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Experimental investigation of whole stress-strain curves of coral concrete

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HIGHLIGHTS

- Constitutive relationship of coral concrete in different strength grades was studied.
- Stress-strain curves of coral concrete in different strength grades were analysed.
- Failure of coral concrete under uniaxial compression test was studied.
- Possible applications of coral concrete in engineering structures were suggested.

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ABSTRACT

The constitutive relationship of coral concrete (CPC) was researched using prismatic specimens under uniaxial compression. The equal stress cycle loading and unloading and equal strain monotonic loading methods were adopted. The elastic modulus (E_c) and Poisson's ratio (μ) were determined. The results showed that when the specimen strain was close to the maximum, CPC was rapidly damaged in the form of splitting. The whole stress-strain curve ascent stage was composed of concave and convex curves, while the descent stage was relatively short. The ratio of residual stress (σ_{ri}) and peak stress (σ_{0i}) was 0.30–0.50, and with increase in the strength grade, σ_{ri}/σ_{0i} decreased. The two-part constitutive equations of CPC were presented, which could reflect all the characteristics of the compression tests. With increase in the strength grade, the μ of coral concrete first increased and then decreased. The E_c of CPC tended to increase. To expand the application of CPC in island engineering construction, superfine cement paste, silicon mortar, or polymer could be used to strengthen the coral surface. Adding steel bar, steel fibre, or organic fibre into CPC could also increase the CPC strength and tenacity.

1. Introduction

A coral reef is a special rock-soil that mainly includes aragonite and high-Mg calcite, with more than 96% $CaCO_3$, and it is abundant in the South China Sea islands. These reefs provide a kind of new engineering material, i.e., coral aggregate, for developing islands [1,2]. Coral concrete (CPC) is composed of coral debris as a coarse aggregate, coral sand as a fine aggregate, seawater, and cement. This material can be useful in improving the marine power in China, developing the South China Sea islands, and building basic infrastructure. Engineering activities such as the construction and repair of concrete structures may sometimes require ships to transport sand and water from the mainland, which may located be far away from the coral island. This would be expensive as well as subject to natural conditions such as stormy waves. It is therefore difficult to ensure that the engineering activities will be completed on time. Under the condition that the local ecological environment is not affected, it may be feasible to obtain raw materials locally from the reef island. It is of theoretical significance and practical value to use seawater and coral reef sand dug up from construction of docks and dredging waterways, as well as to collect coral and coral sand washed by the waves, instead of using fresh water and normal aggregates.

Studies on CPC in China and other areas have mainly concentrated on investigating the durability, mix proportion design, and the basic physical and mechanical properties of CPC. In 1951, American scholar Dempsey [3] reported that the corrosion to dense, high-quality CPC was negligible, but CPC exposed to a humid environment for a long time might be corroded. In 1982, Australian scholar Vines [4] discovered that CPC from Samoa in the South Pacific had poor strength structure and durability. In

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