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Performance of Coral Aggregate on Mechanical and Durability Properties of Concrete - A Review

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Abstract:
Coral concrete is a type of aggregate and is generally light and porous, with rough surface, little adherence to the attachments and high concentration of sea salts. Coral concretes are mainly required in the Construction of offshore structures. This types of aggregate complies low grade of strengths, little corrosive resistance and is highly brittle. These features influences the workability, mechanical properties, and durability properties of developed concrete. The objective is to analyse the performance of coral aggregate on workability, mechanical and durability properties such as (shrinkage, chloride) of concrete. In this backdrop, this paper gives an account of properties of low stability hydrated products of the Portland cement under sea condition, low strength and stiffness of coral aggregates having large connected porosity with weak interface microstructure between the cement matrix and coral aggregates.

Keywords: Coral aggregate, Physical & Chemical Properties, Strength, Durability properties.

1. Introduction

With the exponential improvement of society, it is very difficult to meet the people's demand because of very limited resources of land. In past different nations have also increases their investment in marine engineering and constructed lots of artificial ice lands also. Concrete is a vital establishment material in the marine foundation development [1-2]. The conveying of coarse and other aggregates from inland increases expenditure of the adventure as well as effect the schedule of work because of various changes in climatic condition of the ocean [3]. So the importance of coral aggregates comes into the picture to execute the development of the work. The general concrete mixed design is not recommended because Coral aggregates have unpleasant surface and permeable structure [4-5]. Several researchers investigated the performance of coral aggregate; hence there is a need to compile and analyse the performance of aggregate in a single platform. The objective is to review the performance of coral aggregate on mechanical and durability properties of concrete.

2. Physical, Chemical , Mineralogical properties of coral aggregate :-

Coral concretes are made using Portland cement and it has a compound shape like antlers, honey-combs and cage shape structure [6-7]. The angularity of coral concrete is high and its roundness value (lies in the range of 1.1 and 4.0 [8].The coral polyps forms outer shell of limestone by absorbing Ca $(OH)_2$ and CO_2 in the sea-water during its growth [9].Coral aggregate contains aragonite and calcite, two mineral composition with the fundamental chemical composition of Calcium carbonate, which represents 96% [9]. A few scientists

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contemplated that the apparent density and bulk density of coral is 1800 kg/m^3, 900kg/m^3 & porosity upto 50% and has a higher water absorption (W/A) than that of ceramsite coarse aggregates [10-11].

As compared to ceramsite coarse aggregates the W/A proportion for one hour is more than 16% [12]. This conduct is ascribed to the higher assimilation rate of the water absorption ratio and crushing rate (upto 24-38%) exhibit in bigger pore size of coral particles in the range from 5-19mm [13-14]. The specific gravity of coral aggregate depends on depth of the burial location in the ocean. [15]. In this way, the physical, chemical and mineralogical properties of coral aggregate are essential parts of the investigation of concrete.

(a) Treated coral aggregate (b) Internal porosity (red section)

Fig(1):- Shows Morphological characteristics of coral aggregates [8]

3 Property of coral aggregate:-

3.1 Workability:

Workability is generally measured by slump test. It can be described as a consistency measure. The slump of coral concrete is affected by Volume rate of coral aggregates. The coral concrete is generally formed with higher sand rate and sand ratio for the most part utilized is concentration at 45% to 60% [16– 17]. The fluidity and water absorption of coral sand affects the workability of coral aggregate deeply. It was observed that coral aggregate and the decay of sand content are inversly releated to each other, which brings a temporary increase in fluidity, however as compared to coral sand the water absorption is greater for coral coarse aggregate resulting gradually decrease of fluidity in the mixing process [16]. Depending upon the type of concrete prepared by coral particles also affect workability. The concretes prepared with fine aggregate coral particles shows better workability comparing concrete that of river sand [18]. It was also observed that the flowability of normal concrete of river sand made with specific water consumption can be attained by coral aggregates in addition of chemical admixtures [6]. The particle size of coral aggregate can be reduces due to the behaviour of aggregates, internal friction of coral concrete, mechanical agitation caused by fragmentation. with the behavior of coral aggregates, it needs to expand the amount of cement paste during mixing, and select the proper w/c proportion to over come the problems of large slump loss, poor flow and so on [19]. Figure 2 shows workability of concrete for coral manufactured sand. It is observed from the figure that flow ability of concrete decreases, particularly when the variation is above 60%.

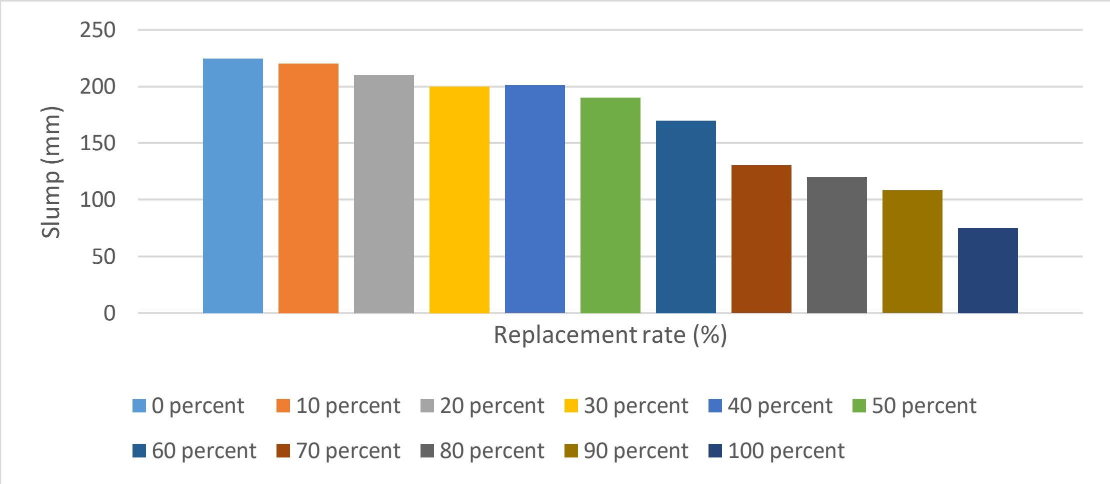

Fig 2:- Workability of concrete for coral manufactured sand [19]

4. Mechanical Properties:

Strength of coral concrete is the essential parameter and it releated to the pore structure and the interfacial transition zone [20]. These low strength concretes are used for formation of the Sea walls, road pavement and other port structures etc [21]. It was observed that with the utilization of chemical admixtures, mineral admixtures and different segments to improve the mechanical behavoirs of aggregates. The coral aggregate shows the minimal effect on the compressive strength because of reducing the water-cement ratio 20-30% and increasing the cement content and mineral admixture coral concrete shows the strength upto 55.7 Mpa [17]. As compared to normal concrete, strength developed of coral concrete is different,the strength develops of coral aggregate rapidly increase with the performance of salts in coral aggregate, and 7 days strength upto 80% of 28 days strength [22].It was observed that strength of coral aggregate depends on the coral sand rate. Coral sand rate and curing age are directly releated to the strength of aggregate [16]. The high strength of coral aggregate is identified with two perspectives. First of all, inorganic sodium chloride conveyed by the concrete to-itself or utilizing seawater blending, particularly Cl ions, respond presence of Al_2o_3, Alo_2 in concrete to shape Friedle's salts [23]. Besides, aggregate assimilate dampness in underlying blending, supplying a dampness contrast between bond aggregate and stone amid the concrete solidifying; in the meantime, bond hydration prompt expanded slender pressure, which turns into the primary power the water discharge from aggregates. This differential dampness and narrow stretch prompt an interior restoring impact [24]. The strength grade is important factor on which the coral concrete depends. It is observed that the coral concretes are more brittle within the higher strength grade [17], as compared to ordinary and light aggregate concrete the interfacial bond strength of aggregates is high when the strength grade is below C40 resulting in higher tensile strength.The concrete prepared with different strength grades such as C55, C50, C40, C30, C20 the strength is increased by 8%, 9%, 12%, 19% and 33% respectively [25]. Surface features, shape, stiffness are some factors on which modulus of elasticity of concrete is depends. with the increases in the strength level, the amount of coral aggregate decreases, rigidity of concrete is increases, as a result modulus of elasticity of coral concrete increases [17].Figure 2 shows the compressive strength of coral aggregate at different curing days [22]. It is observed from the figure that 7days strength is upto 80 percent of 28 days strength.

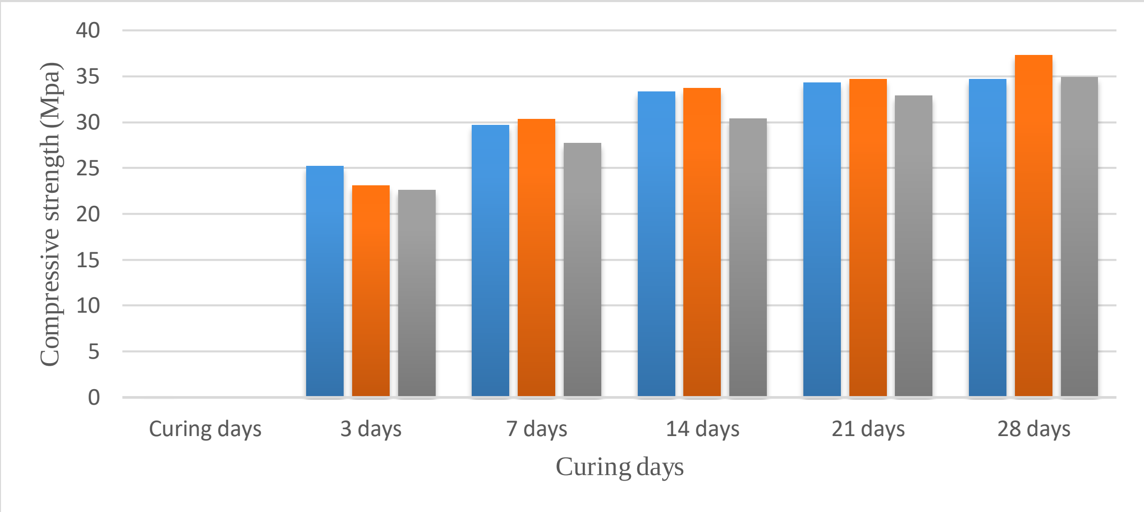

Fig 3:- The compressive strength of coral aggregate at different curing days [22].

5. Durability Properties:

5.1 Shrinkage:

Shrinkage is one of the essential factors which effects the durability properties of coral aggregates. Storing water, cement based materials are some factors on which shrinkage depends. Water discharged during the hardening phase of cement -based materials which will maintain the relative moistness, and advancing further hydration and as a result reduced the shrinkage [26-27].

Drying shrinkage and autogeneous shrinkage are the types of shrinkage of high strength concrete. It was observed that shrinkage rate of coral concrete made by ocean water and coral sand was more prominent as compared to normal concrete, and naphthalene water reducing agent has a high efficient which can effectively reduce its shrinkage [28].It was observed that the concrete prepared by coral sand, shows littler workability comparing concrete that of river sand . Moreover, it was concluded that coral aggregate has a better shrinkage that of normal concrete [29-30].It was found that prewetted coral aggregate of pore structure plays an important character in shrinkage behaviour of concrete. Ultra high performance concrete (UHPC) effects the Prewetted aggregates however as compared to saturated coral aggregates (SCA) the shrinkage rate is greater for high performance concrete [31]. Figure 4 shows the shrinkage behavior of coral aggregate for different percentage of aggregate replacement.

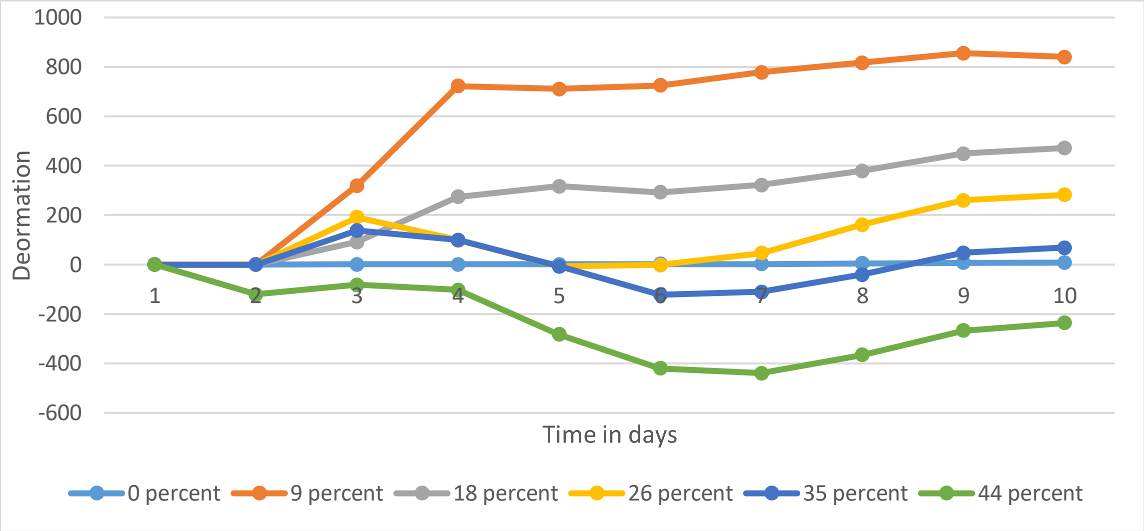

Fig 4:- Shrinkage behavior of coral aggregate for different percentage of aggregate replacement [31]

5.2 Chloride attack:

Free chloride ion content in surface layer (Cs) and the total free chlorine ion content (Cf) in concrete, and curing age are important factor on which chloride ion depends. It was observed that the free chloride ion content of the coral concretes at different strength levels increased with the exposure time [32-33].The coral concretes is higher chloride ion diffusion than that of ordinary concretes; while the chloride ion diffusion of coral concretes in underwater area and splash zone can reach 15 times and 7.4 times of that in atmospheric area [32,34].With the increasing the curing time and strength grade can reduce the chloride ion diffusion of coral concrete. Moreover, as compared to river sand concrete,coral sand concrete has better resistance to chlorine penetration [35]. As a result due to the internal curing effect porous light weight aggregate leads to an increase in resistance to chloride ion penetration [36].

In the streaming seawater, $CA(OH)_2$, the hydration product of the concrete is continuously drained away under the focus slope of the pore arrangement and the outer condition, which prompts the pulverization of the gel structure [10]. In the meantime, the high salt condition of the ocean, the $CA(OH)_2$ and Al stage in the solid are powerless against the erosion of $SO4_2$, which will prompt the insecurity of the item in the bond stone framework. Moreover, high concentration of chloride particle would decrease the expansion as chloride restricting hydrated calcium aluminate to frame new product [32-33].

6. Conclusion:

Performance of coral concrete on workability, mechanical properties, durability properties (like shrinkage, chloride attack) are compiled and analysed in this study. It is observed from the study that:-

1. Performance of coral aggregate concrete on workability, mechanical properties, durability properties (like shrinkage, chloride attack) are effected because of a rough surface and porous structure.
2. For the replacement of coral sand with manufactured sand slump of concrete is decreases, when the replacement is greater than 60%.

3. The mechanical properties affect the performance according to the curing age of coral concrete.
4. Durability behaviours of coral aggregate are better for the replacement of saturated coral aggregate as per deformation is concerned even up to 100% replacement.

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