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Application of natural seaweed modified mortar for sustainable concrete production

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Application of natural seaweed modified mortar for sustainable concrete production

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Abstract. The effect of seaweed such as Eucheuma Cottonii (gel) and Gracilaria Sp. modified mortar on the properties of sustainable concrete was investigated. Pre-experiment and main-experiment was conducted to carry out this study. Pre-experiment was conducted to study the compressive strength of the sustainable concrete. The main-experiment studied the compressive and splitting strength. Results showed that seaweed modified mortar yielded satisfactory compressive and splitting strength of 30 MPa and 5 MPa at 28 days.

1. Introduction

Sustainable concrete plays significant role in ecological development [1]. Global sustainability is driving a number of studies for achieving green construction [2]. As concrete is becoming the standard construction material currently, green concrete is the requirement for the sustainable development [3]. Therefore, a range of studies has been performed on manufacturing green concrete [4]. The outcomes of these studies made sustainable concrete as ‘green ‘concrete and less carbon emission material [5]. Currently, the world is facing two serious problems such as lack of sustainability and emission control [6].

Green concrete requires durability and longer life time [7]. Polymer adhesives can improve the mechanical properties of concrete [8]. However, Polymers can be made more durable through polymerization of monomers [9]. Concrete composed of polymers is known as polymer concrete [10]. If polymer is mixed together with cement and aggregates, then the mixture is called polymer modified concrete. Polymer modified sustainable concrete has great binding strength [11]. Hence, it can be used for maintenance work [12].

Currently, rubber is being added to the polymer modification process to produce high quality synthetic resin which in turn can produce synthetic resin modified concrete. [13]. Although the use of organic polymer has already been studied in the development of polymer modification process the use of carbohydrate polymer hasn’t been reported till to date [14]. The present study aims to explore the use of seaweed in the polymer modification process. Seaweed such as Eucheuma Cottonii (gel) and Gracilaria Sp. (powder) were introduced in the present work as these species comprise agarans and carrageenans. Eucheuma Cottonii is classified as polysaccharides which comprises kappa carrageenan. This species can be used in emulsification, condensation, and stabilization purpose [1]. Gracilaria Sp. is classified as polysaccharide that comprises agarose and can be used to prepare strong gel [15]. In

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addition, these two species contain rheological properties as thickening agents that may be used as epoxy resin in polymer modification process [16]. After considering all these benefits, seaweed modified mortars are likely to attain outstanding bonding and durability to attain sustainability. Therefore, the present work examined the compressive and splitting tensile strength of seaweed modified concrete.

2. Materials and methods

Materials utilized in the present study were mortar and seaweed. Two specific species of seaweeds were employed in this study such as Eucheuma Cottonii (gel) and Gracilaria Sp. (powder). The Eucheuma Cottonii was collected from raw heated seaweed and Gracilaria Sp. was collected from the powder.

In the present work, mortar mix composition of cement: sand: water was 1: 1: 0.5. However, the proportion of seaweed in the mix design was listed in Table 1.

Table 1. Proportion of gel and powder seaweed in mortar.

Experiments	% seaweed gel of the cement weight	% seaweed powder of the cement weight
Pre-experiment	0.1; 0.6;1.1;6	0.1; 0.6;1.1,6
Main-experiment	-	0.1; 0.3; 0.6;1.1; 2.1, 5.1

2.1. Pre-experiment

This study was carried out in two parts, pre-experiment and main experiment. Pre-experiment was performed to study the compressive strength of seaweed modified mortar at the end of 7 and 14 days curing. The proportions of seaweed used in the mix design are shown in Table 1. The outcomes of pre-experiment shall define which seaweed is going to be employed in the subsequent experiment.

2.2. Main-experiment

After the completion of pre-experiment, the main-experiment was conducted. The main-experiment examined compressive and splitting tensile strength of seaweed modified mortar. The proportions of seaweed used in the main-experiment are shown in Table 1. Each of the compressive strength of the samples was measured after 7, 14, and 28 days while splitting tensile strength was determined after 28 days. The results of seaweed modified mortars shall be weighted to control specimens.

2.3. Specimen test

Samples were made according to ASTM C-305 [17]. Cube-samples measuring 50 mm x 50 mm x 50 mm were used in the pre-experiment. Cube-samples measuring 50 mm x 50 mm x 50 mm and cylinder-samples measuring 150 mm x 300 mm were used in the main-experiment. Five samples were prepared for each mix design. Compressive strength of the samples was measured by ASTM C-39. However, splitting tensile strength was determined by ASTM C-496.

3. Results and discussions

In the pre-experiment, seaweed gel modified concrete attained high compressive strength after 7 days of curing. The highest compressive strength of 30 MPa was achieved by CS-07-0.6 gel (Figure 1). It was observed that after 14 days of curing compressive strength of CS-14-1.1 gel (22 MPa) was reduced compared to CS-14-1.1 powder (25 MPa) (Figure 2). However, compressive strength of CS - 07 and 14 powder showed stable performance.

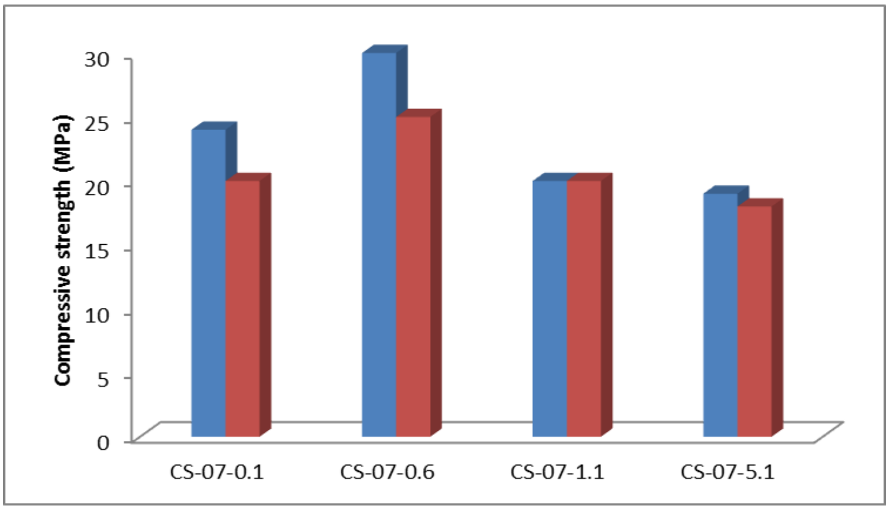

Figure 1. Compressive strength after 7 days, of seaweed modified mortar gel and powder, where (blue) gel and (red) powder.

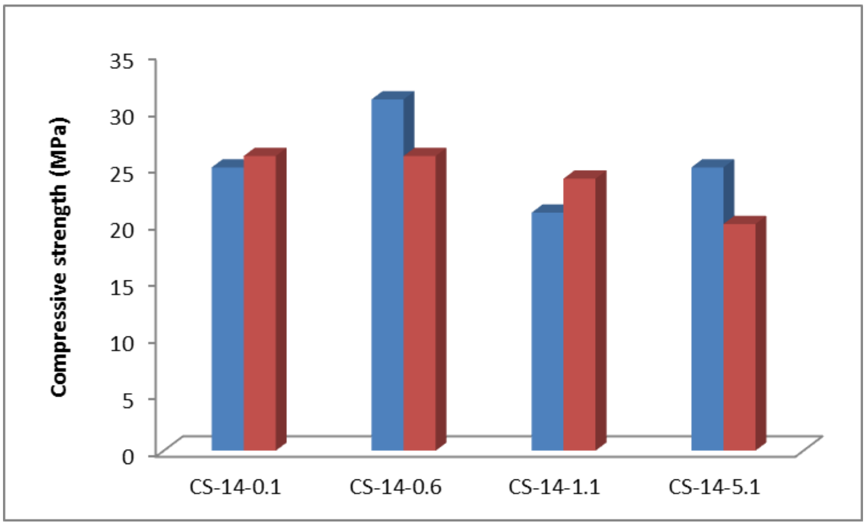

Figure 2. Compressive strength after 14 days, of seaweed modified mortar gel and powder, where (blue) gel and (red) powder.

Seaweed gel and seaweed powder (Gracilaria Sp.) modified mortar have properties of gelling and thickening. Therefore, Gracilaria Sp. formed stronger gel compared to that of Seaweed gel. For this reason Gracilaria Sp. Gel modified mortar increased the bonding strength of the specimen. The outcomes of the pre-experiment showed that the seaweed powder of Gracilaria Sp. becomes the suitable natural polymer of the main-experiment.

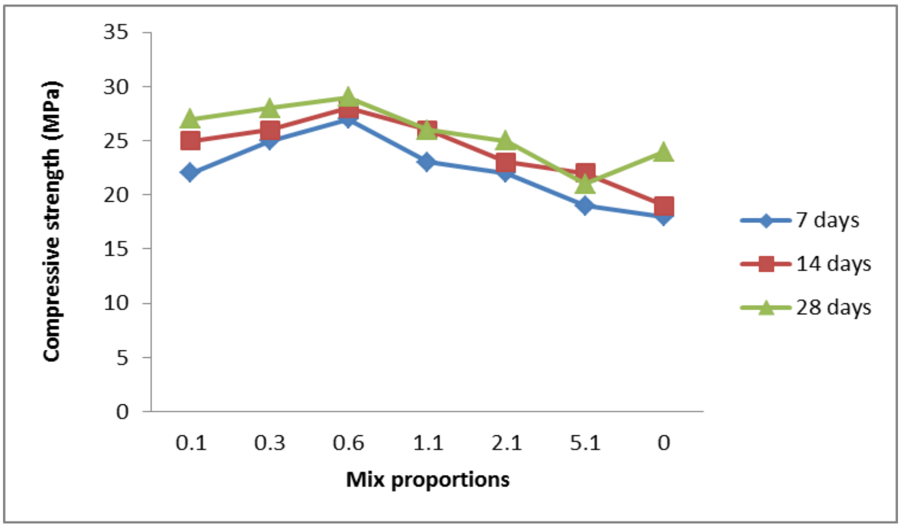

Figure 3. Compressive strength after 7, 14, and 28 days of seaweed powder modified mortar.

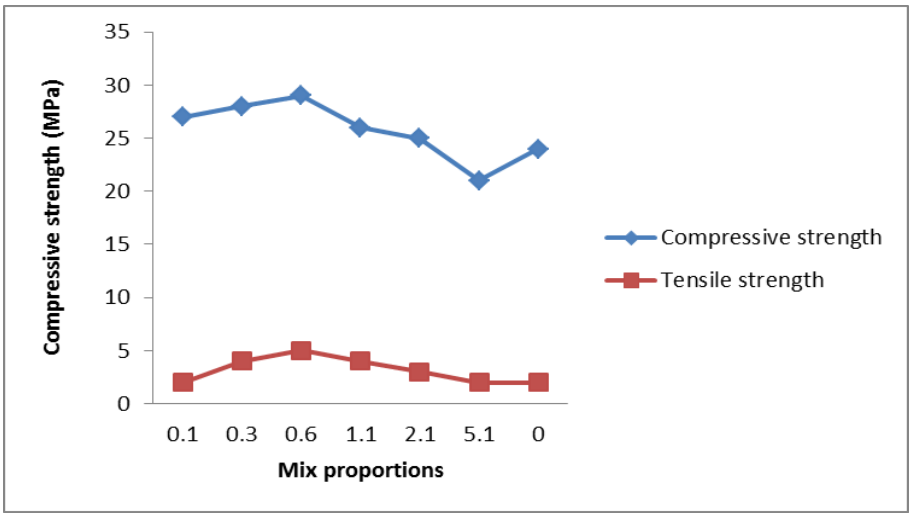

Figure 4. Compressive strength and splitting tensile strength of seaweed powder modified mortar.

Main-experiment examined both compressive and splitting strength of the different mix proportions of seaweed modified mortar and control samples. It has been observed that mix design of CS-0.6 has the maximum compressive strength of 26 MPa after 7 days; 27 MPa after 14 days; and 28 MPa after 28 days (Fig 3). It can be seen that compressive strength of CS-0.1, CS-0.3, and CS-0.6 was steadily increased after 7 days, 14 days and 28 days. On the other hand, compressive strength of CS-1.1, CS-2.1, and CS-5.1 was slowly declined after 7 days, 14 days and 28 days. Control samples have attained lower compressive strength (17 MPa after 7 days; 18 MPa after 14 days; and 24 MPa after 28 days) than other mix designs, except of CS-6 after 28 days. From the outcomes of the main-experiment it was observed that higher proportion of mortar sample (CS-1, CS-2.1, and CS-5.1) did not increased the bonding strength. Therefore, the optimum mix proportion was selected CS-0.6.
As the mortar produced outstanding compressive strength, the addition of seaweed powder was likely to improve its tensile strength. It was observed from Fig. 4 that the desired splitting tensile strength was attained by mix proportion of CS-0.6. It was observed that CS-0.6 achieved the maximum splitting tensile strength of 5 MPa. Moreover, control samples attained 2 MPa of splitting tensile strength. It could be due to the formation of strong gel and improved the bonding strength which made the performance seaweed powder modified mortar outstanding [1].

Seaweed modified concrete possess outstanding binding and adhesion strength with the aggregates. For this reason, it can be used for maintenance works. As added to the cement, seaweed fills the porous portions and improves its performance [2]. Gracilaria Sp. and Seaweed gel contain identical features for binding and condensing. Due to the agarans and carrageenans of these two species they can be considered handy for cement hydration phase. Gracilaria Sp. contains lesser shrinkage but more ductility than Seaweed gel [1]. It may be due to the outcomes of pre-experiment achieved improved compressive strength with seaweed powder than seaweed gel. It is noticeable that raw Seaweed gel was prior to be used with the mortar and achieved cement hydration. Gracilaria Sp powder was active in binding and condensing. As Gracilaria Sp. contains minor shrinkage and abundant ductility, it can enhance bonding capacity. Therefore, it is clear that main-experiment outcomes showed improved compressive and tensile strength for CS-0.6. Results revealed that high proportion of seaweed (CS-1.1, CS-2.1, and CS-5.1) did not increase compressive strength of the mortar. It can be observed that lower proportion of seaweed (CS-0.1, CS-0.3, and CS-0.6) increased compressive strength of the mortar. As Gracilaria Sp. contains lower shrinkage and abundant ductility, the splitting tensile strength of seaweed modified mortar was improved. In addition, the mix proportion of CS-0.6 was the optimum.

4. Conclusions

Seaweed gel and Gracilaria Sp. (powder) may be applied as natural polymer. These two species showed great performance in binding and condensing and can improve bonding strength. Results showed that Gracilaria Sp. powder modified mortar achieved improved compressive and splitting tensile strength than control samples. CS-0.6 was the optimal mix proportion for better mortar performance. The commercial application of this technology is expected to be encouraging for the production of sustainable concrete.

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