Effect of Seawater on the Compressive Strength of Steel Fiber Reinforced Concrete.

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Abstract - This research aims to compare the compressive strength of concrete using fresh water and seawater for curing and compare the compressive strength of steel-reinforced concrete using fresh water and seawater for curing. A total of 24 cubes of specimens measuring 150×150×150mm using M30 grade concrete cubes were cast. Twelve of them are cast by adding 1% crimped steel fibres and the remaining twelve are cast without steel fibres. Six of them are cast and cured with freshwater, six of them are cast with fresh water and cured in seawater. From the remaining twelve which are cast by adding 1% crimped steel fibres, six of them are cast and cured with fresh water and six of them are cast with fresh and cured in seawater. These cubes are tested for compression test at the curing ages of 7 and 28 days. After the compression test is done a small piece of the cube from inside is extracted and sent to an analytical laboratory to study the microstructure of the cube by using a scanning microscope analysis.

Key Words: *Compressive Strength, Steel fibres, Crimped Steel Fibre, Scanning Electron Microscope Analysis, SEM Analysis.*

1. INTRODUCTION

About 70% of the earth's surface is covered with water. Of that 97% is ocean water remaining 3% is freshwater. Icecaps and glaciers contain over 68 % of the world's fresh water, while groundwater contains just over 30 %. The surface water of lakes, rivers, and swamps contains only about 0.3% of our freshwater. Most of the structures near the seashore deteriorate by physical or chemical action due to seawater. This research aims to increase the strength of concrete by adding 1% of crimped steel fibres to the concrete. This is to overcome the strength loss in structures which are exposed to seawater. Using M30 grade concrete casting and curing of concrete specimen cubes in fresh water and casting with fresh water and curing seawater, by comparing the compressive strength between them. The primary chemical constituents of seawater are the ions of chloride, sodium, magnesium, calcium, and potassium ions. In seawater containing up to 35,000 ppm of dissolved salts, sodium chloride ($NaCl$) is by far the predominant salt. The pH value of seawater varies between 7.4 and 8.4. Corrosion of reinforcing steel occurs below a pH of 11. The chemical reactions in concrete are mainly due to the attack due to magnesium sulphate ($MgSO_4$) presence. The mode of attack is crystallisation. Potassium and magnesium sulphates ($K4SO_4$ and $MgSO_4$) present in saltwater can cause sulphate attack on concrete because they can initially react with calcium hydroxide $Ca(OH)_2$, which is present in the cement formed by the hydration of dicalcium silicate (C_2S)and tricalcium silicate (C_3S). The attack of magnesium sulphate ($MgSO_4$) is particularly damaging, forming soluble magnesium hydroxide($Mg(OH)_2$), which forces the reaction to form gypsum. Chloride ions can penetrate the concrete and cause accelerated corrosion of the reinforcement. The concrete is strong in compression and weak in tension to provide ductility to the concrete we add fibres to concrete to increase the strength of the concrete. There few types of concrete fibres, which are steel fibres, polypropylene fibres, nylon fibres, asbestos, coir, carbon and glass fibres. Mostly steel fibres are used in the concrete to increase the tensile strength of the concrete.

2. Literature Review

Venkateswarlu and Deepthi (2016) studied the behaviour of Crimped steel fibre Reinforced Concrete with Wood Waste Ash and observed that combining wood waste ash (0, 10, 20, and 30%) with crimped steel fibres (0, 0.5, 0.75, and 1%) in the M30 grade concrete. The workability and durability of the concrete are tested by performing a compaction factor test, compressive strength test, split tensile strength test and flexural strength test for a curing age of 28 days. For the Compressive strength test, specimens of size 150×150×150mm cubes were cast. Split tensile test, the specimens of size 150×300mm cylinders were cast and for the flexural strength test, the specimens of size 500×100×100mm were cast. From the results, it is observed that the compaction factor decreases with an increase in the percentage of wood waste ash added to the concrete which is due to the absorption of water from the mix. That means the workability of concrete decreases by adding wood waste ash. And also the compaction factor decreases with an increase in the percentage of crimped steel fibre in the concrete due to obstruction and friction caused by the crimped steel fibres. That means the workability of concrete decreases when crimped steel fibres are added. The compressive strength of concrete that has been added with wood waste ash at 28 days test, compressive strength increases as the percentage of Wood waste ash added increases up to 20%. Compressive strength reached its maximum with a 20% addition of wood waste ash. Also, when crimped steel fibre is added, the compressive strength increases up to 0.75 %, but after that, the strength value decreases. The optimal content of crimped steel fibre is 0.75 % by volume. The split tensile strength of the concrete that has been added with wood waste ash, split tensile strength increases as the percentage increase of wood waste ash up to 20%. Also, when crimped steel fibres are added, the split tensile strength increases up to 0.75 %, after that strength decreases due to the absorption of water from the concrete mix by wood waste ash. The flexural strength of concrete is increased with the addition of wood waste ash by up to 20% and flexural strength increases up to 0.75 % when crimped steel fibre is added. It concludes that adding crimped steel fibre up to a certain percentage is suitable to use in concrete works.

Sunil and Purvi (2016) studied XRD and SEM analysis of Bio-fibre reinforced concrete and observed that Powder X-Ray diffraction with filtered 0.154 nm Cu, Ka radiation is used to study the XRD analysis at room temperature. Samples are scanned continuously from 100 to 80 degrees at a rate of 2 degrees per minute. The X-ray powder diffraction was performed on four samples: R3, R2, S3 and S28, where R3 & R28 denote plain concrete curing times of 3 days and 28 days respectively, and S3 & S28 denote bio-fibre reinforced concrete curing times of 3 days and 28 days. Fluorite (CaF_2) and Quartz or Silica (SiO_2) have predominance peaks, according to XRD analysis. Because the cement hydration process took longer than 3 days, no hydration compounds such as C_3S and C_2S were found in the plot. The predominance of Halite is revealed by XRD analysis. While equal peaks are observed for calcite ($CaCO_3$), quartz or silica (SiO_2), and fluorite (CaF_2). The presence of calcite indicates that the concrete hydration process has begun, forming a C-S-H gel. The presence of a large amount of halite in the plot indicates that the concrete complex has chemically reacted with the bio-fibre, and the reason for bio-fibre degradation is due to alkali in nature. The morphology of a biodegradable matrix surface was investigated by scanning microscope analysis. The surfaces of the matrix are being biodegraded, according to the XRD results. It was observed that the matrix's surfaces are undergoing biodegradation, resulting in high roughness. Some concrete matrix has been noticed to be attached to the fibre, delivering exceptional fibre matrix adhesion. It illustrates that the optimum length for proper bonding between the concrete matrix and fibre is available. The XRD results reveal that Halite and sucrose of fibres react with concrete complex, which is beneficial for proper bonding, but bacteria such as Streptococcus mutants may develop in and around the fibres, react with sucrose, and cause fibre decomposition. Adding Sida Cardifolia bio-fibre to concrete mixtures demonstrates the early hydration process and results in increased compressive strength, indicating that fibres in the concrete complex have a good response. Furthermore, SEM results show that adhesion is properly generated as a result of chemical activity within the bio-fibre concrete complex. The SEM result shows that the optimum length is available for proper bonding between the concrete matrix and fibre, which explains why the concrete mix has good tensile strength and ductility. The presence of sucrose, the optimum length, and the optimum quantity of sida cordifolia fibre all play a role in the ductile and bonding nature of bio-fibre concrete before it fails.

Rahul et al. (2016) Study on "Behaviour on High Strength Crimped Steel fibre Reinforced Concrete Grade M90" observed that concrete with Ordinary Portland cement with a 7-day compressive strength is 45.20 MPa, as well as fine and coarse aggregates passing through 4.75mm and 10mm sieves, were employed. The fineness modulus of sand was 2.803 and that of 10mm coarse aggregate was 7.52. To make M-90 grade high strength concrete with mix proportions of 1:0.99:1.52, with a W/C ratio of 0.23, a total of 54 cubes of size (100X100X100) mm were cast for compressive strength test and 54 cylinders of diameter (150×300) mm in length were cast for spilt tensile test. All specimens were cast with steel fibres ranging from 0 to 4% by weight of cement, with a 0.5% variation. The fly ash percentage is 23% and the silica fume level is 7%, keeping the cement weight constant. The compressive strength test and spilt tensile test were done at curing ages 7 and 28 days. The compressive strength of the cube at 7 and 28 days increased constantly as the fibre content increased up to 3.5% of the total fibre volume content in High strength concrete. In High strength concrete, the maximum strength obtained at 7 and 28 days is 66.40 MPa and 94.30 MPa respectively at a 3.5 % fibre volume percentage. After that strength decreased by 4% of fibre volume fraction in High strength concrete. For split tensile strength tests at 7 and 28 days, the maximum strength is obtained at the 3% fibre volume fraction in high strength concrete, which are 9.25 Mpa and 11.26 Mpa respectively. After that split tensile strength decreases with an increase in the percentage of steel fibres in high strength concrete. It concludes that the crimped steel fibres are suitable for increasing the compressive strength and split tensile strength in high strength concrete.

Adithya and Magudeswaran's (2017) studies on Sem Analysis on suitable High-Performance Concrete observed that using M60 concrete grade with a water-cement ratio of 0.31, seven concrete mix variants were created. The principal concrete elements were replaced with alternative by-products, cement was replaced with Fly ash (30% and 35%)Silica fume (7.5%) and fine aggregate was completely replaced with manufactured sand. By 30 %, 40%, and 50 %, the coarse aggregate was partially replaced with recycled aggregate. Seven concrete mixes were casted Mix -1(Normal concrete), Mix -2 (7.5 % S.F+ 30% F.A+ 30% RCA), Mix-3 (10% S.F+ 3. 5% F.A+ 30% RCA), Mix-4 (7.5 % S.F+ 30% F.A+ 40% RCA), Mix-5 (10% S.F+ 35% F.A+ 40% RCA), Mix-6 (7.5 % S.F+ 30% F.A+ 50% RCA) and Mix-7(10 % S.F+ 35% F.A+ 50% RCA). At the age of 28 days, the compressive strength of seven concrete mixes was evaluated, and only mix 4 outperformed the other five mixes when compared to the standard mix. After 28 days of curing, the concrete cubes were tested for compressive strength, and Mix 4 yielded a reasonable value, which was somewhat lower than the standard concrete mix. The pozzolanic activity of silica fume and fly ash led to the strength of mix -4. The chemical reaction of silica fume and fly ash with Portlandite $Ca(OH)_2$ results in the formation of more C-S-H gel, which provided the strength to the mix. Mix-4 had a similar rate of hydration to regular concrete, but the presence of minerals elements was quite different from Mix-1, which influence the strength of the concrete mix. Although the concrete mix's strength was not as high as expected, it nonetheless reached a level of strength that allows it to be used as a substitute for regular concrete mix in some concreting works. According to the SEM analysis, adding M-sand, Recycled Coarse Aggregate (RCA), silica fume, and fly ash to the mix results in the production of additional C-S-H gel, which aids in the attainment of Mix-4's fair strength. Mix-4 had a similar rate of hydration to regular concrete, but the presence of minerals elements was quite different from Mix-l, which manipulates the strength of the concrete mix. According to the findings, substituting cost-effective materials for concrete ingredients improves the strength and microstructural behaviour of the concrete.

Qingyong Guo et al.(2018) studied the Effect of Mixing and Curing Sea Water on Concrete Strength At Different Ages and observed that M15 grade concrete with w/c ratios of 0.45 and 0.50. And M20 grade concrete with w/c ratios of 0.45 and 0.50 was used to make four separate groups of concrete. Which are namely concrete A, B, C, and D. Each set of concrete is cast and cured using freshwater (FF), cast and cured with seawater (SS), cast with fresh water and cured with seawater (FS) and cast with seawater and cured in freshwater (SF). A total of 192 concrete specimens of dimension 100×100×100mm cubes were cast and tested for compression test for curing ages of 7, 14, 28, and 90 days. At 7 days of curing, the concrete cast and cured with seawater (SS) and concrete cast with seawater and cured in freshwater (SF) showed a rapid increase in strength when compared to the concrete cast and cured with freshwater (FF) and concrete cast with fresh water and cured in seawater (FS). The early increase in strength in concrete SS and SF is due to chlorides content in seawater that tends to accelerate the setting of cement due to acceleration of setting of cement the strength of the concrete is improved. While concrete SS, SF and FS observed the rate of gain of strength is less compared to concrete FF at 14, 28 and 90 days test this is due to leaching out of soft hydration product of the cement or the sulphates containing in seawater that retard the setting of cement. Comparing the four types of concrete grades groups D and B are found to be most affected by the seawater. The possible cause for strength deterioration may be due to the dissolution of the compounds rich in lime and the formation of expansive compounds as a result of chloride and sulphate attack of seawater. When comparing the four types of concrete designations FF and SS, it can be seen that concrete strength losses differ depending on the grade of concrete. When compared to concrete FF, the overall strength losses of concrete SS are 1.03Mpa for group A, 2.56MPa for group C, 6.01MPa for group B, and 8.40MPa for group D over 28 days of curing. The losses are 5.37MPa for group C, 6.0MPa for group A, 9.58MPa for group D, and 10.61MPa for group B over 90 days of curing age. The seawater had the greatest impact on Group D and B of all the concretes evaluated. Dissolution of lime-rich compounds and the development of expansive compounds as a result of chloride and sulphate attack by seawater could be the reason for strength deterioration. As a result, it can be stated that higher strength concrete has a lower resistance to strength deterioration than lower strength concrete. When seawater is used for mixing and curing concrete, has an impact on its strength gain. It shows some early strength rises, but then gradually decreases in strength. When comparing concrete specimens made and cured with fresh water to similar concrete specimens made and cured with seawater at age 90 days, concrete specimens made and cured with seawater showed a loss in strength of around 7%, whereas concrete specimens made and cured with seawater showed a loss in strength of around 15%. When using seawater for mixing and curing concrete, the higher grade concrete B showed roughly 9% more strength than the other classes of concrete A, C, and D.

Mukilan et al. (2019) studied Crimped and Hooked End Steel Fibre Impacts on Self Compacting Concrete and observed that Steel fibres(crimped steel fibres and hook end steel fibres) were introduced into the Self-compacting concrete in various amounts in this investigation, including 0.4%, 0.8 %, 1.0 %, and 1.25%. In addition to cement, fly ash was added. To determine compressive strength, cubical specimens of 150 X 150 X 150mm were cast, cured, and tested. And for the split tensile strength test, cylindrical specimens of diameter 150×300mm were cast, cured and tested. Specimens were tested for 7 and 28 days. The strengths of two types of steel fibres, crimped type fibre and hook end type steel fibres, were tested for compressive strength and split tensile strength. It is clear from the results that Steel fibre with a hooked end was found to be more favourable than steel fibre with a crimped end. Approximately 80% of the strength of fibre reinforced Self-compacting concrete may be achieved within only

7 days. At 0.7 % fibre content (70kg/m^3), the hook ends steel fibre compressive strength of concrete is greater than (14.4%) the crimped fibre. At a fibre content of 70 kg/m^3, the hook end steel fibre cylinder splitting strength of concrete is greater than (10.8 %) of that of crimped fibre. At 0.7 %fibre content (70kg/m^3), the hook end steel fibre cylinder compressive strength of concrete is greater than (10.52%) of the crimped fibre. Fibre addition was found to be effective up to 1%, after which it decreased.

Ogunjiofor(2020) studied on Possibility of Usage of Sea Water for Mixing and Curing Concrete in Salty Water Locality is observed that using M15 grade concrete(1:2:4) about 24 specimens of size 150×150×150mm are cast with a water-cement ratio of 0.45. Of 24 specimens twelve are cast and cured with freshwater (CFW), while the remaining twelve are cast and cured with seawater (CSW) and evaluated for compression at curing ages of 7, 14, 21, and 28 days. The results of the workability test performed on the two sets of concrete pastes show that all of the mixes were workable, with the saltwater concrete having a higher slump value than the freshwater concrete. This finding indicates that the salt content of salt water can affect workability. The presence of salt in seawater reduces the setting time of the concrete, from the results of setting time for the two concrete pastes. The lower values of both the initial and final setting times of the seawater concrete paste indicated that. The compressive strength test findings reveal that concrete cubes mixed and cured with saltwater (CSW) have a much higher strength than concrete cubes mixed and cured with freshwater (CFW). The 22.85N/mm^2 result after 7 days of curing illustrates that concrete built with seawater gains strength rapidly in the early stages of curing. When comparing freshwater and seawater concrete, the strength improvements in freshwater concrete during 7 days of curing (20.24N/mm^2) were significant. When compared to CFW, the rise in strength of CSW was slightly higher on the 14th day of curing. CSW gained 35.89 %, while CFW gained 34.89 %. When comparing the CFW's 14th-day compressive strength of 27.30 N/mm^2 to its 21st day compressive strength of 30.85N/mm^2, there was a minor increase in strength, but the strength gain in CSW from 14 days to 28 days was minimal when compared to other days' results. When compared to the 21-day result, the CSW had a minor increase in strength of 0.34 % at 28 days, but the CFW had a significant increase in strength. On average, the compressive strength of concrete mixed and cured with seawater was comparable to that of concrete mixed and cured with fresh water. There was a modest improvement in strength when comparing the CFW's 14th-day compressive strength of 27.30 N/mm^2 to its 21st day compressive strength of 30.85N/mm^2, but the strength gain in CSW from 14 to 28 days was minimal when compared to other days' results. The CSW had a minor gain in strength of 0.34 per cent at 28 days when compared to the 21-day result, whereas the CFW had a large increase in strength. On average, the compressive strength of seawater-mixed and cured concrete was comparable to that of fresh-mixed and cured concrete.

Abdul Ahad et al. (2019) studied on utilization of seawater for construction, as an alternative to potable water. This investigation aims to find the compressive strength of the concrete cast and cured using seawater and freshwater. Seawater consists of 3.5 grams of salt in one litre of water. The cubes were cast using 3.5 grams of salt in one litre of freshwater. The concrete is of M30 grade with a water-cement ratio of 0.45 is used. A total of 24 specimens of size 150×150×150mm cubes were cast using M30 grade concrete, twelve of them are cast and cured in seawater and the remaining twelve are cast and cured in the freshwater. A compressive strength test is done on the 24 cubes at curing ages of 7, 14, 21 and 28 days. It is observed that at 7 days, the compressive strength of cubes increased up to 4 -6% and at 14 days the compressive strength increased up to 9 -11%. A gradual decrease in compressive strength is observed at 28 days. The decrease is up to 1 -4% when compared to the strength of the concrete cast and cured with seawater to freshwater. The average compressive strength obtained for cubes using fresh water and seawater was 33.4N/mm^2 and 35.80N/mm^2.

Amusan and Festus (2014) studied the effect of seawater on the compressive strength of concrete and observed that the concrete was made using M15 grade concrete with a water-cement ratio of 0.60. A total of 140 cubes of concrete specimen measuring 150×150×150mm cubes were cast. From that 70 cubes are cast and cured with seawater and the remaining 70 cubes are cast and cured in freshwater. Again from that 70 cubes are divided into 35 for each set. Concrete of four different sets (FF,FS,SF,SS). FF - Concrete cast and cured with freshwater, FS - Concrete cast with fresh water and cured with seawater, SF - Concrete cast with saltwater and cured with freshwater, SS - Concrete cast and cured with seawater. When compared to the FF control batches, which have a lesser strength at the early stage, the results reveal a substantial rise in strength at 7 days for concrete designations SF, FS, and SS, respectively. Also, by the 14th day, all batches had increased in strength, with FF, SS, and SF batches increasing at a faster rate than FS batches. When compared to control batches, the rate of strength gain increased proportionately at 21 days, with a modest drop in strength gain in FS batches. The rate of strength gain increased for all batches at 28 days, although the compressive strength of SS batches was higher than that of the control, FF batches, at 28 days. The batches attained their maximum strength after 90 days, although more than 90% of that level was achieved after 28 days. It was found that the strength of the concrete cast and cured with seawater rapidly increases for all curing days, surpassing the strength of control cast concrete (FF). The compressive strength of concrete batches FF is about 20N/mm^2, which is consistent with the compressive strength of 1:2:3 mix at 28 days. Even at 28 days and 90 days, the strength of concrete batches cast with saltwater and cured with freshwater (SF) was observed to have increased. Fresh-fresh water scenarios occur in buildings built on inter lands and mainlands in practice. Fresh-salt water scenarios commonly occur in houses or buildings located near a lagoon or at the sea. In practice, salt-fresh water situations are uncommon, although they are common in locations with a scarcity of freshwater or when the available surface water is salty. Structures built in the ocean or sea show signs of saltwater conditions. Finally, corrosion of embedded steel in reinforced or prestressed components can be prevented by painting or coating the steel with a cement slurry prepared with fresh water. Additionally, when designing the member, a higher concrete cover could be given.

Keneth celestine et al. (2020) studied the interpretation of the mechanical study of concrete using crimped steel fibres and observed that the concrete is made with M30 grade cement and ordinary Portland cement grade 53, which is long-lasting and high-quality, as well as coarse and fine aggregates of different sizes. Superplasticizers conplastSP430 in the form of sulfonated naphthalene polymers, as well as steel fibres of length 50 mm and diameter 1 mm with an aspect ratio of 50 and a fissile strength ranging from 750 MPa to 1100 MPa, are also added to the mix. There are specimens with Crimped steel fibres and specimens without Crimped steel fibres that are tested. Suitable cubes with dimensions of (100×100×100 mm), suitable cylinders with dimensions of (100×200mm), and ideal prisms with dimensions of (500×100×100 mm) were cast and tested for constriction, split fissile, and flexure strength with and without fibre fortified concrete Ordinary Portland Cement, mulct aggregate, and granule aggregate of 10 mm were utilized to cast the specimens. The fibres were added to the concrete mix in different proportions: 0.5%, 1%, 1.5%, and 2%. The specimens are then cast for testing on compression, flexure, and split tensile machines. A total of 60 specimens are cast 20 of them are cubes, 20 are cylinders and 20 are beams. The addition of silica fume to concrete improves its compression strength. For the compressive strength test, a cube specimen of 100×100×100 mm was used. The compressive strength of Cubes comprising 0.5%, 1%, 1.5%, and 2% volume of steel fibres that have been cured for 7 and 28 days have been tested. The average compressive strength for controlled concrete is 27.8 N/mm², and 28 days is 35.2 N/mm². For 0.5,% 1 %, 1.5%, and 2 % of 7 days, the results are 41.2 N/mm², 46.2 N/mm², 47 N/mm², and for 28 days of healing, the values are 43.7 N/mm², 45.2 N/mm², 48.2 N/mm², and 49 N/mm², respectively. The specimen size is 500×100 ×100 mm, the concrete grade is M30, and the reintroduction of mineral admixture and extension of varied proportions of steel fibres are all constant parameters. When compared to standard mix, adding silica fume to the mix can reduce the strength by up to 10%. Mould and healing for 7 and 28 days are allowed to be tested to acquire the optimal value of flexural strength. For 7 days of the regular mix, the moderate value of flexural resilience is 4 N/mm², for 0.5 % it is 4.25 N/mm², for 1% it is 4.75 N/mm², for 1.5% it is 5.25 N/mm², and for 2% it is 4.75 N/mm², and for 28 days of the regular mix, the moderate value is 4.5 N/mm², for 0.5% it is 4.3 N/mm², for 1% it is 4.8 N/mm2, for 1.5 % it is Tensile test with a split The optimum cylinders of size 100×200 mm specimens are moulded and healed for 7 and 28 days, respectively. They were carried out to determine the split fissile tenacity of M30 concrete with and without crimped steel fibres. 7.07 N/mm², 8.06 N/mm², 8.32 N/mm², and 9.054 N/mm² are the average values of split tensile strength of concrete after 7 days. 7.23N/mm², 8.25N/mm², 8.55N/mm², 9.1N/mm² for 28 days. The study shows that M30 grade concrete with silica fume has a restricted % reinstatement with various crimped steel fibres fortified in concrete whose compressive, flexural, and split tensile resilience tests For 7 days, specimens had a moderate compressive strength of 33.504 N/mm². The specimens have a moderate compressive strength of 44.26 N/mm² after 28 days. Specimens had a modest flexural strength of 4.5 N/mm² after 7 days. The specimens' moderate flexural strength after 28 days is 4.67 N/mm². 7.9 N/mm² is the moderate split fissile strength of specimens after 7 days. The moderate split fissile strength of specimens is 8.1 N/mm2 after 28 days. It is observed that adding Crimped steel fibres to concrete raises the strength of the concrete.

Ravinder and Rafat (2019) studied Strength properties and microstructural analysis of self-compacting concrete incorporating waste foundry sand. This paper shows the outcomes of experimental analysis on the effect of waste foundry sand (WFS) as a fine aggregate replacement on the fresh, strength and micro-structural properties of self-compacting concrete (SCC). Characteristics strength and microstructural examinations were carried out up to the age of 365 days. Test outcomes show that all concrete mixes displayed the characteristics of fresh state Self-Compacting Concrete. The 28-day compressive strength of Self Compacting Concrete was 58 MPa. There was a 6.38 – 18.76% decrease in the strength of SCC with the use of about 5–30% WFS at 28 days. Micro-structural outcomes of XRD and SEM authenticate the experimental results. Hence, WFS could be properly used in the manufacturing of SCC.

3. CONCLUSIONS

From the previous studies, it is observed that the strength of the concrete cast and cured with the seawater increased rapidly at the early stages of curing when compared to the concrete cast and cured in the fresh later strength decreases gradually for concrete with seawater. While adding crimped steel fibres to the concrete the strength of the concrete increases up to a certain percentage of adding steel fibre. After that strength gradually decreases with the increase of the percentage of steel to the concrete.

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