DRYING SHRINKAGE OF CONCRETE CONTAINING SHRINKAGE REDUCING ADMIXTURES WITH AND WITHOUT SUPPLEMENTARY CEMENTITIOUS MATERIALS

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Abstract - *This paper summaries the current knowledge about the shrinkage, types of shrinkages and mainly deals with the drying shrinkage of concrete. The effect of shrinkage reducing admixtures in drying shrinkage with and without using Supplementary cementitious materials is discussed. Initially the definitions & classification of Shrinkage is discussed. Followed by that different articles of drying shrinkage and the effects of shrinkage reducing admixtures are reviewed.*

Key Words: **Shrinkage, Drying Shrinkage, Shrinkage Reducing Admixtures, Supplementary Cementitious Materials**

1. INTRODUCTION

Concrete is the most important component of the infrastructure and our society, including all the buildings and roads. Its durability is very very important in conserving the resources and maintaining a better construction system. Since the major durability related issues takes place at later ages, as the concrete has attained the adequate strength. Researchers have found that concrete mix which used sea water as mixing water has higher strength when compared to normal water used as mixing water. And the slump value for concrete mixed with sea water is higher than that for mixed in fresh water, workability is higher for concrete mixed in sea water [1]. Here the standard drying shrinkage is included in which the concrete loses water to the environment and causes certain volumetric change. Concrete volume change is a phenomenon which is unavoidable, from very early age to long-term behavior. Therefore, concrete structures are exposed to self-stresses or shrinkage cracking which not only cause structural defects but also affects the serviceability, durability, and aesthetics of concrete structure. Cracking of concrete takes place through different conditions and shrinkage develops by various mechanisms. [2,3]

Researchers found that at lower super plasticizer dosage, the fluidity of concrete mix decreases with an increase in temperature. It may be due to following mechanisms: 1. with the increase of temperature, water demand get increases, 2. at a higher temperature the viscosity of cement paste decreases. It is also observed that with the increase of temperature the saturation dosage of super plasticizer will also increases which is obtained from marsh cone test. With the increase in temperature the less in flow and water demand also increases. There will be a decrease in water demand with the increase of temperature by utilization of super plasticizer. It is also found that with the increase of temperature the initial and final setting times of cement paste decreases with and without super plasticizer. As the temperature affects fluidity, during mix proportioning certain factors like, ambient temperature of the concrete, fluidity loss with time and setting and hardening behavior of the cement [4].Researcher's found that as the super plasticizer increases the compressive strength of concrete mix increases and the workability reduces. With high silica fume content, it is found that the effect of super plasticizer gets diminished.[5]. It is obtained that for super plasticized concrete large increase in slump can be maintained for several hours by second and third dosage addition, there amount will be same as that of initial dosage. As a solution to slump loss issues repeated dosages of super plasticizers are used [6].

Concrete shrinkage is a vital concern when focusing on the durability of a concrete structure. Over time the shrinkage will induces cracking which would affect the concrete life expectancy. These volume changes are offered by the drying of concrete over a long period of time, since observations are made recently on the early age or plastic drying problems. Concrete is still moist at early ages and there will be difficulties in measuring the fluid material. The early age is shorter when compared with the long service life of concrete. Concrete performance will be changed during this period. In accordance with the chemical reactions, concrete loses fluidity and plasticity and turns to be set and even hardened. Temperature and volume change will also occur during this process. Long term shrinkage can be well measured. It is generally measured from the starting point of 24 hours after the time of concrete mixing or placing; at the time of mould or formwork removal. Drying shrinkage can be continued for many years.[2]

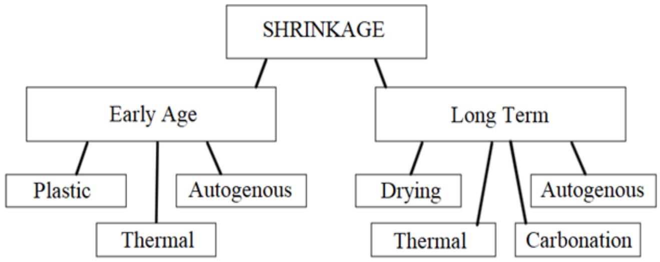

Fig.1: Stages of shrinkage

1.1 Shrinkage Of Concrete

Shrinkage of concrete takes place in two distinct stages: early and later ages. The early stage is defined as the first day, while the concrete is setting and starting to harden. Concrete at an age of 24 hours and beyond it refers to later age or long term. Concrete is demolded at this stage and standard shrinkage measurements are conducted. Shrinkage is most often evaluated over a long time period of months or years. There are different types of shrinkage named plastic shrinkage, drying shrinkage, autogenous shrinkage, thermal shrinkage and carbonation shrinkage. Plastic shrinkage is the drying shrinkage which occurs at the plastic stage of concrete. Drying shrinkage refers to the reduction in concrete volume due to loss of water from the concrete. Autogenous shrinkage is the reduction of apparent volume or length of cement-based materials under seal and isothermal conditions Thermal shrinkage refers to change in volume that occur when concrete undergoes temperature fluctuations. Carbonation occurs when cement paste in the hardened concrete reacts with moisture and carbon dioxide in the air. [2]

During first few hours concrete is still in a semi fluid or plastic state, the plastic state in conventional concrete is influenced by two volume changes, plastic settlement and plastic shrinkage, can result in cracking if restrained. The mould used for the plastic shrinkage study was ASTM C1597 based mould, coupled effect of plastic settlement and plastic shrinkage crack was identified. Riaan Combrinch et al. (2018) studied about the interaction between settlement and shrinkage cracking in plastic concrete. Five different cracking behaviours of plastic concrete have been identified in the study. The cracking behaviour includes pure plastic shrinkage crack, pure settlement crack, plastic shrinkage crack amplified by settlement crack, settlement crack amplified by plastic shrinkage crack and jump crack behaviour. The mould used for plastic shrinkage study was ASTM C1579 based mould, but coupled effect of plastic shrinkage crack and plastic settlement crack was identified.[3]

The drying shrinkage primarily works with the physical structure of the hydration product and porosity network. It can be explained by the differences in the types of water lost at the various stages of drying that affect the rigidity of concrete skeleton and porosity network. OPC concrete contains a high amount of water and has low strength and modulus of elasticity; it leads to measuring a greater high shrinkage tendency. In contrast, the drying shrinkage increments decrease with the decrease in water to binder ratio. A high capillary pressure between the wet and dry areas of the micro pores network may cause due to the loss of water from the capillary pores and the gel pores. Higher drying shrinkage is measured with a increase in temperature, relative humidity reduction (50%) and increase in air movement around the concrete and the time length for which the specimen is subjected to drying conditions.[2,7,8]

1.2 Drying Shrinkage In Concrete

It is the reduction in concrete volume due to the loss of water from the concrete. Concrete will shrinks as the water is lost. Free water will escapes to the surface of concrete as bleed water initially, as heavier aggregate particles settle. This bleed water then evaporates to the surrounding environment. Concrete will be subjected to drying as bleed water has disappeared and so the excess water will be pulled out from the interior surface.[7, 8]

Creep in concrete is a phenomenon characterized by two parts basic and drying creep. Basic creep is caused due to the sliding and consolidation processes between the gel particles due to the water molecules rearrangement in the capillary pores of the cement paste. Drying creep is an additional creep deformation caused when concrete is exposed to drying. For Creep and Drying Shrinkage of Concrete Containing GGBFS, Higher GGBFS percentage exhibits higher shrinkage and creep strains than plain concrete. The amount of cement replacement by GGBFS is 20%, 40%, 60% by weight of cement [9].

Drying Shrinkage of Hybrid Fly ash-Basalt Fiber Geopolymer Paste Concluded that replacement of Fly ash with basalt fibers in geopolymer pastes resulted in increased setting times and strength and reduced drying shrinkage of paste. The total porosity and critical pore size of this paste were reduced with increasing basalt fiber content. The basalt fiber acted as small reinforcing fibers enhanced the development of CSH, CASH and NASH which then improves the properties of paste. Therefore total porosity and critical pore size of fly ash geopolymer paste reduce with increasing replacement content in fly ash which makes the paste denser and homogenous when compared to fly ash geopolymer[10].For the drying shrinkage and cracking resistance of concrete made with ternary cementitious components. It is found that the compressive strength of concrete cured under drying condition was decreased as the partly replacement of by slag and/or fly ash. Slag increased the drying shrinkage of concrete while the drying shrinkage was decreased by the addition of fly ash. Addition of super plasticizer significantly reduced the drying shrinkage. Based on the results in ternary system of Portland cement-slag-fly ash, the addition of fly ash reduced the compressive strength and it is preferable to reduce replacement level of slag when considering the reduction of drying shrinkage[11]Due to its strength, economy and fast placement Roller compacted concrete (RCC) has accepted as a paving material. The effect of GGBS Content and Aggregate Characteristics on Drying Shrinkage of Roller Compacted Concrete suggests that the drying shrinkage strain of Roller Compacted Concrete increased with increase in replacement level of cement with GGBFS. When compared to conventional concrete, RCC mixes has 50% lesser shrinkage strain because RCC mix has a lesser amount of cement and water[12].Due to the moisture migration from concrete to its environment drying shrinkage can cause stress and micro cracking that can leads to larger crack formation. Over a period from 28 to 55 days of age, to monitor shrinkage and the time-dependent micro structural evolution in concrete Research develops a nonlinear ultrasonic (NLU) technique, second harmonic generation (SHG).By using nonlinear Rayleigh surface waves, SHG method monitors the drying process. This demonstrates a acoustic nonlinearity parameter suitable for finding the evolution of micro scale damage in concrete [13].

When discussing the effect of heat curing treatment on the drying shrinkage behavior and microstructure characteristics of mortar incorporating different content ground granulated blast-furnace slag, The drying shrinkage of untreated and heat-treated mortar decreases with the increase of the amount of GGBS due to the filling and micro-aggregate effect of GGBS. An optimal content of about 40% GGBS is required to restrain drying shrinkage for untreated and heat-treated mortar. The drying shrinkage of untreated and heat-treated mortar with 40% GGBS addition is0.0499% and 0.0550% at 28 days [14].

When lithium slag is used as a supplementary cementitious material , it is found that it can improve the mechanical properties of matured concrete, like the compressive strength, elastic modulus, drying shrinkage and creep, if right amount of lithium slag is used in concrete mixtures[15].Hydro carbon particles may have some performances on the drying shrinkage of cement mortar, the amount of poly(1,4-isoprene) substance added to mortar have effects on the drying shrinkage for modified isoprene cement mortar. It is observed that the shrinkage values varies with the change in the isoprene contents, shrinkage rate decreases with time[16].Ultra-high performance concrete (UHPC), exhibits higher autogenous shrinkage than ordinary concrete, due to the high binder content and low water to cement ratio and there was a reduction in strength. 3 different techniques to reduce the shrinkage are studied: binder content reduction; using high levels of shrinkage reducing admixture; and partially replace mixing water with crushed ice. It is found that shrinkage reduced without compromising its mechanical strength. It suggests that, optimal binder-to-sand ratio is between 1–1.1; the optimal dosage of shrinkage reducing admixture is 1%; and replacing of mixing water with crushed ice up to 50% by weight has given a significant shrinkage reduction [17].

Studies are conducted on the strength and drying shrinkage of concretes with the natural sand replaced with furnace bottom ash (FBA) at 0%, 30%, 50%, 70% and 100% by mass. It was found that with the increase of the FBA sand content the compressive strength and the drying shrinkage decreased at fixed water–cement ratios. At fixed workability, with the increase of the FBA sand content the drying shrinkage increased and compressive strength was comparable with the control concrete beyond 30% of replacement [18] .Study to clarify the effect of various aggregate materials characteristics on the drying shrinkage property in mortar and concrete specimens incorporating fourteen kinds of Fine aggregate materials, characteristics of fine and coarse aggregate materials play an important role in controlling the drying shrinkage .Limestone sand and blast furnace slag sand can restrain the drying shrinkage of mortar specimens about 22% and 30%. With the increase of aggregate shrinkage strain drying shrinkage strain is also increased. specific surface area and 6–30 nm in diameter pore volume of aggregates influence of aggregate characteristics on drying shrinkage[19] Study on the effect of luffa fibres by different chemical treatments of luffa fibres on cracking resistance and drying shrinkage of cement mortar. They used natural vegetable fibres for sustainable construction to improve the performance of cementitious materials. Results indicated that treated luffa fibers had a stronger effect on the early cracking than untreated luffa fibres, the drying shrinkage effect was compared between treated and untreated luffa fibres. [20]

2. SUPPLEMENATRY CEMENTITIOUS MATERIALS

Supplementary cementitious materials are the ones which provide the properties of concrete through pozzolanic activity. Usually the advantages of SCM is the economic gain obtained by replacing a part of the Portland cement by industrial by-products. The pozzolonic reaction products will fill in pores and refines the pore size distribution. Typical examples of SCMs are fly ash, ground granulated blast furnace slag (GGBFS), silica fume, rice husk ash and metakaolin.Fly ash is the most commonly used pozzolanic material and it is the by-product from thermal power plants.GGBFS is also known as slag cement, a nonmetallic product consisting of silicates and aluminates of calcium and other bases.. M N Haque et al. (1998) studied the properties of high strength concrete using fine fly ash. The study concluded that 10% replacement level can reduce the w/c ratio by 35% and gives higher strength for concrete. Optimum percentage is taken as 20% replacement which gives maximum 28 day compressive strength for concrete [21] . A Oner et al. (2007) studied on the optimum amount of the ground granulated blast furnace slag (GGBS) on the compressive strength of concrete. Total 32 mixtures were prepared and optimum dosage was found out by moisture curing the specimens for 7, 14, 28 and 365 days. The results concluded that after an optimum dosage of 55% of total binder content, the addition of GGBS does not shows any improve in the compressive strength. With presence of unreacted GGBS acting as a filler material in the paste ,that can be explained [22].The addition of Fly ash, will show an increase in compressive strength and by replacing 25% of weight of cement with Fly ash, the mix will give highest strength [23]. Fly ash at 20% replacement level the compressive strength was found to be 29N/mm2 and density about 1700 Kg/m3 [24]. The strength of aerated concrete can be produced up to 25MPa by partial replacement of cement with about 25% of Fly ash and GGBFS. Fly ash and GGBFS enables the large utilization of waste product, which will reduce the energy cost [25]. It is found that fly ash based concrete sets faster than GGBFS based concrete. The vicat test results shows that behavior of setting depends on the admixture dosage [26].certain observations shows that increase of Fly ash content in the mix will decreases the density of aerated concrete due to Fly ash's low specific gravity .At 20% replacement level of Fly ash maximum compressive strength is achieved [27]. The optimum quantity of Fly ash is found to be 25% [56]. Mahesh V Raut et al. (2015) reviewed the effect of fly ash on shrinkage cracking and durability of concrete under hot and humid local conditions. Study on the Additional effect of fly ash on internal curing of concrete is also conducted .The paper gives an overall of advantages of fly ash to increase the workability, long term strength, durability and reduce the heat of hydration of concrete. It also suggests that concrete with partial replacement of sand by fly ash can be encouraged as it contributes to sustainable engineering and also improves the properties of concrete[28].Reshma Rughooputh et al. (2014) investigated on partial replacement of cement by ground granulated blast furnace slag in concrete. The drying shrinkage showed a slight increase slowly with partial replacement of GGBS. An optimum GGBFS of 30% is taken for improving fresh properties of concrete and for improving hardened concrete it is 50% [29] .Chi Sun Poon et al. (2001) compared the strength and durability performance of normal and high strength pozzolonic concretes at elevated temperature. Pulverized fly ash (PFA) showed better performance at high temperature followed by GGBS, OPC and CSF (condensed silica fume) concretes, to obtain a maximum relative residual strength after exposed to elevated temperature of about 800°C, 40% GGBS replacement is required [30] .V Saraswathy et al. (2013) conducted studies on influence of activated fly ash on corrosion resistance and strength of the concrete. For different mixes the studies conducted are Anodic polarization tests, electric resistivity and pulse velocity measurements, quantitative and qualitative measurement of corrosion was also taken in to account. All results suggests that up to a critical level of 20-30% replacement, activated fly ash improved both corrosion resistance and strength[31].M J McCarthy et al. (1999) investigated on maximizing the use of fly ash as a binder. Cement volume of 30% can be considered as a replacement level in concrete but his studies suggests that beyond a particular percentage replacement level there arise early strength problems.[32] Gafari E et al. (2016) investigated on ultra-high performance concrete with supplementary cementitious material. The supplementary cementitious materials used are silica fume, fly ash and ground granulated blast furnace slag. High dosages of silica fume lead to high autogenous shrinkage. This process occurring in early ages results in high internal stresses that causes micro cracks and then affects durability. Study with fly ash and GGBFS reduced the autogenous shrinkage. It was obtained that by the reduction of fine pores in specimens containing fly ash and GGGBS, autogenous shrinkage can be reduced [33]. M J McCarthy et al. (2005) obtained high volume fly ash cements for concrete construction. Beyond 30% replacement level is commonly adopted and for high range practical concrete design strength optimum value is taken as 45%, Low-lime fly ash was used [34]. Certain experimental results shows that the increase of Silica Fume content from 0 to 30% shows a significant increase in compressive strength, but it results in a relatively lower increase in tensile strength [35]. For mixes with Fly ash improved workability was found and for mixes with GGBFS decreased workability was obtained. The 7-day strength decreased with the increase in percentage of Supplementary cementitious materials. It is found that 7day strength of Fly ash is higher than that of GGBFS [36]. The workability of concrete mix with about 50% GGBFS & 50% recycled coarse aggregate was found to be adequate. It is also obtained that the Compressive strength, flexural strength and splitting tensile strength of this mix is less compared to the control mix [37]. Certain investigations conducted on mineral admixtures concluded that when cement is replaced with mineral admixture, it gives better strength and workability.

When the mineral admixture used is fly ash, the mix obtained by replacing about 15% of cement with fly ash has given higher strength. And here optimum percentage of fly ash obtained is 15% for M_{35} concrete mix. For GGBFS the optimum replacement for M_{35} mix was found to be 50%.It provides higher strength and workability [38].

3. REPLACEMENT OF FINE AGGREGATE

The aggregates occupy about 70-75% of total volume of concrete.Different materials used as alternatives for Fine aggregate are, blast furnace slag, manufactured sand, crushed glass, copper slag, recycled aggregates, fly ash aggregate, steel slag etc. The use of such materials not only results in natural resource conservation but also an effective utilization of byproduct from various industries. The study conducted on steel slag gives that its properties are comparable to that of natural aggregates. The percentage replacement of fine aggregate with steel slag is about 60%.

Researchers have obtained that for concrete containing induction furnace slag about greater than 30 % the compressive strength of normal concrete mix is lower. For concrete containing induction furnace slag up to 30%, the slump is found to be greater compared to all other mixes. Investigators have concluded that the fine slag can be used as a replacement to fine aggregate in concrete. For this Fine slag the replacement ratio can be limited to 30% [39].

4. SHRINKAGE REDUCING ADMIXTURES

Shrinkage reducing admixtures are surfactants that reduce the shrinkage of cementitious material to an extent including autogenous shrinkage, drying shrinkage, plastic shrinkage and chemical shrinkage. Mechanism of SRA on different type of shrinkage is similar mainly reduced surface tension, reduced concentration of pore solution ions, adjusted relative humidity and expansion effect. [40] Hyung Sub Han et al. (2006) conducted experimental study on development and performance assessment of the high-performance shrinkage reducing agent for concrete. While the effect was more prominent at higher amounts, to prevent deterioration of the compressive strength and other physical properties, the recommended value of dosage of SRA by the authors are dosage less than 2% [41]. Petro Lura et al. (2007) discussed how the evaporation of water causes concave menisci to form on the surface of fresh concrete. These menisci cause both settlement of the concrete and development of tensile stress in the concrete surface, which increase the potential for development of plastic shrinkage cracks. Specifically this paper investigated the development of plastic shrinkage cracks in mortars containing a commercially available shrinkage reducing admixture. Mortars containing SRA shows smaller and narrow plastic shrinkage cracks than plain mortars under same environmental conditions. In the paper authors also suggested that lower surface tension of the pore fluid in the mortars containing SRA results in less evaporation, reduced settlement, reduced capillary tension and lower crack inducing stresses at the topmost layer of the mortar [42]

4.1 Characteristics of SRA

SRA is a surfactant with a hydrophilic tail and hydrophobic head. SRA get adsorbed on the non-polar interface of SRA in the pore solution and results in the decrease of the surface tension. In addition as a non-ionic surfactant, some SRA`s will adsorbs on the water –solid interface which results in decrease of interfacial energy of the hydration products and the cement particles and changes the surface polarity and dispersion of the particles are improved. Due to the hydrogen bonding interactions between the polar units of the SRA, which causes the surface tension reduction and reduction of interfacial energy to make SRA to reduce shrinkage by suppressing the water absorption.[43]

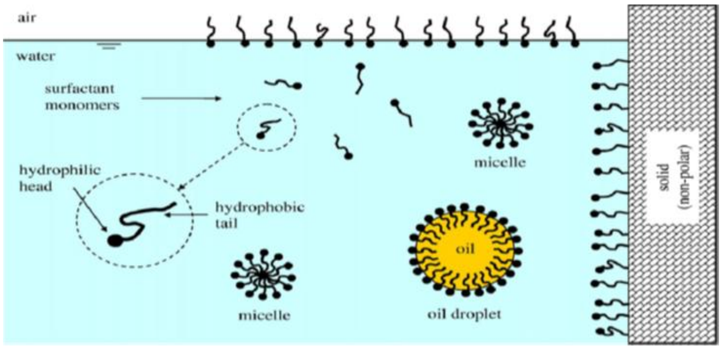

Fig-2: Interaction of the surfactant molecules with polar solvent

4.2 Hydration

SRA’s have great effects on the hydration of concrete. Temperature peaks of hydration decreased gradually with the increase of SRA contents. SRA slowdowns the early development of the cement paste’s microstructure [44, 45].The main reasons for this are;

1. SRA molecules get adsorbed on the water-solid interface and forms an ‘organic molecular film’ that reduces the interfacial energy of the hydration products and the cement particles, and thus hinders the hydration reaction.
2. SRA molecules reduces the polarity cement paste, there by reduces the alkali contents and the pH value, which causes the hydration retardation.
3. SRA increases the surface area and also the water demand of the products of hydration, which causes not enough free water to allow hydration

4.3 Workability

Some of the results of shows that the SRA has a improved effect on the workability of concrete .Researchers found that slump of ultra-high-performance fiber-reinforced concrete having 0% ,1% and 2% of SRA are 235mm ,245mm & 250mm, SRA increased slightly the workability[46]

5. EFFECT OF SRA ON SHRINKAGE

The use of shrinkage-reducing admixtures (SRA) will improve performance of concrete in terms of lower risk of cracking related to drying shrinkage. Some SRA mainly acts on drying and weight loss leading to shrinkage. Concrete mixtures with SRA have a lower rate of evaporation than plain concrete mixtures after first hours of drying. During the initial few days mixtures with SRA showed very low shrinkage rates. The findings indicate that when the internal humidity is relatively high or when a higher porosity exists in the material, SRA will be more effective. SRA’s beneficial effect is primarily due to the redistribution of the porous structure varying, by the decrease in larger pores percentage. Due to the delayed hydration reaction found in

SRA mixtures, they increased the total porosity. The relative small delay in hydration ,which will also cause a reduction in degree of hydration and also water retention may cause reduction in self-desiccation and autogenous shrinkage.SRA addition caused a slight reduction in the compressive strength and elastic modulus.SRA concrete mixtures requires a lesser time to cracking and crack opening due to the plastic or long term drying shrinkage[47].SRA s are used in in different percentages like (0%, 1%, 2%, and 4%) in High-performance concrete. Results showed that SRA reduces some mechanical properties of HPC effectively. Shrinkage strains of HPC with SRA was only 41 % higher that of concrete mixtures without SRA [48].SRA is beneficial to low w/c ratio concretes undergoing self-desiccation, in addition to their normal usage to reduce drying shrinkage [49] The effects of shrinkage-reducing admixtures used in self-compacting concrete on its strength and durability concluded that the SRAs influence on fresh properties of concrete are minimal. Both drying and restrained shrinkage development were Restricted with varying rates of SRA incorporated in SCC mixtures [50].Farshad Rajabipour et al. (2007) explains why concrete containing SRA shows a delayed setting and a slow strength development. SRA have significant benefits in reducing the magnitude of drying and autogenous shrinkage but it can cause negative side effects such as it reduces the rate of cement hydration and strength development in concrete. To examine the influence of SRA on cement hydration, the study explores the interactions between SRA and cement pastes pore solution. SRA is mainly composed of surfactant and can significantly reduce the interfacial tension. However, these surfactants can also self-aggregate in the bulk solution and this may limit the surface tension reduction capacity of SRA [51].

For the effect of shrinkage-reducing admixture and expansive agent on mechanical properties and drying shrinkage of Engineered Cementitious composite (ECC), It is found that compressive and tensile strength of ECC will greatly reduce with the increasing of SRA, rather, the compressive strength of ECC will enhance with the increase of expansive agent. Study indicates that the 1% addition of SRA reduced 15% 28-day compressive strength. 1% addition of SRA reduced 17% 28-day tensile strength and 27% 90-day drying shrinkage [52] SRA increased the total porosity, which may be due to a delayed hydration reaction that can be observed in SRA mixtures. Thus, higher retention of water and consequently higher relative humidity which exhibit a lower capillary stress concrete with SRA [53]. Use of SRA and expansive products showed a improving effect on shrinkage reduction. Autogenous shrinkage can be significantly reduced, and even eliminated, with the incorporation of SRA and Expansive products [54]. With the increase in the dosage of SRA, the workability decreases. It takes place due to, as SRA is added it leads to decrease in the mixing water, which in turn reduces the fluidity of mix. Investigations also found that as the percentage of SRA is increased the compressive strength is decreased. This takes place due to the reduction in the rate of hydration in concrete. Investigators also suggest that SRA addition can delay the development of cracking in concrete. It is observed that the optimum percentage of SRA was found to be 2% [55].For mixes with Fly ash and SRA the workability is higher than that of control mix but less than mix with Fly ash only. There observed a positive synergic effect when SRA is used with Fly ash, that it delayed the occurrence of Crack than mix with SRA and Fly ash alone [56].

6. CONCLUSIONS

As we come to know that the shrinkage is the volume change in concrete which takes place due to the loss of moisture from the concrete.Shrinakge occurs in two stages; early age and long term shrinkage. The early stage is commonly defined as the first 24 hrs after casting, while the concrete is setting and starting to harden. Later ages, or long term, refer to the concrete at an age of 24 hours and beyond. There are different types of shrinkages like plastic shrinkage, drying shrinkage, autogenous shrinkage, thermal shrinkage & carbonation shrinkage. Due to shrinkage lots of cracks may get developed at the concrete surface and that may affects the durability of the concrete structure. Therefore the shrinkage needs to be avoided in order to enhance the life span of the concrete structure. Researchers provide great interest on the usage of Shrinkage Reducing Admixtures which tremendously reduces the shrinkage. Shrinkage reducing admixtures are Surfactants which are added during batching can significantly reduce both the early and long term drying shrinkage. It is obtained by treating the cause of drying shrinkage within the capillaries and pores of the cement paste. So the concrete volume change can be effectively retarded with the proper usage of SRA.

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