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The Effect of Sea Water Sea Sand Mixed Self Compacting Concrete Infrastructure development in coastal areas and isolated islands

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***Abstract:** The United Nations and the World Meteorological Organisation predict that around 5 billion people will lack clean water and even drinking water (Source: Conference on Our World in Concrete and Structure in Singapore). Based on the aforementioned phenomenon, given the abundant potential of seawater resources, there is an idea to use seawater as a concrete admixture, especially in building locations that often interact with seawater. Research is carried out in an effort to find alternatives to improve the mechanical properties of concrete such as compressive strength values, split tensile strength, namely by using additives as self-compacting concrete technology and making seawater and sea sand as a substitute for fresh water and river sand.*

***Keywords:** Self compacting concrete; Sea water; Sea sand; Mechanical properties.*

1. INTRODUCTION

The use of marine sand and seawater as admixtures in self compacting concrete (SCC) has several drawbacks that need to be considered including; Seawater contains chlorides that can accelerate corrosion of reinforcing steel in concrete; Although SCC concrete with marine sand and seawater can achieve higher early strength, long-term effects on concrete strength; The use of seawater and marine sand can affect the resistance of concrete to the environment. The salt content in seawater can accelerate the degradation process of concrete and reduce the service life of the structure; If using sea sand, special treatment such as washing with fresh water is required to reduce the salt content. This treatment may increase production costs. In practice, the use of marine sand and seawater in SCC concrete should be carefully considered, especially in terms of structural durability and environmental impact.

Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete [1].

With the continuous increase in infrastructure development around the world, the supply of river sand and freshwater for making concrete is facing a huge shortage, especially for coastal areas. To solve this problem, researchers have begun investigating the possibility of using seawater and ocean sand as alternatives [2].

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With the development of the marine economy and the deployment of national maritime forces, a large number of coastal port structures and civil engineering projects need to be built. Traditional concrete manufacturing will over- consume river sand, ore, and freshwater resources, while violating the concept of sustainable development. In order to solve the problems of resource shortage and high transportation costs, it is imperative to prepare seawater concrete and marine sand [3].

To address the major challenges related to water scarcity and fine aggregate availability in low-lying areas and remote islands, the aim is to utilize seawater, marine sand, and Portland composite cement to produce high-performance Self-Compacting Concrete (SCC) [4].

A critical review of the utilization of sea sand and seawater as raw materials for concrete and its impact on the properties of the resulting concrete, including flexibility, short- and long-term strength, and durability. Concrete made from marine sand and seawater exhibits faster early strength development than ordinary concrete, yet achieves similar long-term strength. The use of marine sand and seawater can significantly affect the chloride-induced corrosion of steel, but has only an insignificant impact on the carbonation process of concrete [5].

Extensive research has been conducted on seawater marine sand concrete (SSSC) in recent years due to the shortage of fresh water and river sand in many coastal areas [6].

Natural sea sand and seawater, as a sustainable alternative material to reduce environmental pollution and resource shortages of traditional concrete production using river sand and fresh water, are receiving increasing attention from researchers around the world [7].

Development of a new type of ultra-high performance concrete, namely ultra-high performance seawater marine sand concrete. The development of ultra-high performance seawater marine sand concrete addresses the challenges associated with the shortage of freshwater, river sand, and coarse aggregate in producing concrete for marine construction projects [8].

Seawater marine sand self-compacting concrete has now been treated as an ideal material in building island and beach structures. The feasibility of application techniques in real engineering has been recognized by investigating the properties of the material, but the environmental impact is rarely a concern at the current stage [9].

Although self-compacting concrete (SCC) is currently used in many countries, there is a fundamental shortcoming in terms of the intrinsic durability of the material itself [10].

Chloride ion penetration is an important parameter affecting the service life of concrete structures, especially in aggressive environments [11].

This study can provide an insight into the utilization of seawater and sea sand in concrete and the impact of on Self Compacting Concrete.

2. LITERATUR REVIEW

Self-compacting concrete offers a rapid rate of concrete placement, with faster construction times and ease of flow around congested reinforcement. The fluidity and segregation resistance of SCC ensures a high level of homogeneity, minimal concrete voids and uniform concrete strength, providing the potential for a superior level of finish and durability to the structure. SCC is often produced with low water-cement ratio providing the potential for high early strength, earlier demoulding and faster use of elements and structures [12].

Concrete construction practice has always preferred fresh mixes, which are easy to handle and place [13]. However, this could only be achieved by adding more water to the mix or by greatly increasing the amount of cement paste. It was also discovered very early in development of ‘modern’ concrete that the high level of consistence (workability) [14]. based on high water content made the fresh mix very prone to severe segregation and greatly reduced the strength of the hardened mix. It became firmly embedded in ‘good concrete practice’ from the late 1800s until the advent of plasticisers and superplasticisers in the 1970s that fresh mixes of very high consistence, fluid, ‘runny’ mixes, were synonymous with very poor quality hardened concrete, which was best avoided. The alternative approach to raising consistence (workability) by a much increased cement paste content led to problems due to excessive heat generation during hardening and greatly increased the cost of such concrete.

Using seawater for mixing concrete is potentially advantageous from a sustainability perspective.

Sea sand is a widely available form of sand on comparing with the river sand. Sea sand is not used widely because it may contain chloride, sea shells in large numbers and other harmful chemicals like Fe2O3, V2O5, Cr2O3, Ga2O3, Br2O and Re2O7. A large number of individual works have been done worldwide on sea sand as partial/full replacement of fine aggregates in concrete, the general material properties of sea- sand, effect of chloride content in strength and workability, effect of rainfall on the chloride content, alkali – aggregate reaction. It also consists and understanding of the likely dangerous chemical components, effect of shell content on workability and strength, effect of size and uniformity of sea sand in concrete. By understanding the material properties of sea- sand, it can be effectively utilized as fine aggregate in concrete [15].

Validated marine sand and seawater in concrete production, that marine sand improved concrete durability by at least 42.3% and 11.5% in aspect of sorptivity and chloride penetration respectively, while seawater showed little effect. More durable concrete can be produced by utilizing SiMn slag, marine sand and seawater for potential industrial application [16].

The durability behaviour of seawater sea sand concrete and seawater sea sand concrete–filled fibre-reinforced polymer/stainless steel tubular stub columns. Effects of NaCl of seawater on the strength of seawater sea sand concrete and on the deterioration of fibre-reinforced polymer. Seawater sea sand concrete–filled did not show any deterioration in strength after a 2.5-year exposure to an indoor environment or a 1.5-year immersion in NaCl solution, that a hydrothermal environment (e.g. full immersion in solution) is much more aggressive to fibre-reinforced polymer than a dry environment [17].

It is an important approach to study the replacement of fresh water and river sand by seawater and sea sand to improve resources shortage and achieve sustainable development, workability, mechanical strength, drying shrinkage behavior and microstructures of seawater and sea sand concrete (SSC). That adding seawater and sea sand can lead to the increase of early compressive strength and the declining of workability, while the utilization of seawater and sea sand can result in the decrease of later strength. With the rising of curing age, SSC with adding SCMs (FA/LC2) has similar or better comprehensive performance than OPC-SSC. Scanning electron microscope (SEM) analysis also confirmed that the SSC with mineral admixtures has a more uniform and compact microstructure after long-term curing, and the SSC with 25% LC2 content has the best microstructural property. X-ray diffraction (XRD) and thermogravimetry analysis (TGA) also proved that LC2 system had better chemical reaction performance and higher early activity than FA system [18].

The over collection of river sand from river beds affects our ecological cycle directly or indirectly and so instead of river sand, sea sand that is enormously present in nature at sea shores has become common. Sea sand is less expensive and reduces the overall construction cost, which also helps to protect river sand from being destruction. It is validated using spectroscopy results that incorporation of sea sand adds strength to the structure and can be preferred for any construction purpose [19].

Rheological measurements undertaken to illustrate the applicability on fresh self-compacting concrete of a model for the relative viscosity and yield stress of suspensions, that the aspect ratio, angularity, and surface texture of aggregates affect the viscosity and yield stress [19].

The primary environmental problems connected to cement production are the enormous energy usage, which is one of a key component of concrete, and the emissions of CO2 into the atmosphere. Due to its widespread use as a construction material, concrete is given a lot of consideration when it comes to economic issues and reduces CO2 emissions to the extent that it is a component of cement. As industrialization expands, the quantity of waste material/byproducts generated grows as well, creating an ecological challenge that must be addressed aggregate combinations including sea sand and micro silica are employed to combat global warming and lower CO2 emissions associated to the manufacture of cement. compressive strength and tensile strength of concrete by utilizing k-fold validation neural network. For the productivity enhancement of the concrete mix made using sea sand and micro silica, the Multi-Taguchi Optimization Algorithm in the civil environment is employed. concrete constructed with partial substitution of cement and fine aggregate has greater compressive and split tensile strength is more than control concrete [20].

Modeling of seawater-mixed concrete at a variety of scales appears to be nascent. A primary challenge with the large-scale adoption of seawater-mixed concrete remains the absence of codes and specifications that address the use of such material. As an increasing number of structures are constructed using seawater-mixed concrete and a greater understanding of long-term behavior is obtained, it is hoped that greater adoption for the right applications will eventually follow [21].

Self-compacting concrete (SCC) can flow into place and compact under its own weight into a uniform void free mass even in areas of congested reinforcement. The research reported in this thesis examined the production of SCC with readily available UK materials, with the overall aims of evaluating test methods and establishing a suitable mix design procedure. There have been significant recent developments and applications of SCC in several countries, notably Japan. A literature survey gave an understanding of the advantages and properties of SCC, test methods and the range of constituent materials and their relative proportions for its successful production. A range of SCC mixes can be produced with the common features of a lower aggregate content than conventional concrete and the use of superplasticizers. Most mixes also contained one or more of pulverized fuel ash, ground granulated blast furnace slag and an inert powder filler. A mix design procedure, based on a method suggested by Japanese workers, has been developed. This includes optimisation of the mix with a linear optimisation tool from a commercial spreadsheet package [22].

3. RESEARCH METHODOLOGY

A. General

This type of research is in addition to literature review also conducted experimental tests on the effect of additives made from seawater and sea sand mix design self compacting concrete on compressive strength, split tensile strength, and flexural strength of concrete containing Portland cement composite (PCC). To achieve the objectives of this study, it is necessary to plan the stages of implementation of testing the compressive strength of cylinders, tensile strength of split cylinders and tensile tests of steel reinforcement using a Universal Testing Machine with a capacity of 100 tonnes following ASTM C39 - 01 standards[23]. Testing the flexural strength of beams using a Flexural Compressor Machine with a capacity of 2000 kg following ASTM C293-02 standards[24]. Testing the modulus of elasticity was carried out using a Combined Compressometer Extensometer following the ASTM C469-02 standard[25]. The reinforced concrete beams used as objects in this study are double reinforced concrete beams using without and with glenium and pozzolite additives. Testing of concrete beams is carried out with single point loading which is static with monotonic loading until the beam collapses.

The research obtained through testing the characteristics of concrete forming materials includes testing the characteristics of coarse aggregate, fine aggregate, fresh concrete and hardened concrete. From the test of fresh concrete obtained results in the form of slump values while hardened concrete obtained results in the form of compressive strength (fc'), split tensile strength (splitting), flexural strength and modulus of elasticity at the age of 28 days.

Figure 1. Hydraulic Pump

To determine the deflection, a dial gauge with an accuracy of 0.01 mm is used.

(a) (b)

Figure 2. (a) *Universal Testing Machine (b) Flexural Compressor Machine*

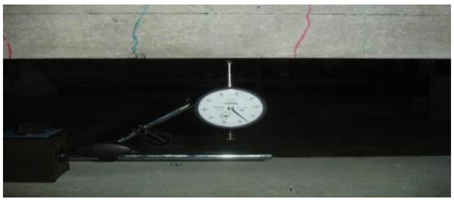


Figure 3. Deflection gauge

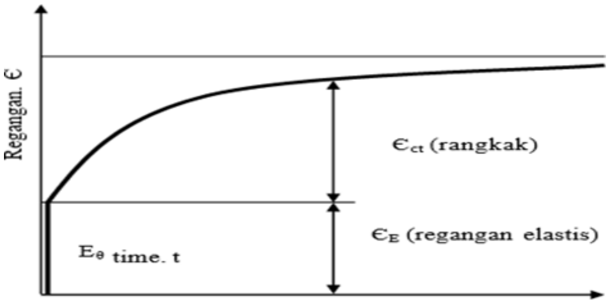


Figure 4. Strain - Time Curve

Table 1. Mix design of concrete

W/C (%)	**Volume 1 m^3**					
	Water (kg)	Semen Portland Cement composite (kg)	Aggregate		Superplasticizer (kg)	Steel fiber (kg) (0.3% x volume)
			Sea Sand (kg)	Coarse Aggregate (kg)		
40	166	414	721	1007	2.07	23.1

B. Materials For Self Compacting Concrete (Scc)

Concrete is generally composed of three main constituents: cement, aggregate and water. However, admixtures can also be added to change the properties of concrete. Cement is a mixture that is chemically active after contact with water. Aggregates function as mineral fillers that can prevent changes in the volume of concrete after stirring is complete and improve the durability of the resulting concrete. In general, concrete contains air voids of about 1% - 2%, cement paste (cement and water) of about 25% - 40%, and aggregate (fine aggregate and coarse aggregate) of about 60% - 75%. To obtain good quality concrete, the properties and characteristics of each constituent material must be considered carefully.

- **Type I Cement (Portland)**

Portland cement is the most widely used construction material in concrete work. According to ASTM C-150, 1985, standard[26]. Portland cement is defined as hydraulic cement produced by grinding clinker consisting of hydraulic calcium silicates, which generally contain one or more forms of calcium sulphate as additives ground together with the main ingredients [27]. Cement is an important and widely used binding agent in physical development in the civil construction sector. When added with water, cement becomes a cement paste which, when it dries, has the strength of stone. When added with fine aggregate, the cement paste becomes a mortar which, when combined with coarse aggregate, becomes a fresh concrete mix which, when hardened, becomes concrete. The main function of cement is to bind the aggregate grains to form a solid mass and fill the air voids between the aggregate grains. Although the composition of cement in concrete is only 10%, due to its function as a binding agent, the role of cement is important.

- **Aggregate**

Aggregates used in concrete mixes can be either natural aggregates or artificial aggregates. In general, aggregates can be categorised by their size, namely coarse aggregates and fine aggregates. The boundaries between coarse and fine aggregates differ from one discipline to another. However, a size limit between fine aggregate and coarse aggregate can be given as 4.80 mm (British Standard) or 4.75 mm (ASTM Standard). Coarse aggregate is rock whose grain size is larger than 4.80 mm (4.75 mm) and fine aggregate is rock smaller than 4.80 mm (4.75 mm). Aggregates with a size greater than 4.80 mm are further divided into two: those with a diameter between 4.80 - 40 mm are called concrete gravel and those greater than 40 mm are called coarse gravel. Aggregates used in concrete mixes are usually smaller than 40 mm. Aggregates larger than 40 mm are used for other civil works, for example for road works, retaining walls, dams, and others. Fine aggregates are commonly called sand and coarse aggregates are called gravel, spilit, or crushed stone in concrete work. According to ASTM C-150, 1985, standard[26]. Portland cement is defined as hydraulic cement produced by grinding clinker consisting of hydraulic calcium silicates, which generally contain one or more forms of calcium sulphate as additives ground together with the main ingredients[27].

Coarse aggregate has a great influence on the strength and structural properties of concrete. Therefore, the coarse aggregate used should have sufficiently hard grains, be free from cracks or weak planes, be clean and not covered by layers. In addition, the properties of the coarse aggregate also affect the aggregate-mortar bond and the mixing water requirement. Aggregates with smaller grain sizes have the potential to produce high strength concrete. In accordance with the aggregate quality control for various concrete grades, the coarse aggregate used must fulfil the requirements: Coarse aggregate should consist of coarse, non-porous grains. Coarse aggregate containing flat grains can only be used if the amount of flat grains does not exceed 20% of the total aggregate weight. The grains of coarse aggregate should be permanent, meaning that they are not broken or destroyed by the effects of weather, such as sun and rain; Coarse aggregate should not contain more than 1% mud (determined by dry weight). By mud, we mean those parts that can pass through a 0.063 mm sieve (sieve No. 200). If the mud content exceeds 1%, the coarse aggregate should be washed before use; Coarse aggregate should not contain substances that can damage concrete, such as alkali-reactive substances; The hardness of the aggregate grains is checked with a Rudeloff 20 tonne testing vessel or with a Los Angeles testing machine, where no weight loss of 50% is allowed; Fine coarse aggregate consists of grains that vary in size, meaning it must be well graded. The gradation and shape of fine grains are important factors in the production of high- strength concrete. As with coarse aggregates, the grain shape and surface texture of fine aggregates can affect the water demand and compressive strength of concrete. Fine aggregates with the same gradation but a 1% difference in coarseness can result in a difference in water demand of approximately 5 litres/m3 of concrete[28].

The amount of cement paste required per m3 of concrete decreases as the coarse aggregate/fine material volume ratio increases. Due to the large amount of cement contained in high-strength concrete, the amount of fine particles also tends to increase. As a result, sand can also be kept to a minimum as long as it is sufficient to achieve the desired closeness and density. In this way, it is possible to make higher strength concrete even if the same cementitious base material is used. Fine aggregates with a fineness modulus ranging from 2.5 to 3.2 are good for making high-strength concrete. Concrete mixes made with sand that has a fineness modulus of less than 2.5 will be sticky, resulting in poor flowability and more water is needed to correct this. Sometimes it is possible to combine sands from different sources to improve gradation and increase concrete strength[28].

– Water

Water is required in the manufacture of concrete to trigger the chemical process of cement, to wet the aggregates and to facilitate concrete work. Water acceptance criteria for high-strength concrete need not be specially considered if the water used is of potable quality. Otherwise, it should be tested in accordance with ASTM C-94[28] standard[29]. Water containing harmful compounds, contaminated with salt, oil, sugar, or other chemicals, when used in concrete mixes will reduce the quality of the concrete, and may even alter the properties of the concrete produced. In addition, such water can reduce the affinity between the aggregate and the cement paste and can also affect the ease of work. Since cement paste is the result of a chemical reaction between cement and water, it is not the ratio of the amount of water to the total weight of the mixture that is important, but the ratio of water to cement or what is commonly called the water cement ratio. Excessive water can cause a lot of water bubbles after the hydration process is complete, while too little water will cause the hydration process not to be fully achieved so that it will affect the strength of the concrete.

- Additive

Admixtures are materials that are added to the concrete mix at the time or during mixing. The function of these materials is to change the properties of the concrete to make it more suitable for a particular job, or to save costs[30]. The addition of additives to a concrete or mortar mix does not change the bulk composition of the other ingredients, as these additives tend to be substitutes within the concrete mix itself. Since the purpose is to improve or change certain properties and characteristics of the resulting concrete or mortar, the tendency for the composition to change in weight-volume terms is not as pronounced as compared to the initial composition of the concrete without additives. Additives are used to modify the properties and characteristics of concrete for example for ease of working, economy, or for other purposes such as energy saving.

A concrete admixture known as superplasticiser has been developed and is now widely used in Japan and Germany. Superplasticiser is a new type of additive that can be called a ‘water-reducing chemical additive’, which consists of; Condensation of melamine formaldehyd sulfonate with chloride content of 0.005%; Sulfanot naphthalin formaldehyde with negligible chloride content; Modified lignosulfonate without chloride content. All three types of additives are made from organic sulfonates and are called superplasticisers because they can reduce the water in the concrete mix while the concrete slump increases to 8 in (208 mm) or more. They are classed as a means of producing ‘flowing’ concrete without the undesirable segregation that commonly occurs in concrete with large amounts of water. They can also be used to increase the strength of concrete, as they allow a reduction in water content while maintaining the same workability. Because of the ‘flowing’ properties that superplasticisers impart to concrete, they are useful for moulding concrete in difficult places such as where there is dense reinforcement. Superplasticiser will not ‘thin’ all concrete mixes completely, hence the mix must be planned accordingly.

The recommended dosage is 1 to 2% by weight of cement. Excessive dosage may result in reduced compressive strength of the concrete[31]. In the research conducted on Self Compacting Concrete (SCC), the superplasticiser used was glenium 311, which is the third generation of superplasticiser for concrete and mortar specifically to improve the flow value of fresh concrete.

- Seawater as a concrete admixture

The use of seawater as a concrete admixture, So, the use of seawater in concrete has both advantages and risks[32]. It is important to consider environmental factors and project-specific needs, some relevant information:

a. Effect of Seawater on Concrete: Seawater has a high salt content, including chloride (Cl). These chlorides are aggressive towards other materials, including concrete; Research shows that the use of seawater in concrete mixing and curing can affect concrete properties, such as compressive strength, porosity and sorptivity; Early Strength: Concrete mixed with seawater tends to have higher early strength than regular concrete; Corrosion of Steel: The use of seawater can affect the corrosion of steel in concrete due to chlorides; Porosity: Concrete mixed with seawater has lower porosity.
b. Importance of Environmental Considerations: While there are benefits in early power, the environmental impact must also be considered; Salt in seawater can eat away at the durability of concrete in the long run.
c. Alternative: If possible, consider alternatives such as fresh water or blended water that has a lower salt content.

- Sea sand as concrete mixing material

The use of marine sand as a concrete admixture, The use of marine sand in concrete has both advantages and risks[33]. It is important to consider environmental factors and project-specific needs, some relevant information:

a. Characteristics of Marine Sand: Marine sand is characterised by fine, uniform grains. The size ranges from 0.55 to 2.5 mm; In contrast to land-based sand, which averages 0.55 to 3 mm in size; The salt content in marine sand can affect the properties of concrete, so special considerations are needed.
b. Treatment of Sea Sand: To reduce the impact of salt, marine sand can be treated with certain treatments, such as washing with fresh water; Research shows that concrete mixes using untreated marine sand produce concrete compressive strengths of around 16.36 MPa; With the watered treatment, the compressive strength increased to 17.52 MPa, and with the washed treatment, it reached 22.14 MPa.

c. Importance of Environmental Considerations: While there are benefits in early power, environmental impacts must also be considered; Salt in seawater can eat away at the long term durability of concrete.

C. Fresh Concrete

Fresh concrete is concrete that is still in a liquid state after the end of casting[34]. The properties of fresh concrete include; Easy mixing and blending process; Easy in the process of transport (handling); Easy to achieve sufficient density and non-porous. In working with fresh concrete, three important properties that must always be considered are workability, segregation and bleeding.

Workability, Workability is the nature or matter of how easy/least fresh concrete is worked, transported, homogeneity, stability, compaction properties and minimising air pores of concrete. Newman (1965) proposed that the notion of workability be defined on at least three different properties, namely; Compatibility or ease with which concrete can be compacted and air voids removed; Mobility or ease with which concrete can flow into a mould; Stability or the ability of concrete to remain as a homogeneous, coherent and stable mass while being worked and vibrated without segregation of its main ingredients.

Segregation, Segregation is the separation of the main elements of a heterogeneous mixture so that it is no longer evenly distributed or dispersed. In concrete mixes the differences in particle size and specific gravity of each mix are the main causes of segregation, but this can be mitigated by the selection of appropriate gradations and good workmanship.

Bleeding, The tendency of water to rise to the surface in freshly compacted concrete is called bleeding. This rising water carries cement and fine grains of sand, which when the concrete hardens will form a membrane. This is due to the inability of the solid elements of the mix to retain all the water of the mix as it goes down. Based on the amount, bleeding can be expressed as a decrease in the total unit height of the concrete[30].

D. Hard Concrete

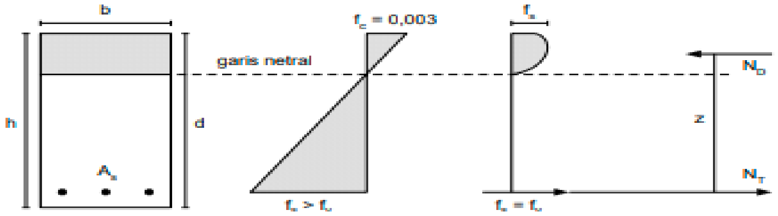
Basically, the strength of concrete is important because it gives an overall picture of the quality of concrete where strength is directly linked to the structure of the hardened cement mixture[35]. In addition to the water-cement ratio and the degree of compaction, it is also influenced by the crushing strength of the concrete.

Drying shrinkage is the reduction in the volome of a concrete element when it loses water content due to evaporation. Shrinkage is not a completely reversible process. If a unit of concrete is saturated with water after full shrinkage, it will not expand to its original volume.

E. Flexural strength of reinforced beams

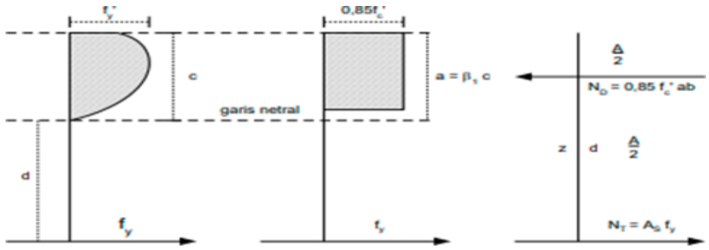
Creep or lateral material flow is defined as the addition of strain over time due to an acting load. The initial deformation due to the load is the elastic strain, while the addition due to the same load continuing to act is the creep strain[36]. Creep occurs with decreasing intensity after a certain time interval and may end after several years. The creep value for high strength concrete is less than that of low strength concrete. Generally, creep does not have a direct impact on the strength of the structure but will result in a redistribution of stresses under the applied load and subsequently an increase in deflection. Creep will increase with the increase in cement water factor and cement content. The flexural analysis of doubly reinforced[37] square beams as shown in Figure 5, is related to the determination of the nominal flexural strength Mn of a cross section with the values of b, d, d‘, As, As’, fc' and fy for the analysis of doubly reinforced concrete beams basically not much different from that of tensile reinforced square beams. The most important thing to analyse is the compressive steel reinforcement stress (fs') which is a function of the strain at the exact position of the stress point of the compressive steel

reinforcement.



(a) (b) (c) (d)

Figure 5.a Beam resisting ultimate moment



(a) (b) (c)

Figure 5.b Equivalent voltage block

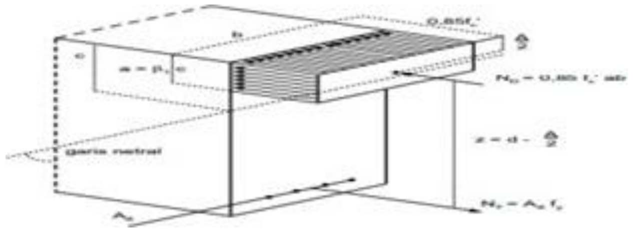
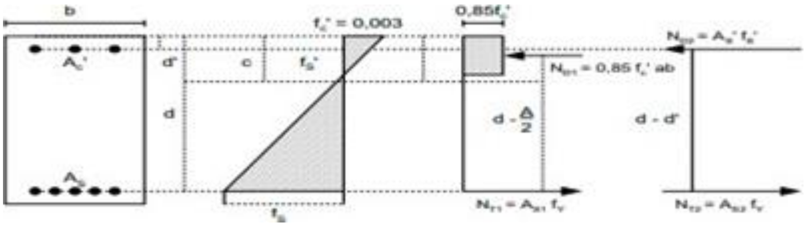


Figure 5.c Equivalent stress block for strength analysis



(a) (b) (c) (d)

Figure 5.d Analysis of double reinforcement Basically, reinforced concrete beams are viewed from two different perspectives in resisting forces.

The forces referred to here are ND compressive forces for concrete and compressive steel, the total compressive force is divided into two components, namely the compressive force resisted by ND1 concrete and the force resisted by ND2 compressive steel reinforcement. Thus, to analyse the inner resisting moment of the beam, two inner moment couplings are taken into account, namely the coupling of the compressive concrete pair with tensile steel reinforcement and the compressive steel reinforcement pair with the addition of tensile steel reinforcement as can be seen in Figure 5.

4. RESULTS AND DISCUSSION

A. Mix Design

Calculation and trial mix design *f'c* is 25 MPa by using the developmet of environment (DoE) method obtained aggregate composition and cement water factor as follows:

Table 1: Calculation and trial mix design *f'c* is 25 MPa

No	Calculation and trial mix	Mix design *f'c* 25 MPa
1	Required compressive strength	25 MPa
2	Fineness modulus of sand	2,50%
3	Fineness modulus of gravel	7,29%
4	Maximum size of aggregate	20 mm
5	Specific gravity SSD of sand	2,544
6	Specific gravity SSD of gravel	2,593
7	Sand water content (Wp)	3,47%
8	Gravel water content (Wk)	1,10%
9	Sand absorption (Rp)	1,63%
10	Gravel absorption (Rk)	1,42%
11	Percentage of best combined aggregate for SCC	
	a. Sand	50%
	b. Gravel	50%
12	Volume of 15 x 30 cm diameter cylinder	0,0053 m^3
13	when the compressive strength f'c is more than 35 Mpa then the required average compressive strength, f'cr is	38,16 MPa
14	From the graph of water cement ratio (fas) and compressive strength from SNI 2002, it is obtained for a compressive strength of 35.66 MPa,	fas 0,50
15	Estimated initial slump is	10 cm
16	Overall free water content 190 kg[38].	205 kg/m^3
17	Establishment of cement content (kg for 1 m^3 concrete)	410 kg
18	Calculation volume of aggregate (crushed stone + sand) required for 1 m3 concrete Volume of Aggregate	664,427 kg

19	Superplasticiser used was 1.5% by weight of cement	6,15 kg
20	Retarder used was 0.5% by weight of cement	2,05 kg

B. Slump Test

The slump measurement was carried out to determine the workability of the concrete mix. The workability of concrete mixtures is a measure of the ease with which the mixture can be stirred, transported, poured and compacted without causing separation of the concrete constituent materials. The level of workability is influenced by the composition of the mixture, physical conditions and the type of mixing material, so the level of the self compacting concrete mix shows the slump flow is 62 cm. While the flexural strength value of additive concrete experienced an increase of 4.5% from the flexural strength of normal concrete.

Figure 6. Slump test

C. Reinforced Concrete Beam Loading

Table 2: Results of loading tests reinforced concrete beams

No	Reinforced concrete beams	Nprmal	Self compacting concrete	Steel fiber 5%	Units
1	Flexural strength	22,56	24,96	27,84	MPa
2	Momen max	2,94	3,25	3,63	Ton.m
3	Cracking loads	1,40	1,50	1,60	Ton
4	Yield loads	4,50	5,00	5,40	Ton
5	Ultimate loads	4,70	5,20	5,80	Ton
6	Deformance at the time of initial cracking	2,00	1,74	1,67	mm
7	Deformance at the time of yielding	15,42	13,95	10,13	mm
8	Deformance at the time of ultimate load	29,00	25,58	24,35	mm
9	Deflection Ductility	2.00	2,48	2,79	-
10	Curvature Ductility	1,034	1,015	1,003	-
11	Initial crack width	0,16	0,15	0,11	mm
12	Ultimate crack width	3,00	2,60	2,20	mm
13	Crack length averaged	3,7 - 27,6	3,6 - 26,0	2,7 - 25,2	mm
14	Cracking angle to vertical axis averaged	21,6	15,4	7,7	$(^0)$

Show is table 2, above, it is clear that the cracking load in normal concrete is smaller than self compacting concrete, as is the case with additive concrete plus 5% fibre, and the maximum yield load occurs at 5% fibre addition with an increase of 20.00% against normal concrete and 11.11% against additive concrete without fibre.

Show is fig 7, this is also the case with the ultimate load. Fibre concrete experienced an increase in flexural strength of 23.40 % against normal concrete and 10.64% against additive concrete. While the condition that occurs in the load-induced deflection with the maximum deflection occurs in normal concrete at 16.03% and 11.79% self compacting concrete against 5% fibre concrete.

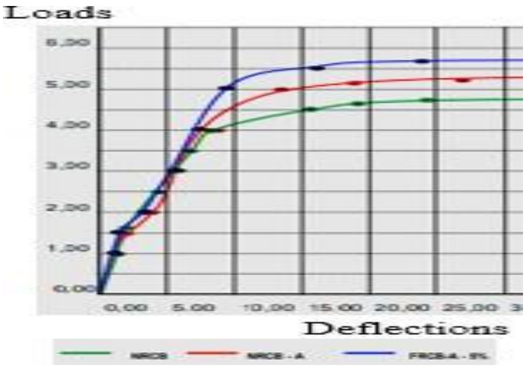


Figure 7. Relationship of load and deflection

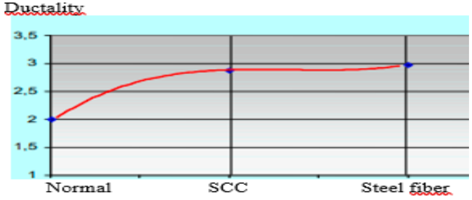


Figure 8. Relationship of ductility and concrete

The difference in ductility between normal and fibre- enhanced reinforced concrete is shown in table 2. To determine the ductility value of each specimen, it can be calculated from the load - deflection curve and moment - curvature relationship curve.

Show is fig 8, normal reinforced concrete beams have a deflection ductility of 24.00% less than additive concrete, 39.50% less than 5% fibre concrete with the highest ductility occurring in reinforced concrete plus 5% fibre by 1.39 times greater than normal concrete, while that occurs due to moments against curvature the highest ductility occurs in the addition of 5% steel fibre by 3.00% of normal concrete.

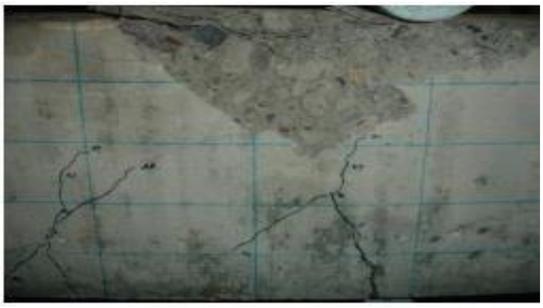


Figure 9. Crack pattern of additive concrete

The cracking pattern was observed based on the crack model that can be seen in the grid of the reinforced concrete beams. In normal concrete beams, the first crack occurred at the position under load, precisely the bottom fibre of the middle section of the beam at Pcr 1.4

tonnes as well as later with additive concrete beams at Pcr 1.5 tonnes, and 5% fibre concrete. the initial crack occurred when the reinforced concrete beam received a load of Pcr 1.6 tonnes.

Based on the observation of the cracks as attached in table 2, it can be seen that the first crack length ranges from 3.76 -

27.6 mm with a crack width of 0.06 - 0.16 mm for normal concrete, the first crack length ranges from 3.60 - 26.00 mm with a crack width of 0.04 - 0.15 mm for additive concrete and the first crack length ranges from 2.70 - 25.20 mm with a crack width of 0.02 - 0.11 for 5% fibre concrete. Judging from the initial position, the crack is classified as a type of flexular crack where the crack pattern forms a vertical line parallel to the axis line perpendicular to the long axis of the beam. beam length. Along with the increase in load, the As more cracking occurred along the beam span, the crack pattern changed its slope to form an angle of 68.4° for normal concrete, 74.6° for additive concrete, and 82.3° for 5% fibre concrete with respect to the horizontal axis of the beam. After flexural cracking occurs, the cracking is controlled by the presence of tensile reinforcement while the increase in crack width continuously develops with increasing load, show is fig 9.

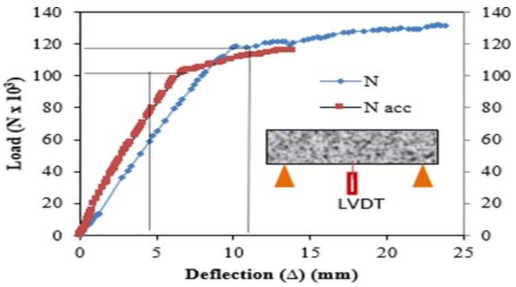


Figure 10: Relationship between load and deflection

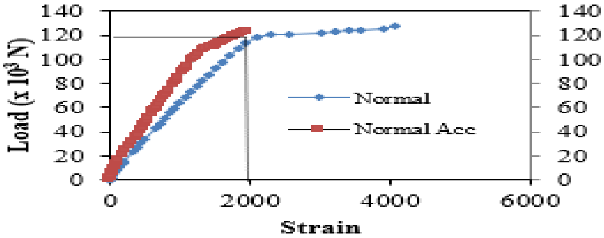


Figure 11: Relationship between load and strain

Figure 10 shows the load-deflection relationship for normal beam without acceleration (N) and normal beam with acceleration (N acc). In the N beam a straight line is formed until a load of 118.95 x 103 N and a deflection of 10.17 mm, while in the N acc beam a straight line is formed until a load of 102.63 x 103 N and a deflection of 6.74 mm. In the N beam the deflection that occurred was 23.77 mm when the maximum load was 131.78 x 103 N. In the N acc sample the deflection that occurred was 13.85 mm when the maximum load was 115.78

x 103 N.

Figure 11 shows the load and strain relationship of concrete in beams N and N acc. In the N beam a straight line is formed until a load of 118.23 kN and a strain of 2080.75, while in the N acc beam a straight line is formed until a load of 102.67 kN and a strain of 1231.92. In the N beam condition the beam failed at a load of 127.07 kN and a concrete strain of 4070.42. In the N acc beam condition the beam failed at a load of 123.01 kN and a concrete strain of 1955.87. In test specimen N the elasticity line is longer than in test specimen N acc so that test specimen N has higher ductility than test specimen N acc. N acc is brittle because the bearing capacity of the reinforcement is not able to withstand the load given due to the corrosion process in the reinforcement.

The use of natural sea sand and seawater, as a sustainable alternative material to reduce environmental pollution and resource shortage of traditional concrete production using river sand and fresh water. The development of a new type of ultra-high performance concrete, namely ultra-high performance self compacting concrete mixing sea sand and sea water production technology. The development of ultra- high performance seawater marine sand concrete addresses the challenges associated with the shortage of freshwater, river sand and coarse aggregate in producing concrete for marine construction projects.

5. CONCLUSIONS

Use of marine sand and seawater in SCC concrete should be carefully considered in practice, especially in terms of structural durability and environmental impact. Other alternatives, such as the use of fresh sand, also need to be evaluated based on project needs and resource availability.

The characteristics of fine aggregates in the form of sea sand were found to conform to ASTM specifications, so that the aggregates can be used for construction. can be used.

Using seawater as a substitute for water can be used as an SCC concrete mix material. The compressive strength of SCC concrete with marine materials compressive strength is higher than SCC concrete with normal materials.

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