# PORTLAND COMPOSITE CEMENT AS AN ECONOMICAL SUBSTITUTE FOR ORDINARY PORTLAND CEMENT

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Ordinary Portland Cement (OPC) is manufactured by heating limestone and clay to a very high temperature (1450 $^0$C) to produce clinker and grinding clinker with gypsum in order to control the rate of the hydration process. The clinker production process emits a very high amount of carbon dioxide ($CO_2$) to the atmosphere and hence any reduction in the clinker percentage reduces the environmental pollution caused by cement manufacturing process. This can be achieved by mixing cement replacement materials such as limestone, fly ash and slag. Cement thus produced is termed Portland Composite Cement (PCC). Fly ash and slag being waste by products of coal energy and steel manufacturing processes respectively help to recycle the otherwise problematic dumping of those materials.

In this study, 35% of clinker was replaced with a combination of limestone, fly ash and slag mixed in different percentages. Five different mixes of PCC were prepared carefully simulating the cement manufacturing process. All five mixes of PCC were cheaper than OPC. Concrete cubes manufactured using OPC and the five mixes of PCC were prepared and subjected to compressive strength test, slump cone test, slump flow test, concrete density test and water permeability test.

Test results achieved for concrete made with OPC and all five mixes of PCC were acceptable according to the applicable standards. Cube strength results obtained after 28 days were satisfactory for all six mixes but PCC mixes showed a lower strength than OPC. However, they all produced almost the same strength after 90 days indicating a continuous strength gain in PCC mixes after 28 days.

Further, all five mixes of PCC produced high values of initial slump thus making them more suitable for pumping into higher elevations. Slump retention, initial flow and flow retention showed mixed values all within the acceptable ranges. Dry and wet densities of all six mixes were also acceptable. Measured water penetration values for all six mixes were less than the minimum concrete cover (20 mm) recommended in Tables 3.3 & 3.4, BS8110:1997.

Production cost calculated using raw material costs for all five PCC mixes are less than that of OPC making them more financially feasible than OPC. Out of the five different mixes tested, there is no overall best performer in every aspect. However, depending on the type of application, one of the five mixes can be

selected to better suit the requirement. Considering the reduction of damage to the environment in producing PCC this study shows that PCC is more financially feasible and environmentally friendly.

Keywords: Cement, OPC, PCC, Clinker

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