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The Performance of Self Compacting Concrete in the Building Infrastructure

Subhashish Dey*, K. Ramanjaneya Goud and S.K.John Basha

Civil Engineering Department, Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal, India
*Corresponding Author Email id: subhasdey633@gmail.com

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Abstract

Concrete is the most widely used construction material because of its mould ability into any required structural form and shape due to its fluid behavior at early ages. Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens (cures) over time. Through compaction using vibration is normally essential for achieving workability, the required strength and durability of concrete. Inadequate compaction of concrete results in large number of voids. Affecting strength and long term durability of structures, self compacting concrete (SCC) provides a solution to these problems. And it is able to compact itself without any additional vibration. In this concrete, cement replacement with some material like flyash, metakaolin, ground granulated blast furnace slag (GGBS) etc. because to reduce 5-7% of CO_2 emissions in cement and due to the curing of concrete large amount of water is required. To overcome the high consumption of water it is needed to study the self-curing concrete. The cement reacts with water and other ingredients to form a hard matrix that binds the materials together into a durable stone-like material that has many uses. This investigation will shown scientific basis for potential design of SCC materials for concrete structures.

Keywords: *Concrete, Self compacting concrete, Metakaolin, Curing, Compaction and Structures*

1. Introduction

Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens (cures) over time. In the past lime based cement binders were often used, such as lime putty, but sometimes with other hydraulic cements, such as calcium aluminates cement or with Portland cement to form Portland cement concrete. Many other non cementations' types of concrete exist with different methods of binding aggregate together, including asphalt concrete with a bitumen binder, which is frequently used for road surfaces and polymer concretes that use polymers as a binder. When aggregate was mixed with dry portland cement and water, the mixture forms fluid slurry that is easily poured and molded into shape (Kovler and Jensen. 2005; Hasselman, 1969). The cement reacts with water and other ingredients to form a hard matrix that binds the materials together into a durable stone-like material that has many uses. Often, additives are included in the mixture to improve the physical properties of wet mix or finished material. Most concrete was poured with reinforcing materials embedded to provide tensile strength and yielding reinforced concrete. Concrete is one of the most frequently used building materials. Its usage worldwide is twice that of steel, wood, plastics and aluminum combined. Globally, the ready-mix concrete industry, the largest segment of the concrete market, is projected to exceed $600 billion in revenue by 2025 ((Kumar and Bhattacharjee, 2003; Mehta and Monteiro, 2014).

1.1 Self Compacting Concrete

Self-consolidating concrete or self-compacting concrete (SCC) is a concrete mix which has a low yield stress, high deformability, good segregation resistance (prevents separation of particles in the mix) and moderate viscosity (necessary to ensure uniform suspension of solid particles during transportation, placement (without external compaction), and thereafter until the concrete sets. In everyday terms, when poured, SCC is highly fluid mix with the following distinctive practical features – it flows very easily within and around the formwork, can flow through the obstructions and around corners "passing ability" is close to self-leveling (although not actually self-leveling), does not require vibration or tamping after pouring and follows the shape and surface texture of a mold (or form) very closely once set. As a result, pouring SCC is also much less labor-intensive compared to standard concrete mixes (Leach and Sales, 1992; Okamura and Ouchi, 2003). Once poured, SCC is usually similar to standard concrete in terms of its setting and curing time and strength. SCC does not use a high proportion of water to become fluid in fact SCC may contain less water than standard concretes. Instead, SCC gains its fluid properties from an unusually high proportion of fine aggregate, such as sand typically 50%, combined with super plasticizers (additives that ensure particles disperse and do not settle in the fluid mix) and viscosity-increasing admixtures (VEA) (Oliveira et al., 2015; Okamura et al., 2000).

1.1.1 Self compacting concrete mix design requirements

High volume of paste

As SCC concrete undergoes self-compaction by its own weight, it has to attain adequate filling ability so that the mix reaches every area. Friction between the aggregates restricts this spreading hence the filling capacity. This issue was solved by increasing the paste content in SCC mix design in a range of 300 to 400l/m^3. The volume of paste implies the combination of cement, water, additions and air. This increase in paste helps separation of aggregates and easy movement of mix.\

High volume of fines (<80μm)

SCC must be designed for sufficient workability to show the property of self-compaction. This workability must not bring segregation and bleeding issues. To limit these risks, SCC is designed to have a large number of fines in a range of 500 kg/m^3. Excessive fines in the form of cement bring chances of an increased heat of hydration. For this, a part of fines was replaced by pozzolans or mineral admixtures like silica fume or fly ash.

High dosage of super plasticizers

Super plasticizers are introduced in SCC to obtain the fluidity and workability. Nevertheless, a high dosage near the saturation amount can increase the proneness of concrete to segregate. The increase of workability by using super plasticizers won't leave segregation or bleeding issues.

I.Use of viscosity modifying agent

The viscosity modifying agent in SCC mix design has the same objective as that of fine particles. These help to attain the flow capacity property for concrete without segregation and bleeding issues. These hold the mix by thickening the paste and holding the water with skeleton created by these agents. Viscosity modifying agents are cellulose derivatives, polysaccharides or colloidal suspensions. The introduction of such products in SCC seems to be justified in the case of SCC with the high water to binder ratio (for e.g. residential building).

II.Less coarse aggregate

To increase the passing capacity of SCC, the volume of coarse aggregate added was less. The coarse aggregate used can be naturally rounded, crushed or semi-crushed aggregate. The coarse aggregate has a main role in increasing the packing density of SCC. So that the volume of coarse aggregate not too high or too low. The size of coarse aggregate can be use between 10mm and 20mm. With the increase in size of coarse aggregate, the passing capacity was decreases. The choice of higher aggregate size is thus possible but only with the low reinforcement content.

III. Addition of admixtures

Admixtures added to SCC can have a retarding effect on the strength and temperature development in the fresh concrete and this has to keep in mind in the construction process. Suppliers of admixture can produce various admixtures suitable for different weather conditions and temperatures. The additions have to be performed based on the guidelines provided by the admixtures.

1.1.2 Methods of testing self compacting concrete

The tests methods presented here are devised specifically for self compacting concrete. Existing rheological test procedure have not considered here, though the relationship between results of tests and rheological characteristics of the concrete is likely to figure highly in the future work, including the standardization work.

1.1.2.1 Slump flow test

The *flow tests* method to determine the consistency of fresh concrete. The *flow* table *test* as shown in Fig. 1 is used to identify the transportable moisture limit of solid bulk cargoes. The slump flow test is used assess the horizontal free flow of self compacting concrete in the absence of obstructions. The test method was based on the determining of slump.

Fig. 1: Slump flow table and V-funnel test apparatus

1.1.2.2 V- Funnel test

V-funnel test on self compacting concrete is used to measure the flow capacity. But the flow capacity of concrete is affected by its other properties as well which may affect the flow capacity of concrete during testing. The UTC-0540 *V Funnel* apparatus was used to evaluate the flow time of freshly mixed self-compacting concrete. This standard covers the method of funnel testing for average flow-through speed, relative flow-through speed and flow-through indices of self-compacting concrete with a maximum coarse aggregate size of 25mm or less. The more increase in flow time after the concrete has remained at rest for five minutes, the greater will be the concrete's susceptibility to segregation (Ryshkevitch, 1953; Palou et al., 2016).

1.1.2.3 L-box test

This test assesses the flow of concrete and also the amount to which it's subjected to blocking by the reinforcement. The test apparatus consist of rectangular section box in the shape of an 'L', with a vertical and horizontal section, separated by a movable gate, in front of which vertical length of reinforcement bar are fitted. The L-box test apparatus is shown in Fig. 2.

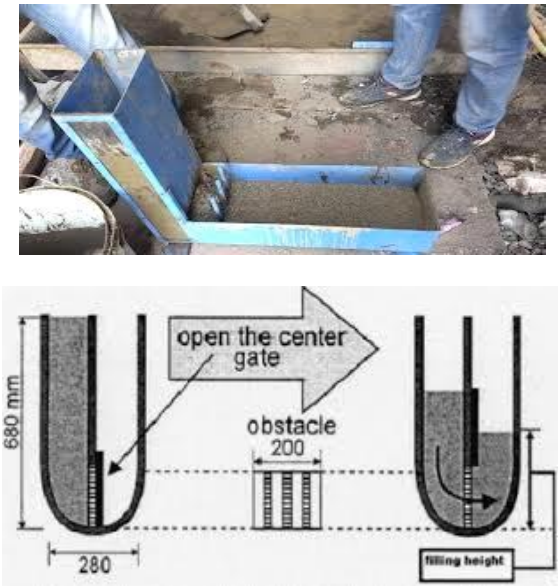

Fig. 2: L-Box test and U-Box test apparatus

1.1.2.4 U- box test

U box test is used to measure the filing capacity of self compacting concrete. U box test was developed by the Technology Research Centre of the Taisei Corporation in Japan. Some time the apparatus is called a "box shaped" test. The apparatus consists of vessel that is divided by a middle wall into two compartments; an opening with a sliding gate is fitted between the two sections. This is a simple test to conduct, but the equipment may be difficult to construct. It provides a good direct assessment of the filling capacity.

1.2 Self Curing Concrete

Self curing concrete is the one which can meet the present and future requirement of curing concrete. Concrete is primarily used in building material. For curing of concrete, require large amount of water. Concrete is a universal construction material and cement, water and aggregates are its ingredients. The strength of concrete depends upon the properties of its constituents and mix proportions and amount of hydration in the concrete. For the complete hydration require good quality of water in certain amount. Curing is the maintenance of a satisfactory moisture content and temperature in concrete for a period of time immediately following placing and finishing so that the desired properties may develop (Rossignolo, 2009; Safi et al., 2013).

Fig. 3: Self curing processes of concrete

Curing has a strong influence on the properties of hardened concrete; proper curing will increase durability, strength, water tightness, abrasion resistance, volume stability and resistance to freezing and thawing etc. As per ACI- 308R the term "curing" is frequently used to describe the process by which hydraulic cement concrete matures and develop hardened properties over time as a result of continued hydration of cement in the presence of sufficient water and heat. As per IS: 456-2000 Curing is the process of preventing loss of moisture from the concrete. Curing of concrete plays a major role in the developing strength and hardness of concrete, which may leads to improvement in the durability and performance. Curing is a process of promoting the hydration of cement and consists of control in temperature and moisture movement into the concrete (Schiller, 1971 and Uysal and Sumer, 2011).

1.2.1 Advantages of self curing

I. When properly applied, provides a premium-grade film, which optimizes water retention.
II. Protects by reflecting the sun's rays to keep the concrete surface cooler and prevent excessive heat build-up, which can cause thermal cracking.
III. Furnished as a ready-to-use, true water-based compound. Produces hard, dense concrete minimizes hair checking, thermal cracking, dusting and other defects.
IV. Offers a compressive strength significantly greater than improperly or uncured concrete.
V. Improves resistance to the abrasion and corrosive actions of salts and chemicals minimizes the shrinkage.

2. Curing processes of the concrete

Curing is the most important process in concreting. Concrete strength increases with the age of curing. The curing temperature of water in the curing tank should be maintained at 27-30°C. If curing is in a mist room, the relative humidity should be maintained at not less than 95%. Curing should be considered as long as possible up to the time of testing. Generally we are curing the cubes and cylinders are two types.

2.1 Water Curing Processes

The specimens should keep in curing tank for better improvement in strength. Generally curing is done by pounding the curing tanks. The water used for concrete curing should be free from salinity, scrap, vegetation and chemicals. The water curing of various concrete specimens is shown in Fig. 4.

In order to provide adequate circulation of water, adequate space should be provided between the cubes and side of curing tank. Water curing is done by spraying water over the concrete surface to ensure that the concrete surface remains continuously moist. This prevents the moisture from body of concrete to evaporating and contributes in the strength gain of concrete (Zhao et al., 2012; Xotta et al., 2015).

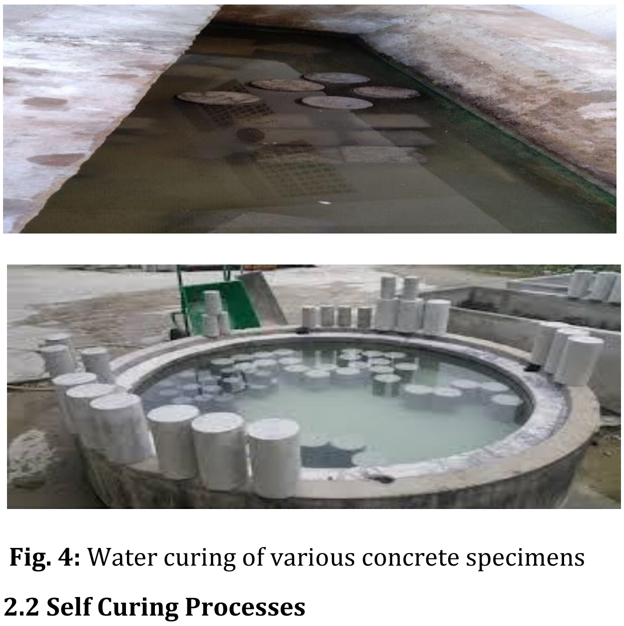

Fig. 4: Water curing of various concrete specimens

2.2 Self Curing Processes

Self-curing concrete is achieved by means of replacing a part of aggregate by light weight aggregate or adding chemical admixtures. The specimen of various self curing concrete is shown in Fig. 5. The self-curing process of concrete takes place from inside to outside, thus reducing the autogenously shrinkage and self-desiccation, especially for the high-performance concrete with relatively low water/binder ratio. There are not available for water then adds self curing agents to improve the strength. The durability and workability of self-curing concrete are improved, compared with conventional air-cured concrete, while the mechanical properties may be either improved or compromised due to the dual function of self-curing agent (Zhutovsky and Kovler, 2012; Krishnudu et al., 2020)

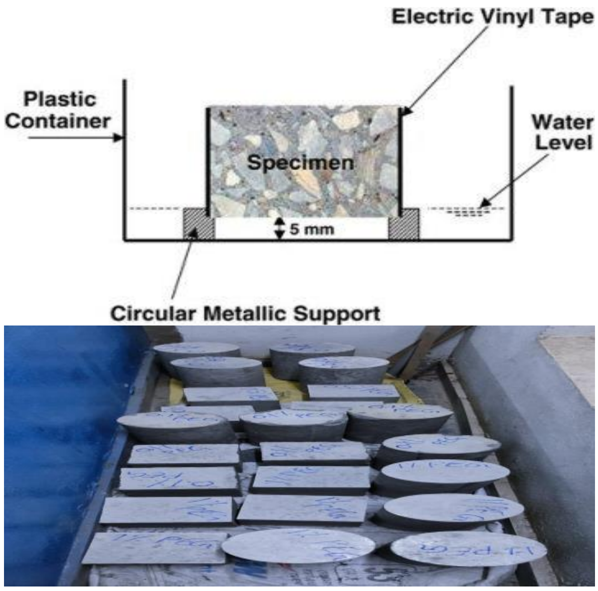

Fig. 5: Self curing of various concrete specimens

Self-curing concrete has been broadly applied in the actual practice, mostly bridge decks and pavements. Self-curing concrete is one type of modern concrete, which cure itself by retaining water in it. The durability properties of *self-cured* SCC are comparable with the traditional *cured specimens.* The main reasons for discrepancies in the performance of concrete are due to the lack of proper compaction and curing. Hence there is a need of concrete that can flow easily through the congested reinforcement and attain better performance without the need of external curing techniques. Self-curing is done in order to fulfill the water requirements of concrete whereas self-compacting concrete is prepared so that it can be placed in difficult positions and congested reinforcements. This investigation was aimed to utilize the benefits of self-curing and self-compacting (Zhang et al., 2020; Wang et al., 2020).

2.3 Hardened Properties of concretes

After complete the curing then conduct hardened properties at 7 and 28 days. Generally the hardened concrete properties are compressive strength, split tensile strength were tested in the concrete laboratory. The density of hardened concrete depends upon the unit weight of constituent materials and volume of void space. The carbonation of harden concrete by atmospheric CO_2 in connections with the corrosions of reinforcing steels. Here, the focus will be effects that carbon dioxide dissolved in water have on concrete. At atmospheric pressure, the carbon dioxide will dissolve slightly in water, producing a solution of carbonic acid (H_2CO_3) with a pH of about 5-6. Now, it should be remembered that pure water by itself will attack concrete. The chemical reactions that can occurred initially the dissolution of carbon dioxide to form carbonic acid (Hou et al., 2020; Rojas, et al., 2020).

2.3.1 Compressive strength of concretes

Compressive strength or crushing strength is the main property observed in the testing of cubes. Cubes are tested to calculate the compressive strength by applying gradual load in the compression testing machine. The compression testing is a testing method that is used to the compressive force or crush resistance of material and capacity of material to recover after specified compressive force and even held over a defined period of time. The measured compressive strength of specimen shall be calculated by dividing the maximum load applied during the test by cross sectional area calculated from mean dimensions of the section shall be expressed to the nearest N/mm². After curing, the specimens are tested for compressive strength as shown in the Fig. 6 by using compression testing machine of 2000 KN capacity (IS: 516 – 1959) (Cao et al., 2020; Qu et al., 2020).

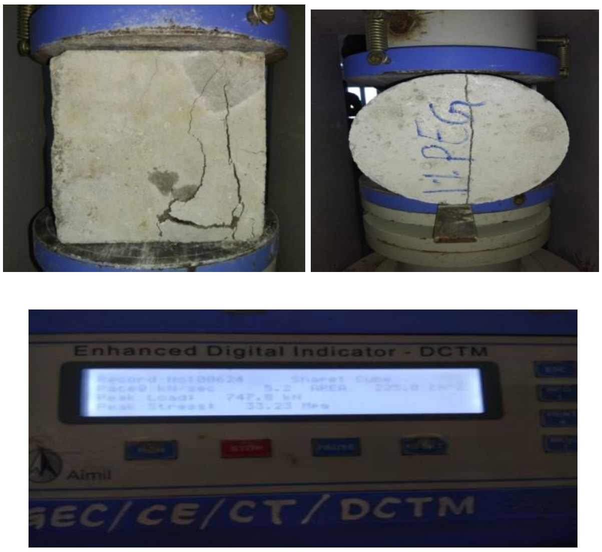

Fig. 6: Compressive and Split tensile strength test of the concrete

2.3.2 Split Tensile Strength of Concrete

Split tensile strength is the most important property of concrete. Concrete is a weak in tension. So that improve the tensile behavior of concrete, split tensile strength is important. The cracking takes place is a form of tension failure. It is important in reducing structure of cracks in the concrete. Cylinders are casted for calculating the split tensile strength. The cylinders are placed in the axial direction by facing cylindrical face to the loading surface. The concrete is very weak in tension due to its brittle nature and not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to find out the tensile strength of concrete to determine the load at which the concrete members may crack. After curing, the specimens are tested for split tensile strength using compression testing machine of 2000 KN capacity (IS: 516 – 1959) (Chand et al., 2014; Ananthi et al., 2017).

2.3.3 Durability of concrete

Durability can be defined as the capacity of structure to required performance during intended service period under the influence of degradation factors. Normally, the concrete is a durable material and requires a little or no maintenance during the life of structure. Durability of concrete depends on the mixed design proportions, workmanship of the work, placing, compaction of concrete and mechanical properties of concrete. Chemical resistance of concrete depends on the selection of materials; weathering action and improved further by introducing air bubbles into the concrete. The durable concrete will retain its original form quality and serviceability when exposed to intended service environment. The quality of concrete depends on the quantity of cement and water, which decides the strength and durability of hardened concrete. A durable material helps in environment by conserving resources and reducing wastes and environmental impacts of repair and replacement.

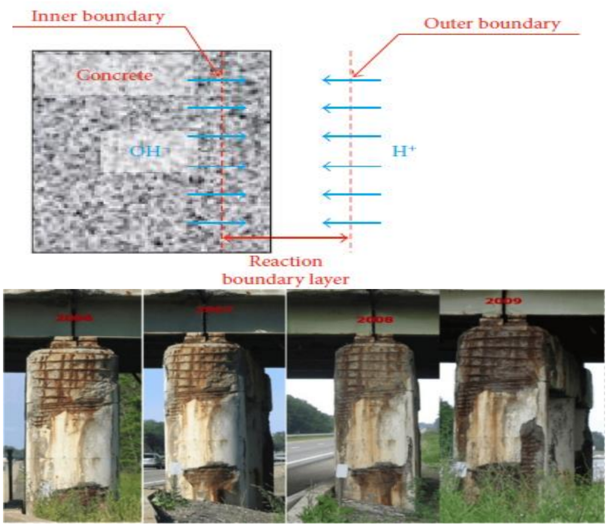

Fig. 7: Effects of acid water on the concrete beam structures

2.3.4 Effect of acid on hardened concrete

The behavior of acids on hardened concrete is conversion of calcium compounds into calcium salts of attacking acids. Hydrochloric acid with concrete produces calcium chloride, which precipitate as gypsum and nitric acid with concrete gives rise to calcium nitrate, as a result of this reaction, structure of concrete gets damaged. If the salt is soluble, the rate of reaction depends on the rate of dissolution of salts. Acid attack completely changes the hardened cement paste on the surface and destroys pore system of the hardened concrete. Therefore in the case of acid attack, the permeability of sound concrete is less important as compared to reaction that takes place. The severity of deterioration of concrete depends on the concentration of acid and temperature. Plain concrete has low strength at tension and low strain at crack. Concretes are randomly distributed to control the crack arrest and increase the tensile strength. The effect of acid water on concrete beam structures is shown in Fig. 7. The binding property of cement in concrete is a result of the hydration reaction products of cement and water. The water evaporation in fresh concrete is mold due to high temperatures, low humidity of air, high wind velocity may prevent the hydration and strength gain. The rate of acid attack is also depends on the capacity of hydrogen ions to be diffused through the cement gel (C-S-H) after calcium hydroxide ($Ca(OH)_2$) has been dissolved and leached out of the concrete. Pronounced increase in the early strength development, resulting in very economic stripping times for precast and in situ concrete. The rate of acid attack is also depends on the capacity of hydrogen ions to be diffused through the cement gel (C-S-H) after calcium hydroxide ($Ca(OH)_2$) has been dissolved and leached out of the concrete.Concrete is the most versatile construction material because it can be designed to withstand the harshest environments while taking on the most inspirational forms. Engineers are continually pushing the limits to improve the performance with the help of innovative chemical admixtures and supplementary cementations materials. The own weight, filling formwork achieving full compaction in the presence of congest reinforcement. The hardened concrete was dense; homogeneous has the same engineering properties and durability as traditional vibrated concrete.

Fig. 8: Scope of self compacting concrete in future applications

2. 4 Scope of self compacting concrete in the future applications

Self-compacting concrete offers a rapid rate of concrete placement, with faster construction times and ease of flow around the congested reinforcement. The compressive strength and split tensile strength are main properties for determining the concrete strength. Self curing concrete contains a chemical agent that reduces the evaporation of water from its surface, primarily by reducing the vapor pressure at the concrete pore solution surface. Self-compacting concrete with a similar water cement or cement binder ratio will usually have a slightly higher strength compared with traditional vibrated concrete, due to the lack of vibration giving an improved interface between aggregate and hardened paste. The strength development will be similar in maturity testing will be an effective way to control the strength development [23-24]. Self-compacting concrete with a similar water cement or cement binder ratio will usually have a slightly higher strength compared with traditional vibrated concrete, due to the lack of vibration giving an improved interface between aggregate and hardened paste. The strength development will be similar in all testing will be an effective way to control the strength development. The development of split tensile strength of concrete is similar to its compressive strength. The different age of curing in concrete influences the quality of paste and splitting the tensile strength. The main reasons for lower splitting tensile strength of concrete made with different age of curing are increase in porosity and distribution of pores. The resistance to indirect tension was significantly affected by the parameters and types of curing. Moreover, the concrete is very weak in tension due to its brittle nature [25-26].

3. Conclusions

Mechanical properties of self-compacting concrete and conventional concrete such as compressive strength and split tensile strength should be conducted. The primary characteristics of self-curing concrete rely on the type of curing agent, particularly this type of concrete is deemed to be workable and flow able. Longer curing results in the higher compressive strength. The compressive strength is more when specimens are cured for 28 days. The cost for SCC is high due to addition of super plasticizers and adding of more cement content. But the main advantages of using SCC is reduces construction cost and also vibration cost. Therefore the labor cost will be reduced. From the analysis concluded that the partial replacement of ordinary portland cement with fly ash does not affect the properties of fresh concrete to perform as SCC. Among the various properties of aggregate, the important ones for SCC are shape and gradation. Better water retention decreases the porosity in concrete leading to better gel formation. By this analysis it also observed that the SCC can be done for low and medium strengths. Self cured SCC specimens with minimum moisture loss exhibited superior performance in terms of compressive strength, open porosity and adsorptive. In concrete with self-curing compounds is very good alternative in water scarce areas and in high temperature regions.

References

Ananthi, A., Ranjith, R., Latha, S.S. and Raj, R.V. 2017. Experimental study on the properties of self-curing concrete. International Journal of Concrete Technology 3(1), 8-13.

Cao, M., Liu, Z. and Xie, C. 2020. Effect of steel-PVA hybrid fibers on compressive behavior of $CaCO_3$ whiskers reinforced cement mortar. Journal of Building Engineering 31, 101314.

Chand, M.S.R., Giri, P.S.N.R., Kumar, G.R. and Kumar, P.R. 2014. Paraffin wax as an internal curing agent in ordinary concrete. Mag. Concr. Res. 67(2), 82-88.

Hasselman D.P.H. 1969. Griffith flaws and the effect of porosity on tensile strength of brittle ceramics, Journal of American Ceramics Society 52, 457.

Hou, C., Zheng, W. and Wu, X. 2020. Structural state of stress analysis of confined concrete based on the normalized generalized strain energy density. Journal of Building Engineering 31, 101321.

Kovler, K. and Jensen, O.M. 2005. Novel techniques for concrete curing. Concrete International 27(9), 39-42.

Krishnudu, D.M., Sreeramulu, D. and Reddy, P.V. 2020. A study of filler content influence on dynamic mechanical and thermal characteristics of coir and luffa cylindrica reinforced hybrid composites. Construction and Building Materials 251, 119040.

Kumar, R. and Bhattacharjee, B. 2003. Porosity, pore size distribution and in situ strength of concrete. Cement and concrete research 33(1), 155-164.

Leach, C.B., CAM Sales, Inc. 1992. Method for curing concrete articles. U.S. Patent 5, 089, 198.

Mehta, P.K. and Monteiro, P.J.M. 2014. Concrete: microstructure, properties and materials. McGraw-Hill Education.

Okamura, H. and Ouchi, M. 2003. Self-compacting concrete. Journal of Advanced Concrete Technology 1(1), 5-15.

Okamura, H., Ozawa, K. and Ouchi, M. 2000. Self-compacting concrete. Structural Concrete 1(1), 3-17.

Oliveira, M.J., Ribeiro, A.B. and Branco, F.G. 2015. Curing effect in the shrinkage of a lower strength self-compacting concrete. Construction and Building Materials 93, 1206-1215.

Palou, M.T., Kuzielová, E., Žemlička, M., Boháč, M. and Novotný, R. 2016. The effect of curing temperature on the hydration of binary Portland cement. Journal of Thermal Analysis and Calorimetry 125(3), 1301-1310.

Qu, Z.Y., Wang, F., Liu, P., Yu, Q.L. and Brouwers, H.J.H. 2020. Super-hydrophobic magnesium oxychloride cement (MOC): from structural control to self-cleaning property evaluation. Materials and Structures 53(30), 1-10.

Rojas, D.P.H., Pineda-Gomez, P. and Guapacha-Flores, J.F. 2020. Effect of silica nanoparticles on the mechanical and physical properties of fiber cements boards. Journal of Building Engineering 31, 101332.

Rossignolo, J.A. 2009. Interfacial interactions in concretes with silica fume and SBR latex. Construction and Building Materials 23(2), 817-821.

Ryshkevitch, R. 1953 Compression strength of porous sintered alumina and zirconia. Journal of American Ceramics Society 36(2), 65–68.

Safi, B., Ghernouti, Y., Rabehi, B. and Aboutaleb, D. 2013. Effect of the heat curing on strength development of self-compacting mortars containing calcined silt of dams and ground brick waste. Materials Research 16(5), 1058-1064.

Schiller, K.K. 1971. Strength of porous materials. Cement and Concrete Research 1, 419–22.

Uysal, M. and Sumer, M. 2011. Performance of self-compacting concrete containing different mineral admixtures. Construction and Building materials 25(11), 4112-4120.

Wang, Y., Liu, F., Yu, J., Dong, F. and Ye, J. 2020. Effect of polyethylene fiber content on physical and mechanical properties of engineered cementations' composites. Construction and Building Materials 251, 118917.

Xotta, G., Mazzucco, G., Salomoni, V.A., Majorana, C.E. and Willam, K.J. 2015. Composite behavior of concrete materials under high temperatures. International Journal of Solids and Structures 64(10), 86-99.

Zhang, J., Ye, C., Tan, H. and Liu, X. 2020. Potential application of portland cement-sulfo aluminate cement system in precast concrete cured under ambient temperature. Construction and Building Materials 251, 118869.

Zhao, H., Sun, W., Wu, X. and Gao, B. 2012. Effect of initial water-curing period and curing condition on the properties of self-compacting concrete. Materials and Design 35, 194-200.

Zhutovsky, S. and Kovler, K. 2012. Effect of internal curing on durability-related properties of high performance concrete. Cement and Concrete Research 42(1), 20-26.