations are mostly coal based which requires a huge amount of coal. Electricity is generated by wind mills, solar power plants, hydroelectric power plants, coal fired power plants(thermal power plants), nuclear power plants etc, since power generated by wind mills, hydroelectric power stations and solar plants is less and power generation by nuclear power plants is not safe greater importance is given on power generation by coal fired power stations as coal is available abundantly in our country, thus coal fired power plants(thermal power plants) are the main power generation centres, but the problem with these power plants is the disposal of ccp's (coal combustion products) which requires large land area, water, energy for their disposal since these particles are very fine if not properly managed will travel through air and disturbs the ecology and are harmful to the people dwelling in the surroundings. Disposal of ccp's is the most debated issue in the recent past. Coal combustion products comprises of fly ash, bottom ash (pond ash), cenospheres, conditioned ash and flue gas desulfurization. Mainly ccp's comprises of fly ash and pond ash about 90% (fly ash 75-80% and pond ash 15-20%) other products are in traces.

II. LITERATURE REVIEW

A. Nazari and S. Riahi studied the flexural strength, thermal properties of self-compacting concrete with different amount of SiO_2 nanoparticles has been investigated. SiO_2 nanoparticles with the average particle size of 15nm were

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partially added to self-compacting concrete and various behaviors of the specimens have been measured. It was observed that nanoparticles contributes increasing the strength of SCC[1]. J. G. Jawahar focused on finding the properties of self-compacting concrete by replacing the aggregate with crushed granite stones of size 20mm and 10mm. The concrete is obtained by replacing the cement with the class F fly ash by 35% and 0.36 water/cementitious ratio by weight. The fresh properties of the concrete were obtained by conducting workability test, V-funnel and L-box test. The test is conducted for different type of mixes. The test reveals that some mixes are successful in slump flow test they were failed in V-funnel and L-box test. He also concluded about the range of coarse aggregate content suitable for particular coarse aggregate blending in self-compacting concrete[2]. Beeralingegowda studied about the properties of self-compacting concrete which is obtained by partially replacing cement with limestone powder. He computed the fresh properties and hardened properties of the concrete. He also found the durability characteristics of the concrete. In this study, he concluded that with 30% replacement of limestone powder in the concrete results in 20% increase in the workability and mechanical properties of the concrete. He also concluded that with 20% replacement of limestone powder results in increase in acid resistance and sulphate resistance of the concrete. He also observed that the chloride content in the specimen is decreased with increase in depth of the specimen[3]. Ameeri investigated about the self-compacting concrete in which the steel fiber is partially replaced. He studied the fresh properties that comprise of flow ability, passing ability and viscosity and computed the hardened properties like compressive strength, split tensile strength and flexural strength of the specimens. He concluded that with the increase in fiber content the workability of the concrete is reduced. He also concluded that at an optimum percentage of 0.75% to 1% replacement of steel fibers, the compressive strength, split tensile strength and flexural strength characteristics of the self-compacting concrete had been improved[4].This thesis of R. Deeb describes the steps taken to develop self-compacting concrete (SCC) mixes with and without steel fibers. For the self-compacting concrete mixes without steel fibers the fulfilment of the flow and cohesiveness criteria are found to be sufficient for the mix design. However, for the design of self-compacting concrete mixes with steel fibers it is found that they must additionally meet the passing ability criterion[5].S. V. Panina investigated about the fresh and hardened properties of self-compacting concrete using recycled concrete aggregate as both coarse and fine aggregates. The concrete was prepared by replacing 25%, 50% and 75% of coarse and fine recycled aggregates. The study consisted of thirteen concrete mixes which reflect the key variables and their effects on the fresh and hardened properties of the produced SCC. The results indicated that the properties of the recycled aggregates SCCs have only a slight difference, in their properties from the natural aggregates SCC. The recycled concrete aggregate as both coarse and fine aggregates can successfully be used for making of SCC[6]. Pai had investigated about the self-compacting concrete where Ground Granulated Blast furnace slag (GGBS) and Silica fume (SF) is partially replaced with cement. He concluded that the flowing ability and passing ability of the concrete were satisfied with the EFNARC guidelines. He observed that the GGBS based self-compacting concrete exhibits improved mechanical properties compared to the SF based self-compacting concrete. He also analyzed that GGBS can be replaced up to 80% to achieve strength of 30Mpa[7].Divya Chopra investigated the effect of rice husk ash (RHA) as supplementary cementitious material as a partial replacement of cement in SCC. Replacing the cement was replaced by RHA in the percentage of 0, 10, 15 and 20% SCC specimens. The results showed that in 15% RHA replacement increases the strength of SCC[8]. S. Yehia has checked the suitability of producing concrete using 100% recycled aggregate. Four grades of aggregate were taken for investigation purpose. grade 1 (maximum size of 10 mm), 2 (maximum size of 25 mm), 4 (mixture of course and fine aggregate along with impurities) and 5 (fine sand). showed that there was a good bonding between recycled aggregate and cement paste no crack formation seen in structure[9].In this experimental investigation SCC is prepared using fly ash and pond ash. Slump flow test, V-funnel test, L-box test were carried out to confirm the self-compact ability of concrete. Compressive strength test, split tensile test, flexural strength test was carried out on SCC. The results revealed that the polluting materials like fly ash and pond ash can be used effectively in Self compacting concrete[10].Jai Prakash Reddy examined the fresh properties of SCC using pond ash. He produced SCC mixes by replacing fine aggregates by pond ash. Polycarboxylic based superplasticizer was used to enhance workability of the concrete mixes. Fresh state properties of SCC like flow property, filling property, passing ability and segregation resistances of the mixes were checked by conducting inverted slump flow test, T500mm flow, V-shaped funnel test, V-shaped funnel test at T5min test, L-Box test method, U-Box test method were carried out according to EFNARC guidelines. he concluded that up to 60% pond ash can be replaced to fine aggregates in self-compacting concrete with further replacements after 60% segregation of concrete takes place. Also, up to 50% replacement level self-compacting concrete can be easily handled at further replacement concrete becomes harsh this may be because coarse texture of pond ash[11]. M. B. Alhasanat reports the effect of addition of Polypropylene (PP) fibers in the performance of Self-Compacting Concrete (SCC) under elevated temperatures. Various SCC mixtures were made with PP fiber at 0.0, 0.05, 0.10 and 0.15% by volume

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added. The specimens were exposed to elevated temperatures (200°C [392°F], 400°C [752°F] and 600°C [1112°F]). It was reported that PP fibers reduced explosive spalling of SCC above 0.05% by volume and increased the porosity significantly[12].V Kannan evaluated the fresh state and mechanical properties of self- compacting concrete (SCC) with binary and ternary cementitious blends of metakaolin (MK) and fly ash (FA). The researcher replaced the cement by Metakaolin (MK) in the percentage 5,10,15,20,25 and 30%. Six SCC specimens he prepared with cement replaced by fly ash (FA) in the percentage 5,10,15,20,25 and 30%. Four specimens were prepared with cement replacement in combination of FA and MK. It was observed that unblended self-compacting concrete shows poor performance in relation to strength and durability of SCC. MK and FA blended SCC gave strong and durable SCC due to pozzolanic reaction of MK and FA[13].

3 MATERIALS AND METHODS

SCC is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in sections with congested reinforcement. SCC consists of cement, aggregates, water and admixtures which are similar to the composition of normal vibrated concrete, however, the less quantity of coarse aggregates, the large quantity of fines with the incorporation of super plasticizer, the low water to cement ratio gives self-compacting concrete.

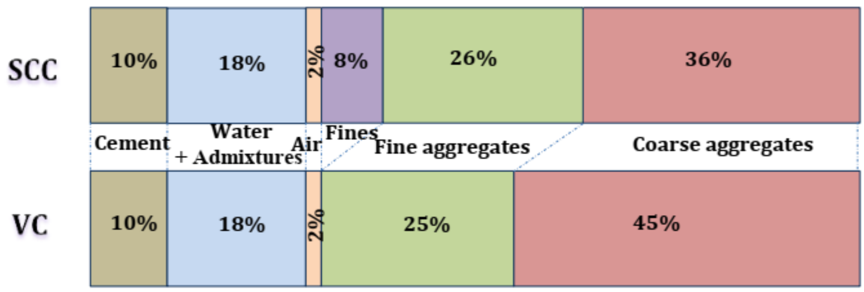

Figure 1: Comparison between SCC and NC

Properties of fresh SCC:

Following are the properties of self-compacting concrete in fresh state required to be tested before testing of mechanical properties of SCC such as Compressive strength, Tensile strength and flexural strength.

Filling Ability- Self-compacting concrete must be able to flow into all the spaces within the formwork under its own weight. The filling ability or flowability is the property that characterizes the ability of the SCC of flowing into formwork and filling all space under its own weight, guaranteeing total covering of the reinforcement. The mechanisms that govern this property are high fluidity and cohesion of the mixture.

Passing ability - Self-compacting concrete must flow through tight openings such as spaces between steel reinforcing bars under its own weight. The mix must not 'block' during placement. The passing ability is the property that characterizes the ability of the SCC to pass between obstacles- gaps between reinforcement, holes, and narrow sections, without blocking. The mechanisms that govern this property are moderate viscosity of the paste and mortar, and the properties of the aggregates, principally, maximum size of the coarse aggregate.

High Resistance to Segregation - During placement and while flowing, the concrete should retain its homogeneity. There should be no separation of aggregate from paste or water from solids, and no tendency for coarse aggregate to sink downwards through the fresh concrete mass under gravity.

Mechanisms of achieving SCC

In the fresh state, SCC should achieve high flow-ability as well as rheological stability which means it must be as fluid as possible in the fresh state to fill under its own weight all the far-reaching corners in the form work and pass through heavy reinforcement without segregation. The methodology of selecting the right amount of materials and admixtures is crucial to achieve this goal. The following three main rules have been suggested by Okamura and Ouchi

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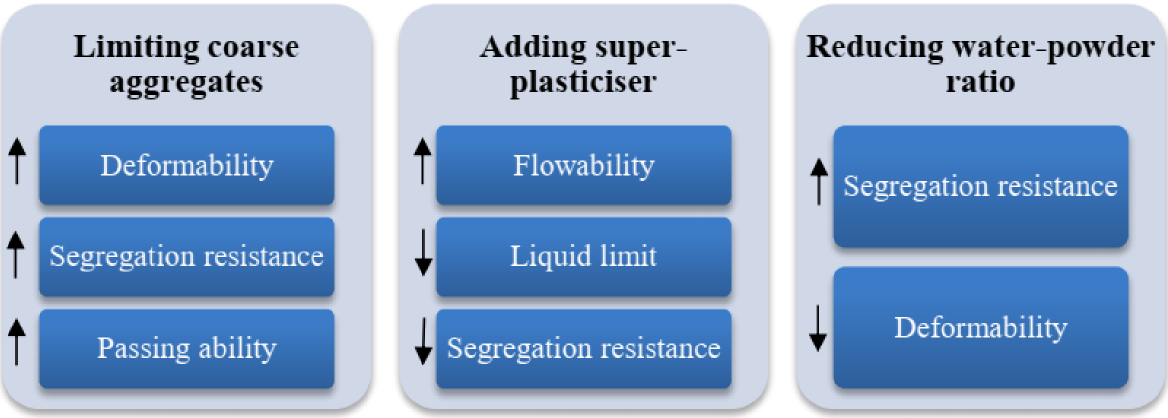

Figure 2: Mechanisms of achieving self-compact ability

Ingredients of SCC

SCC is something different than the conventional concrete or modification of conventional concrete it has similar ingredients such as Aggregate binder, however there blending is changed so as to get the advantage of self-compactness:

- **Cement**: Ordinary Portland Cement, 43 or 53 grade can be used.
- **Aggregates**: The maximum size of aggregate is generally limited to 20 mm. Aggregate of size 10 to 12mm is desirable for structures having congested reinforcement. Particles smaller than 0.125 mm i.e. 125 micron size are considered as fines which contribute to the powder content.
- **Mixing Water**: the quality of water used for normal concrete same can be used for SCC.
- **Chemical Admixtures**: chemical admixtures are an essential component of SCC to provide necessary workability. Superplasticizer, Viscosity Modifying Agent are mainly used for SCC
- **Mineral Admixtures**: Fly ash, GGBFS, Silica Fume, Stone Powder, Fibers

4 TESTING OF SELF-COMPACTED CONCRETE

- Flow Ability Using Slump 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. 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 are recorded and the average flow spread diameter SF is calculated using Equation.(refer fig no.3).

$$SF = (D1+D2) / 2$$

According to the latest mix design guidelines for self-compacting concretes (BS EN 206-9, 2010) two viscosity classes are introduced: viscosity class 1 (VS1) and viscosity class 2 (VS2) depending on whether t500 < 2 sec or ≥ 2 sec.

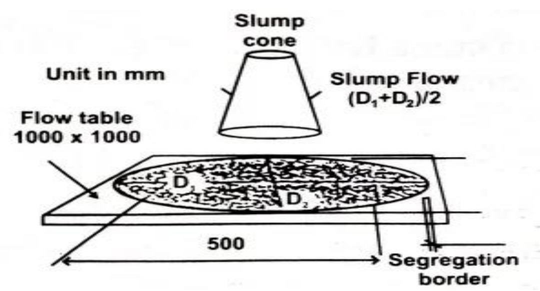

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Figure 3: Slump test apparatus

- Passing Ability Using L-Box Tests

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.(As shown in fig no.4)

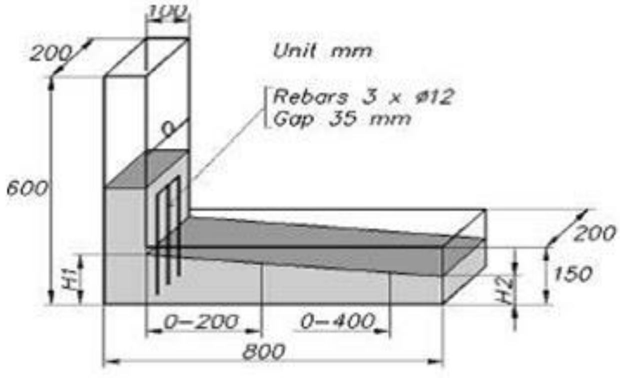

Figure 4 : L-box test apparatus

The passing ability ratio PL should be calculated:

$$PL=H_2/H_1$$

H1 is the mean depth of concrete in the vertical section of the box.
H2 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 from the gate, respectively as illustrated.

It should be mentioned that this test is very sensitive to the operators in terms of the speed of lifting the gate. Slow lifting could result in an increase in t200 and t400.

- Passing Ability Using U-box Test

U box test was developed by the Technology Research Centre of the Taisei Corporation in Japan. Sometime the apparatus is called a “box shaped” test. U Box test is used to measure the filing ability of self-compacting concrete. The apparatus consists of a vessel that is divided by a middle wall into two compartments; an opening with a sliding gate is fitted between the two sections. Reinforcing bar with nominal diameter of 134 mm are installed at the gate with centre to centre spacing of 50 mm. this create a clear spacing of 35 mm between bars. The left-hand section is filled with about 20 liter of concrete then the gate is lifted and the concrete flows upwards into the other section. The height of the concrete in both sections is measured.(Refer fig no.5)

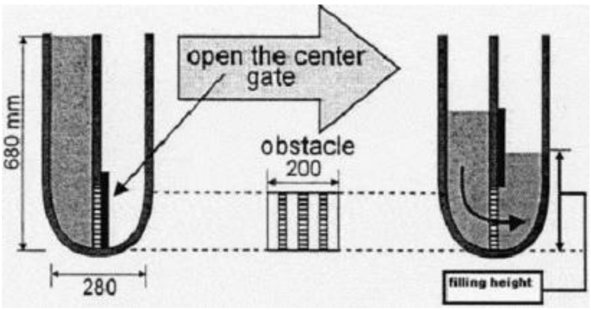

Figure 5 : U-Box Test Apparatus

If the concrete flows as freely as water, at rest it will be horizontal, so H1-H2=0. Therefore, the nearest this test value, the 'filling height', is to zero, the better the flow and passing ability of the concrete.

- Passing Ability Using V funnel test

The equipment for V funnel test on self-compacting concrete consists of a v shaped funnel (As shown in fig no.6). The equipment consists of V-shaped funnel section is also used in Japan. The described V-funnel test is used to determine the filling ability (flowability) of the concrete with a maximum aggregate size of 20mm. The funnel is filled with about 12 liter of concrete and the time taken for it to flow through the apparatus measured. After this the funnel can be refilled concrete and left for 5 minutes to settle. If the concrete shows segregation, then the flow time will increase significantly.

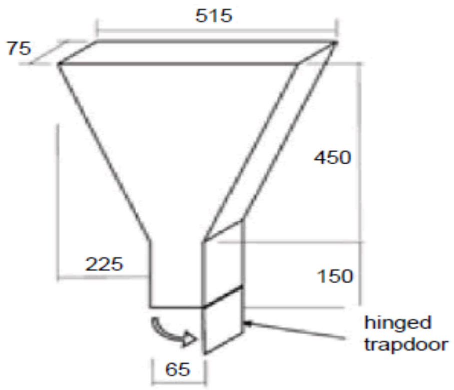

Figure 6 : V Funnel Test Apparatus

This test measures the ease of flow of concrete, shorter flow time indicates greater flow ability. For SCC a flow time of 10 seconds is considered appropriate. The inverted cone shape (refer fig no.6) restricts the flow, and prolonged flow times may give some indication of the susceptibility of the mix to blocking. After 5 minutes of settling, segregation of concrete will show a less continuous flow with an increase in flow time.

CONCLUSION

Concrete can be used for any structural applications with limitation. Self-compacting concrete is the only type of concrete where the vibration effect is ignored, thus making the environment protection near the construction site and also reduce the exposure of workers to vibration, Elimination of problems associated with vibration. Ease of placement results in cost savings through reduced equipment and labour requirement it result make the construction faster. The advantage of SCC makes it desirable all over the world. It is concluded that different products exhibit different properties at the fresh and hardened state. The fresh concrete has been evaluated with the Slump-flow, V-funnel and J-ring tests, and its air content has been measured. All mixes meet the criteria set by these tests. Processes are on the basis of present study, following conclusions can be drawn.

REFERENCES

[1] P. Ezhil, "Utilization of Fly ash and Pond ash in Self Compacting Concrete," vol. 4, no. 08, pp. 1–4, 2016.
[2] J. P. R. M. P. D, "Assessment of Fresh Properties of Pond Ash SCC," Int. J. Sci. Res., vol. 5, no. 7, pp. 1870–1875, 2016, [Online]. Available: https://www.ijsr.net/archive/v5i7/ART2016625.pdf.
[3] R. Deeb, "Flow of Self-Compacting Flow of Self-Compacting," 2013.
[4] A. Nazari and S. Riahi, "Microstructural, thermal, physical and mechanical behavior of the self-compacting concrete containing SiO2 nanoparticles," Mater. Sci. Eng. A, vol. 527, no. 29–30, pp. 7663–7672, 2010, doi: 10.1016/j.msea.2010.08.095.
[5] D. Chopra, R. Siddique, and Kunal, "Strength, permeability and microstructure of self-compacting concrete containing rice husk ash," Biosyst. Eng., vol. 130, pp. 72–80, 2015, doi: 10.1016/j.biosystemseng.2014.12.005.
[6] S. Yehia, K. Helal, A. Abusharkh, A. Zaher, and H. Istaitiyeh, "Strength and Durability Evaluation of Recycled Aggregate Concrete," Int. J. Concr. Struct. Mater., vol. 9, no. 2, pp. 219–239, 2015, doi: 10.1007/s40069-015-0100-0.
[7] M. B. Alhasanat, A. N. Al Qadi, O. A. Al Khashman, and A. Dahamsheh, "Scanning electron microscopic evaluation of self-compacting concrete spalling at elevated temperatures," Am. J. Eng. Appl. Sci., vol. 9, no. 1, pp. 119–127, 2016, doi: 10.3844/ajeassp.2016.119.127.
[8] V Kannan and K Ganesan, "Mechanical properties of cementitious blends of with binary and ternary self-compacting concrete metakaolin and fly ash," J. South african Inst. Civ. Eng., vol. 56, no. 2, pp. 97–105, 2017, [Online]. Available: http://www.scielo.org.za/pdf/jsaice/v56n2/11.pdf.

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International Advanced Research Journal in Science, Engineering and Technology

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DOI: 10.17148/IARJSET.2021.81136

[9] M.K. Rahman, M.H. Baluch, M.A. Malik, “Thixotropic behavior of self-compacting concrete with different mineral admixtures”, Construction and building materials, 50, 2014, pp 710-717.

[10] M.A.FArediwala, M.A.Jamnu, “Relation between workability and compressive strength of self compacting concrete”, International Journal of Advanced Engineering Research and studies, Vol I, Issue 3, pp 9-11.

[11] Prof.Aijaz Ahmad Zende, Dr.R.B.Khadirnaikar, “An overview of the properties of the self compacting concrete”, IOSR-JMCE, pp 35- 43.

[12] Prajapati Krishnapal, Yadav.R.K. and Chandak Rajeev, “Strength Characteristics of self compacting concrete containing fly ash”,

[13] M.Iyappan and Dr.A.Jagannathan, “High strength self compacting concrete with nano silica”, International Journal of Emerging Trends in Engineering and Development, 2014, Issue 4, Vol 5, pp 163-168.

[14] Prof. Shriram H.Mahure, Dr.V.M.Mohitkar, “Effect of mineral admixture on fresh and hardened properties of self compacting concrete”, International Journal of Innovative Research in Science, Engineering and Technology, 2013, Issue 10, Vol 2, pp 5585-5592.

[15] Abbas Al-Ameeri, “The effect of steel fiber on some mechanical properties of self compacting concrete”, American Journal of civil engineering, 2013, Issue 3, pp 102-110. International Journal of Engineering Research & Technology (IJERT) http://www.ijert.org ISSN: 2278-0181 IJERTV5IS020349 (This work is licensed under a Creative Commons Attribution 4.0 International License.) Published by : Vol. 5 Issue 02, February-2016 386

16] B.Beerlingegowda, V.D.Gundakalle, “The effect of addition of lime stone powder on the properties of self compacting concrete” International Journal of Innovative Research in Science, Engineering and Technology, 2013,Vol 2, Issue 9, pp 4996-5004.

[17] B.H.V.Pai, M.Nandy, A.Krishnamoorthy, P.K.Sarkar and C.Pramukh Ganapathy, “ Experimental Study on self compacting concrete containing Industrial by-products”, European scientific Journal, April 2014, Vol.10, pp 292-300.

[18] Dhiyaneshwaran.S , Ramanathan,.P, Baskar.I and Venkatasubramani.R. ” Study on durability characteristics of self compacting concrete containing fly-ash”. Journal of civil Engineering2013,Vol. 7, Issue 3, pp 342-353.

