Scientific Journal Impact Factor (SJIF) : 4.364
International Journal of Modern Trends in Engineering and Research
ISSN (ONLINE) : 2349 - 9745 ISSN (PRINT) : 2393 - 8161

"EFFECTS OF WASTE TYRE RUBBER AS FINE AGGREGATE ON SOME PROPERTIES OF TERRAZZO"

Solomon Ikechukwu Anowai[1] and Pwajok Wisdom Dungat[2]
[1,2]Department of Building, University of Jos, Nigeria

Abstract— This study investigates the effects of partial replacement of fine aggregates with waste tyre crumbs waste tyre crumbs on the properties of Terrazzo. Terrazzo mixes 1:1:2 (Cement: fine aggregates: Coarse aggregate) were made with the fine aggregates partially replaced with 0, 5, 10 and 15% waste tyre crumbs. Terrazzo cubes were cast and cured in water for 28 days. Compressive strengths of the cubes were determined at 7, 14 and 28 days. Water absorption test was also carried out on the cast cubes after 28 days curing. Sound absorption test was conducted by impedance tube method. This study revealed that as percentage replacement of fine aggregates with waste tyre crumbs increases the slump of the wet mixes decreases. It also showed that partial replacement of fine aggregates with waste tyre crumbs resulted to reduction in compressive strength of the terrazzo specimens. The results of water absorption tests showed that partial replacement of fine aggregates with waste tyre crumbs caused reduction in water absorption of the terrazzo specimens. Partial replacement of fine aggregates with waste tyre crumbs also enhanced the sound absorption of the terrazzo specimens. This study recommends partial replacement of fine aggregates with 5% waste tyre crumbs to enhance the water absorption or 10% replacement of fine aggregates with waste tyre crumbs to improve sound absorption properties in terrazzo finish.

Keywords— compressive strength, sound absorption, terrazzo, waste tires crumbs, water absorption

I. INTRODUCTION

An estimated eight hundred and fifty thousand (850,000) discarded tyres are generated in Nigeria and are carelessly discarded, resulting in serious waste disposal problem [1] This is one of the environmental challenges faced by various agencies around the world because waste rubber tyre is non-degradable, even after long period of landfill treatment [2]. Waste tyres impair the growth of vegetation, propagate mosquitoes, spread diseases, easily cause fire producing thick black smoke, sulfur dioxide and other harmful gases which pollute the atmosphere with harmful toxicants, and they adversely affect people's health [3]. There is therefore need to properly dispose these discarded tyres in an eco-friendly and economic manner. To solve this problem, researchers around the world had investigated the possibilities of partially replacing aggregates in concrete with crumps and chips of waste tyre rubber with promising results.

The main method of recycling waste tyre rubber consisted of using the particles as coarse or fine aggregate in concrete [4]. Waste tyre rubber can be used in concrete as chipped rubber to replace coarse aggregate or as crumb rubber to replace fine aggregate. Use of waste tyre as aggregate replacement enhanced the toughness and sound insulation properties of concrete [3]. Recycled waste tyre rubber is a promising material in the construction industry due to its lightweight, elasticity, energy absorption, sound and heat insulating properties [5]. Replacement of aggregates with waste tyre has the additional advantage of saving natural aggregates used in the production of concrete [6]. Rubberized concrete have lower density, increased toughness and ductility, lower tensile and compressive strengths and more efficient sound insulation [7]. Incorporating rubber in concrete improves the dynamic loading behavior, impact, vibration and absorption characteristics [8]. Also Swapnil [9] assert that incorporation of rubber in concrete mixes produces very low unit weights mixes and with high air content.

Terrazzo is a word derived from the Italian to designate any mosaic flooring made by embedding small pieces of marble or colored stone in mortar followed by polishing the surface

[10]. Terrazzo can be precast or cast in**s**itu. Terrazzo is used as floor and wall finish. Like concrete terrazzo is made from cement, water, fine aggregate (marble dust) and coarse aggregate (marble). This research work is conducted to investigate the effects of partially replacing fine aggregates with waste tyre crumb on some properties of Tarrazzo with the aim of utilizing waste tyre crumbs in terrazzo production.

II. MATERIAL AND METHOD

2.1 Cement

Dangote brand of ordinary Portland cement (OPC) with a grade of 42.5R meeting the requirements of [11] was used in this research work. The specific gravity and bulk density of cement used in this study were 3.15 and 1440kg/m^3 respectively.

2.2 Fine Aggregate

The fine aggregate used in this study was marble dust, which falls under zone II in accordance with [12]. The specific gravity of fine aggregate was 2.62

2.3 Water

The water used for this research was clean and free from impurities satisfying the requirements of [13]. The water used for this study was portable drinking water obtained borehole.

2.4 Waste Tyre Crumbs

The waste tyre crumbs used in this study consist of particles ranging in sizes from 4.75 to less than 0.0075mm. The crumbs were produced in cracker mill, which tears the tyres apart and reduces the size of tyre rubber by passing the material between rotating corrugated steel drum. The sample of waste tyre crumbs used in this study is shown in Figure 1.

Figure 1. Batching of Waste Tyre Crumbs

2.5 Batching and Mixing of Materials

The absolute volume method was adopted for the computation of the various quantities of materials used. The mix ratio adopted in this study was 1:1:2 (cement: fine aggregate: Coarse aggregate). Water cement ratio of 0.6 was used for the mixes. The marble dust (fine aggregates) was partially replaced by 0,5,10 and 15% waste tyre crump for the mixes. The terrazzo mixes incorporating waste tyre crumbs as partial replacement of fine aggregates were mixed and cast into 100mm x 100mm x 100mm cubes in oiled steel moulds. The cubes were de-moulded after 24 hours and cured in water for 28 days. The mixing was done manually on non-absorbent platform until uniform mix of the materials was achieved. Cylindrical specimens of 600mm diameter and 30 mm high were also cast and cured in water for 28 days and used for sound absorption test. The slump tests were done on each mix in accordance with the provisions of [14] ascertain the effect different percentage replacements of fine aggregates with waste tyre rubber crumbs on the workability of terrazzo mixes. Figure 2 shows the slump test set up.

Figure 2. Slump Test

2.6 Compressive Strength Test on Cubes

The compressive strength tests were conducted in accordance with the provisions of [15]. The load was applied to the cubes through hydraulic operation of the compression machine until failure occurred. The corresponding peak load and stresses at this point were recorded and used to determine the average compressive strengths. The compressive strength is the maximum compressive load the cube can carry per unit area and calculated as follows:

$F_{cu} = P_{max} / A$

Where: F_{cu} = compressive strength (N/mm^2)

P_{max} = Magnitude of failure load (N)

A = cross sectional area of the cube specimen (mm^2)

The setup for compressive strength test is presented in figure 3.

Figure 3. Compressive Strength Test

2.7 Water Absorption Test

The test specimens were oven dried at 105^{o}C for 24 hours in a hot air oven. After oven drying, the specimens were immersed in water for a period of 24 hours. The water absorption of each mix specimen was then determined by finding the difference in weight of the oven-dried specimen and weight of the specimen after immersion in water for 24 hours expressed as percentage. The water absorptions of concrete specimens were calculated with the formula given by [16] as water absorption = $(W_2-W_1) / W_1 * 100$

Where W_1 = weight of oven dried specimen

W_2 = weight of saturated surface dried specimen after immersion in water

2.8 Sound Absorption Test

The Sound absorption tests were carried out in Department of Physics laboratory, University of Jos, Nigeria. Impedance tube method was used to determine the normal incidence sound absorption coefficient of the terrazzo specimens. Cylindrical terrazzo specimen 600mm diameter and 30mm high were used in this study. The tests were carried out at sound wave frequency of 1000Hz according to specifications of [17]. The sound absorption test apparatus are shown in Figures 4 and 5.

Figure 4. Apparatus for Sound Absorption

Figure 5. Impedence Tube with Microphone

III. RESULTS AND DISCUSSION

3.1 Slump Test Results

The results of slump tests conducted on fresh terrazzo mixes are presented in Table 1. The results show that the slump reduces progressively as the percentage replacement of marble dust with crumb tyre (rubber aggregate) increases. This implies that partial replacement of marble dust with waste tyre crumbs reduces the workability terrazzo mixes.

Table 1. Slumps of Rubberised Terrazzo

S/No.	Mix Identity	Tyre Crumbs (%)	Slump (mm)
1	A0	0	85
2	A5	5	80
3	A10	10	75
4	A15	15	65

3.2 Compressive Strength Test Results

The results of the compressive strength tests are presented in Figure 6. The results show a decrease in compressive strength of terrazzo cubes as percentage replacement of marble dust with crumb tyre (rubber aggregate) increases. The 28 days compressive strengths of the terrazzo specimens were 28, 23, 21 and 16.5N/mm^2 for specimens with 5, 10 and 15% waste tyre crumbs respectively. This implies partial replacement of marble dust with 5, 10 and 15% waste tyre crumbs resulted to 18, 27 and 41% loss in compressive strength of terrazzo respectively. Sethi and Thanvi [18] observed a similar trend in rubberised concrete.

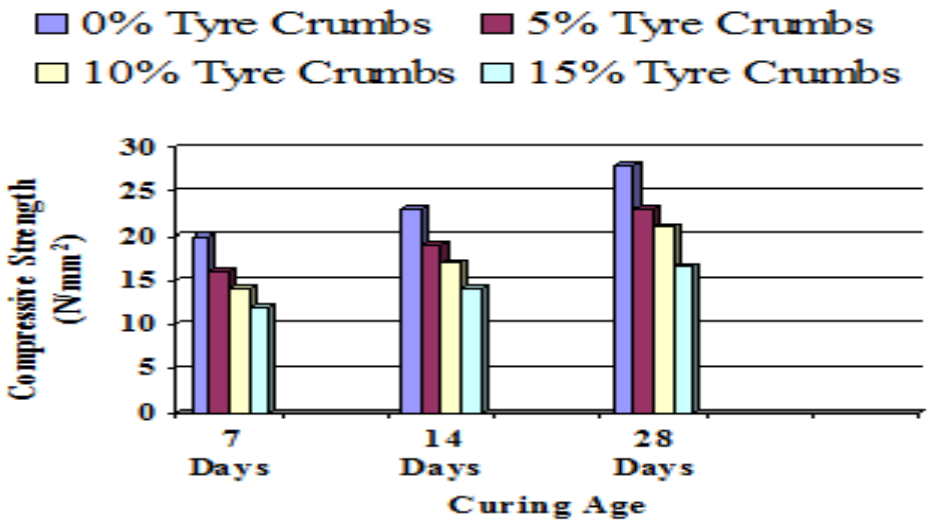

Figure 6. Compressive Strength of Rubberised Terrazzo

3.3 Water Absorption Test Result

The results of water absorption tests are presented in Figure 7. The results show that the partial replacement of fine aggregates with waste tyre crumbs resulted to reduction in water absorption. Replacement levels of 0, 5, 10 and 15% resulted to 5.80, 3.80, 4.20 and 4.75% water absorptions respectively. The mix with 5% replacement of fine aggregate with waste tyre crumbs absorbed the least amount of water compared to other mixes. Therefore rubberized tarrazzo provides a better water absorption compare to the conventional terrazzo.

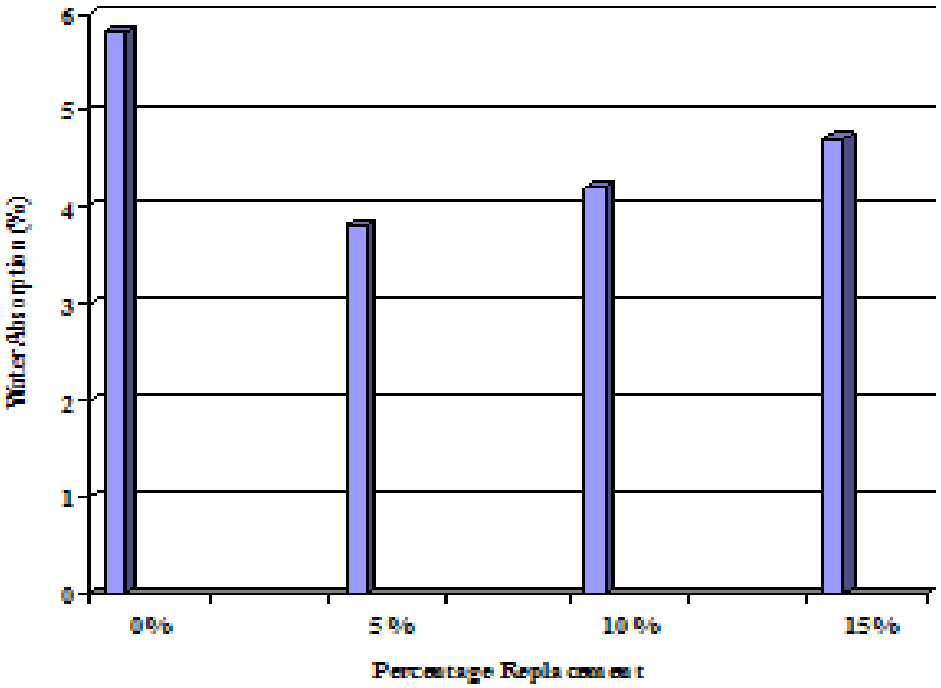

Figure 7. Water Absorption of Rubberized Terrazzo

3.4 Sound Absorption Test Results

The results of sound absorption tests are shown in Figures 8. The results show that the specimen with 10% replacements of marble dust (fine aggregate) with waste tyre crumbs absorbed more amount of sound than other specimens. This implies that terrazzo specimen with 10%

replacement of marble dust (fine aggregates) with waste tyre crumbs is the optimum with respect to sound absorption.

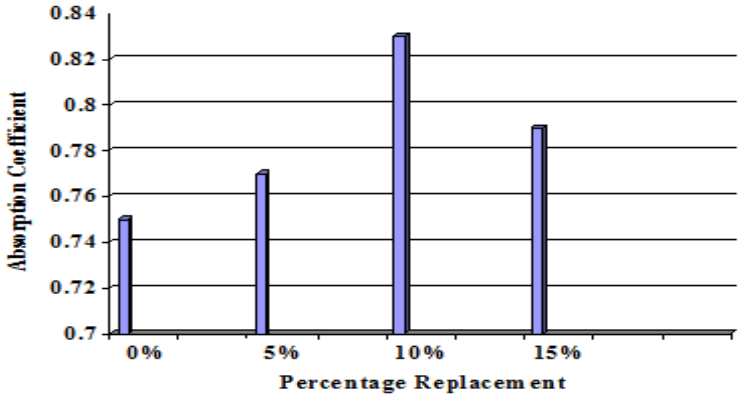

Figure 8. Sound Absorption Coefficient of Rubberized Terrazzo

IV. CONCLUSIONS

Based on the findings of this study, the following conclusions were drawn;

1. The increase in percentage replacement of marble dust with waste tyre crumbs resulted to progressive decrease in the slumps of wet terrazzo mixes.
2. Partial replacements of marble dust (fine aggregate) with waste tyre crumbs resulted to reduction in compressive strength of terrazzo cubes.
3. Partial replacements of marble dust (fine aggregate) with waste tyre crumbs resulted to significant reduction in water absorption in terrazzo cubes. The result for the water absorption obtained shows that 5% replacements of marble dust (fine aggregate) with waste tyre crumbs resulted the least water absorption.
4. Partial replacements of marble dust (fine aggregate) with waste tyre crumbs resulted improvement in sound absorption in terrazzo. The specimens with 10% replacement level absorbed more sound other specimens.

V. RECOMMENDATIONS

Based on the findings of this research work the following recommendations are made:

1. 10% replacement of fine aggregates with waste tyre crumbs is recommended as the optimum replacement where the primary objective is improvement of sound absorption properties of terrazzo finish.
2. 5% replacement of fine aggregates with waste tyre crumbs is recommended as the optimum replacement where the primary objective is reduction of water absorption properties of terrazzo finish.

REFERENCES

[1] Aissien,F.A., Ebewele, R.O. and Hymore, F.K. (2002). Application of ground scrap tyre as asphalt concrete pavements. Proceedings in Nigerian Society of Chemical Engineers, PTI, Warri, Pp 73-91.\
[2] Mahla, R. & Mahla, E.R.P. (2015). Partial replacement of coarse aggregate by waste tyres in concrete. *International Journal of Technical Research*, 4(2), 95-98.
[3] Kotresh, K.M. & Belachew, M.G. (2014). Study on waste tyre rubber as concrete aggregates.*International Journal of Scientific Engineering and Technology*. 3(4), 433-436.
[4] Bani-Hani, K.A. & Senouci, A. (2015). Using waste tyre crumb rubber as an alternative aggregate for concrete pedestrian blocks. *Jordan Journal of Civil Engineering*, 9(3), 400 - 409.
[5] El-Gammal, A., Abdel-Gawad, A.K., El-Gammal, A., Abdel-Gawad, A.K., El-Sherbini, Y. & Shalaby, A. (2010). Compressive strength of concrete utilizing waste tyre rubber. *Journal of Emerging Trends in Engineering and Applied Sciences*, 1(1), 96-99.
[6] Srowa, K. & Dhillon, V. (2017). Experimental investigation of concrete using waste tyre rubber as aggregates. *International Journal of Enhanced Research in Science, Technology and Engineering*, 6(2), 15-20.

[7] Siddique, R., Khatib, J. & Kaur, I. (2008). Use of recycled plastic in Concrete: a review. *Waste Management*, 28, 1855-1852.
[8] Balamurugan, G. and Pushpa, T.B. (2017). An experimental study on composite concrete usingrubber tyre waste and sisal fibre. *International Journal of Innovative Research in Science Engineering and Technology*, 6(4), 5844-5850.
[9] Swapnil, J. (2014). To study on waste tyre rubber as concrete. *International Journal of Research in Engineering Technology and Management.* 3, 1-4.
[10] Karam, G. and Tabbara, M. (2019). Propeerties of precast terrazzo tiles and recommended specifications. *Ceramics*, 55, 84-87.
[11] British Standards Institution (1991). BS 12. Specification for Portland Cements. London,England: BSI.
[12] British Standards Institution (1992). BS 882. Specification for Aggregates from Natural Sources for Concrete. London, England: BSI.
[13] British Standards Institution (1980). BS 3148. Methods of Tests for Water for Making Concrete.London, England: BSI.
[14] British Standards Institution (1983). BS 1881 – 102. Testing Concrete – Method for Determination of Slump. London, England: BSI
[15] British Standards Institution (1983). BS 1881 – 116. Testing Concrete – Method for Determination of Compressive Strength. London, England: BSI.
[16] Neville, A.M. (1995). Properties of Concrete. 5th Edition, Pitman Publishing, London, Uk.
[17] ASTM E1050 (2012). Standard Test Method for Impedance and Absorption of AcousticalMaterials using a Tube, Two microphones and a Digital Frequency Analysis System.
[18] Sethi, A. & Thanvi, S.D. (2016). Development of rubberised concrete using waste rubber tyre as coarse aggregate. *International Journal of Emerging Technology and Advanced Engineering*, 6(9), 71-78.

