Experimental Study of Lightweight Metakaolin Aggregate Applied to Ocean Concrete

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ABSTRACT

In this study with various combinations of materials and binders, metakaolin was utilized as the main material to make a lightweight aggregate for concrete suitable to be used for offshore structures. Five different proportions of metakaolin-made lightweight aggregate were proposed and the objective was to study the effects of different proportions on the properties of the metakaolin made aggregate. Several tests were performed such as point loading tests for crushing strength, sifting analysis, and bulk density analysis. The results of the tests showed that different proportions of metakaolin lightweight aggregate have different effects on the properties of the aggregate. Therefore, a suitable formula must be selected in accordance with the application. Among all groups, group D (cement: slaked lime: metakaolin: fly ash: sand =12.5%: 12.5%: 28.125%: 9.375%: 37.5%) had the best mechanical and physical performance.

KEY WORDS: metakaolin; lightweight aggregate; marine concrete; offshore construction

INTRODUCTION

Due to the skyrocketing price of oil, the exploitation on the energy sources from the ocean is getting more and more popular. A stable, dependable and yet economical offshore platform structural system is highly demanded more than ever. Reinforced concrete, due to its high strength, economic availability, ease of forming into all kinds of shapes, and good resistance to water, is the material most widely used for engineering construction. Therefore, for a large scale offshore platform structural system, concrete appears to be an economical, durable, and strong material. However, to maintain the ability to resist large forces, usually the volume of concrete is high. The result is that the weight of the concrete itself becomes a large burden to the structural system in the marine environment. How to mitigate the mass of the concrete material but maintain its strength, therefore, becomes an important issue for the application of the most widely applied engineering material—concrete to the offshore platform structural system.

To reduce the mass of concrete, many methods have been applied such as; the use of entrained air to occupy part of the volume of concrete with very small voids generated from the admixtures, a reduction in the use of high density aggregate in order to reduce the density of the hardened concrete, or the application of various non-traditional aggregates to reduce the unit weight of the concrete. All of the methods mentioned above have their advantages and drawbacks. In this study, the method of producing a lightweight aggregate by introducing a new mixing material to make a lightweight concrete was used. (Badhan1995, Bijen 1986, Helgesen 1995)

A common way to produce a lightweight concrete, as mentioned, is to reduce the weight of coarse aggregate, the major part of a concrete material. Aggregates that weigh less than 1120 kg/m³ are generally considered lightweight. Natural lightweight aggregates are made by processing igneous volcanic rocks such as pumice, scoria or tuff. Synthetic lightweight aggregates can be manufactured by thermal treatment from a variety of materials such as clays, shale, slate, diatomite, perlite, vermiculite, blast-furnace slag and fly ash. (Mehta, 1980). In this study, in order to find a lightweight concrete suitable for the application of offshore platform structures, various combinations of different kinds of materials and binders, Metakaolin together with cement and slaked lime were utilized as the main materials to make a lightweight aggregate. Five proportions of metakaolin made lightweight aggregate were eventually suggested. In order to determine the effects of different proportion on the properties of the metakaolin made aggregate, several tests were performed such as point loading tests, sifting analysis, and bulk density analysis according to ASTM. After the experimental tests, the results showed that different proportions of metakaolin lightweight aggregate had different effects on the properties of the aggregate. Therefore, a suitable formula must be selected in accordance with the application. Among all groups, group D had the best mechanical and physical performance. It was also found that compared with the traditional fly-ash made light weight aggregates, the metakaolin-made lightweight aggregate had a smaller density and better performance on the strength if the concrete is well proportioned.

BASIC PROPERTIES OF CEMENT AND METAKAOLIN

The Main Compositions of Cement