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Technical Report

Investigation on the flexural behaviour of reinforced concrete beams using phyllite aggregates from mining waste

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ABSTRACT

This paper investigated the flexural behaviour of 12 reinforced concrete (RC) beams made of phyllite coarse aggregates produced as by-product of underground gold mining activity. The beams were tested to failure under four point test. Collapse of the beams which were adequately designed against shear failure occurred mostly through either flexural-shear failure and/or diagonal tension failure. The experimental failure loads averaged approximately 115% of the theoretical failure loads. It was observed that the beams developed early shear cracks and higher flexural crack widths than allowable at service loads. Deflections compared reasonably well with the design code requirement but displacement ductility was low. It is recommended that British Standard (BS) 8110 design concrete shear stress values be multiplied by 0.8 to assure that the predicted shear capacity of phyllite concrete would be low and reasonable as compared to flexural capacity. In that case, BS 8110 can be used to provide adequate load factor against flexural failure for under-reinforced RC beams made of phyllite coarse aggregates.

1. Introduction

Coarse aggregate is a major component of concrete as it takes a high percentage of either the mass or volume of concrete based on any standard mix design. The incidence of increasing rate of natural resource depletion coupled with the high cost associated with some of the traditionally used aggregates calls for the use of new, abundant and cheap materials. This has led to work by several researchers on either the mechanical properties of plain concrete or the bending/shear strengths of beams made from non-traditional aggregate sources.

Waste aggregates obtained from four granite pits in Turkey were used to produce concrete. Physical and chemical properties of the aggregates were found to be adequate when compared with code standards. Tests on concrete made from the granite waste aggregates indicated that the results of compressive strength, splitting tensile strength, static modulus of elasticity, water absorption rate and density are comparable to Turkish and European standards [1]. The mechanical properties of concrete with recycled coarse aggregate were also investigated for ten mixes of concrete with target compressive cube strength ranging from 20 to 50 Mpa. The trends in the development of compressive and shear strength and the strain at peak stress in recycled aggregate concrete were similar to those in natural aggregate concrete [2]. The shear behaviour of four recycled aggregate concrete beams were compared to those of corresponding normal concrete beams. The results showed that whereas the deflections and the ultimate loads were little affected by the type of concrete, the recycled beams developed cracking at lower loads than the corresponding normal concrete beams [3]. In areas where high quality aggregates are not available, silica fume has been incorporated in concrete to enhance its engineering properties. Researchers [4] characterized the properties of recycled aggregates by the addition of silica fume waste. Tests were conducted on concrete made from recycled concrete aggregates with silica fume waste to determine the properties – both physical (density and water absorption) and mechanical (compressive and tensile splitting strength and static modulus of elasticity). The compressive strength of recycled concrete with silica fume was similar to that of conventional concrete with silica fume. The optimum percent of silica fume for compressive strength of the concrete was 8%. The addition of the silica fume was found beneficial in controlling the performance levels in terms of sustained loading as compared to that of recycled concrete. In further experimental research, the behaviour of reinforced concrete beams made from recycled concrete aggregate with 8% silica fume [5] improved in terms of ultimate shear loads and cracking when compared with those of recycled concrete aggregates.

Other researchers have also used non-conventional aggregates in characterizing concrete beam behaviour. A comparative study of concrete properties using coconut shell and palm kernel shell as substitutes for conventional coarse aggregates showed that at least 30% cost reduction could be achieved for similar compressive strength of conventional concrete [6]. Others [7] showed that the structural bond properties of lightweight concrete incorporating

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