Volume: 5 | Issue: 10 | October 2019 || SJIF Impact Factor: 5.614||ISI I.F Value: 1.188 ISSN (Online): 2455-3662

EPRA International Journal of
Multidisciplinary Research (IJMR) Peer Reviewed Journal

ASSESSMENT OF THE IMPACT AND HARDNESS PROPERTIES OF GRANITE-FILLED POLYESTER IN WALL TILE APPLICATION

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ABSTRACT

There has been a growing interest recently, in the use of locally sourced minerals such as granitic and basaltic intrusions in the production of concrete and tiling products. This study identifies the effect of aggregate weight on the hardness and impact strength properties of the polymer concrete tiles (PCTs). The aggregate was sourced from Conrok Quarry processing plant at Ebonyi state. A standard test sieve with mesh size of 75 microns was used. The test piece was formulated with a mix of methyl ethyl ketone peroxide and cobalt naphthanate as initiator and accelerator respectively, serving as curing agents. Samples were cut into test piece dimensions of 150 x150 mm. Hardness and impact tests were used for the evaluation of its application in wall tiles; the result shows a uniform increase in hardness up to 13.6HV at 50% replacement which implies a direct proportionality between hardness and aggregate weight and for impact strength, a similar pattern with increasing aggregate weight up to 50% replacement indicates a peak impact value of 1.25. 50% replacement was the maximum used due to the limitation of trying to achieve dispersive equilibrium using the hand mixing method, as the increasing viscosity impedes flow during casting.

KEYWORDS: ***polymer concrete tile, aggregate, curing agent, granitic intrusion.***

1.0 INTRODUCTION

A tile is a manufactured piece of hard-wearing material such as ceramic, concrete, stone, metal, or even glass, generally used for covering roofs, floors, walls, showers, or other objects such as tabletops. Alternatively, tile can sometimes refer to similar units made from lightweight materials such as perlite, wood, and mineral wool, typically used for wall and ceiling applications. Tiling stone is typically marble, onyx, granite or slate. Thinner tiles can be used on walls than on floors, which require more durable surfaces that will resist impacts (*Maldonado, 2014).* These tiles can use durable low cost fillers which can have their integrity improved by premoulding preparations. One such material system is the polymer concrete tile (PCT), which is often synthesized by loading polyester resin with high levels of aggregates such as fine sand or granite quarry dust.

1.1 Concept of Polymer concretes

Polymer concretes are a type of concrete that use polymers to replace lime-type cements as a binder. In some cases, the polymer is used in addition to Portland cement to form Polymer Cement Concrete (PCC) or Polymer Modified Concrete (PMC). Polymers in concrete have been overseen by Committee 548 of the American Concrete Institute since 1971. Polymer concrete is composed of aggregates that include silica, quartz, granite, limestone, and other high quality material. The aggregate must be of good quality, free of dust and other debris, and dry. Failure to fulfill these criteria can reduce the bond strength between the polymer binder and the aggregate. (Kim, 2013).

Unlike traditional concrete structures, polymer concrete requires no coating or welding of PVC-protected seams. It can also be used as a bonded wearing course for asphalt pavement, for higher durability and higher strength upon a concrete substrate (*Mehta et al., 2013).*

1.2 Concept of Granite quarry dust

Quarry dust is a byproduct of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In quarrying activities, the rock has been crushed into various sizes; during the process the dust generated is called quarry dust and it is formed as waste. So it becomes as a useless material and also results in air pollution. Therefore, quarry dust should be used in construction works, which will reduce the cost of construction and the construction material would be saved and the natural resources can be used properly. The suitability of quarry dust as a sand replacement material shows that the mechanical properties are improved and also elastic modulus. The compressive strength achieved optimum by replacing fine aggregate with quarry dust in ratio of 60: 40 as done by Hmaid-Mir (2015).

Ho *et al.* (2002) explained that granite fines can be used in the SCC production. However, it is important to spot out that, as a waste material, the properties of stone fines are likely to vary with time. Then, after that, the fineness of granite fines could solve durability problems, such as silica-alkali reactions.

2.0 METHODOLOGY

2.1 Materials and Equipment

Conrok Granite Quarry dust, electronic weighing balance, unsaturated polyester resin (UPr), methyl ethyl ketone peroxide (MEKP), cobalt naphthanate, silicon oil, Aluminium moulds, Sieve, Hand brush, Beakers, Spatula, Pipette and Hack Saw.

2.2 Procedure

2.2.1 Aggregate Preparation

The aggregate was collected from the quarry processing plant at the waste heap into a new sac bag. It was then spread out to dry in open air for 4 days. After drying a standard test sieve with mesh size of 75 microns was used. This mesh size was chosen to give a distinct functionally graded matrix on testing so as to get clear results. The electronic weighing balance was used to weigh the aggregates into their respective weight fractions.

The 75 micron particle size of aggregate was subdivided into 20, 30, 40 and 50% of the total tile weight. Each fraction was then tied up and labeled.

2.2.2 Production

The sample formulation was prepared by pouring out the required resin weight for each sample. The initiator and accelerator combination of methyl ethyl ketone peroxide and cobalt naphthanate respectively with resin to hardener ratio of 1 to 100% weight was then added.

In the production of the first pure sample with 0% aggregate, addition of aggregate into the resin was skipped. The cobalt napthanate was added first into the resin and stirred for 2 mins. This was done to achieve a solution that will readily activate the initiator by decomposing it into free radicals and also to prevent ignition with the initiator. Before the addition of the initiator, the mould was prepared for curing by the application of silicon oil in trace amount on its inner surfaces.

Methyl Ethyl Ketone peroxide was then added in 1% of the total resin weight, after which the formulation was stirred again for 40 seconds and then poured into the mould from one edge.

For the samples containing the aggregate, the prepared aggregate was added first into the resin and stirred for 5 mins before the addition of hardener. The same procedure was repeated for both particle sizes. The samples were left to cure for 3 days before they were demoulded. After demoulding, a hack saw was used to cut the samples into dimensions of 100 by 100 mm. The cut out tile pieces were tested for various properties.

Table 2.1: Percentage Weight of Granite Quarry Dust and Unsaturated Polyester (with 2 % hardener)

S/No.	%wt of aggregate for 75 micron particle size.	%wt. of Unsaturated Polyester and hardener; MEKP initiator/cobalt accelerator.
1	0	100
2	20	80
3	30	70
4	40	60
5	50	50

2.2.3 Tests Carried Ou

After fabrication of the samples, the hardness and impact strength tests were carried out.

Precautions taken during fabrication:

a) Aggregate/resin mixture was stirred for 5mins to achieve dispersive equilibrium.
b) Silicon oil was applied as a stain on the inner surfaces of the mould (in trace quantities) as a mould releasing agent.
c) The Cobalt naphthanate accelerator was added first into the filler/polymer mixture and stirred before the addition of MEKP catalyst. This is to prevent ignition from occurring when the accelerator and catalyst come in contact with each other.
d) The resin was poured from the edge of the tray mould, to enable proper directional flow and effective filling.

3.0 RESULT AND DISCUSSION

The test results instituted the effect of aggregate weight on the mechanical properties of the PCTs relevant in the application of wall tiles, this was achieved through characterization of the mechanical properties by dynamic hardness and impact strength tests.

3.1 Hardness Result

Table 3.1: Hardness test result (Hv)

Weight of aggregate (%)	Hardness value
20	10.3
30	9.5
40	12.6
50	13.6
Control mix	7.5

From the result in Table 3.1, 75 micron particles showed a uniform increase in hardness up to 13.6HV (see Figure 3.1). The result revealed that there was a net increase in hardness with increasing aggregate content, compared to the control value of 7.5.

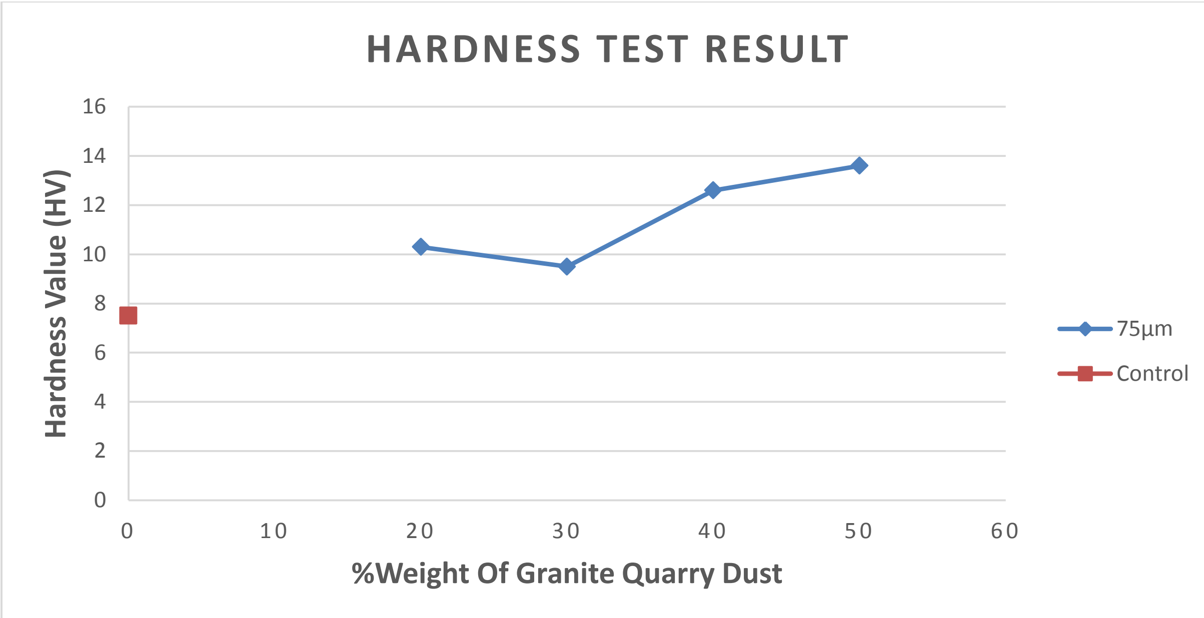

Fig. 3.1: Scatter diagram for Hardness Value against %weight of GrP

3.2 Impact Result

Table 3.2: Impact test result

Weight of aggregate (%)	Impact value J/m
20	0.23
30	0.35
40	0.76
50	1.25
Control mix	0.20

From result in Table 3.2, the result showed steady increase in impact strength of increasing aggregate weight with 50% replacement indicating maximum impact strength of 1.25 (see Fig. 3.2).

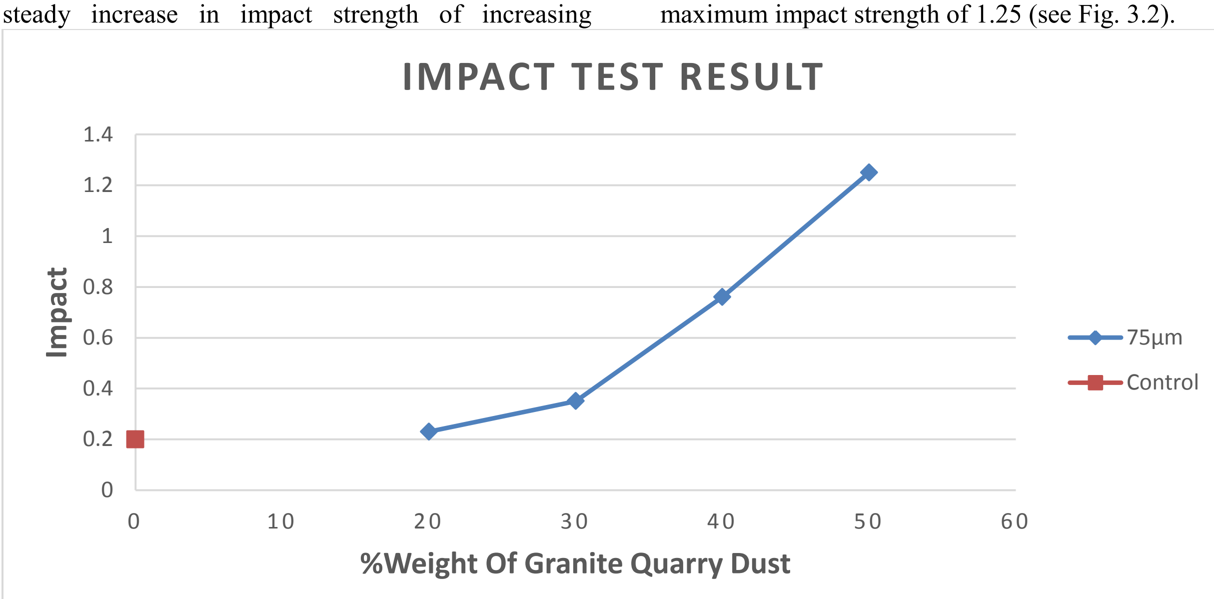

Fig. 3.2: A plot Impact test values against %wt of GrP

4.0 CONCLUSION

For all the tests conducted, the concrete containing granite dust aggregates performed better than the pure polyester control samples. The hardness result showed that the aggregates increased the packing density of the matrix thereby improving its hardness. This is due to the larger particles providing better functional grading with increasing aggregate weight.

The impact result revealed that the 75 micron particles showed a uniform steady increase in impact strength with increasing aggregate weight.

4.1 Recommendation

1. To further improve the impact strength of the 75micron particle size concrete the addition of a compatibilizer such as the silane types can be done.
2. Also a plasticizer can be added to reduce viscosity so as to permit higher percentage replacement of the granite dust.
3. Also the matrix or binder can be varied, for example epoxy type resins can be used as excellent binders with cost as the major limitation.
4. This study recommends the addition of a silane-type compatibilizer in order to improve the impact strength of the 75micron particle size concrete.

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