International Journal of Research Publication and Reviews, Vol (6), Issue (7), July (2025), Page – 5546-5549

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Comparative Analysis of Concrete Produced From Different Additives For Production of Lightweight Precast Concrete Lintel in Ekpoma, Edo State, Nigeria

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A B S T R A C T :

This study is the comparative analysis of concrete produced from different additives for production of lightweight precast concrete lintel. The additives are rice husk, worn out type and sawdust. The aim of this study was to compare the concrete produced from different additives used in production of Lightweight precast concrete lintel with the objectives of determining the compressive strength, determining the weight of the concrete and determining the optimum percentage of the partial replacement of the additives that will produce concrete of minimum compressive strength of 20N/mm2 for structural lightweight concrete based on BS 8110- 2:1985. The study was conducted through experimentation in the concrete lab of Jid Construction Company in Bayelsa State. Series of mixes were done involving sand, stones, cement and water with partial replacement of sand with additives in 0%, 5%, 10%, 15%, and 20% respectively. The 0% was the control mix. Total of 117 concrete cubes of 150 x 150 x 150 mm were cast and cured. The compressive strength and the concrete density at age 7 days, 14 days and 28 days were conducted. The results of the experiment were organized and presented using tables as statistical tool. The results of the experiment showed that replacement of sand with rice is beneficial for the production of lintel for structural concreting at optimum replacement of 20%. At 20% replacement the compressive strength of rice husk was 20.05N/mm2. Low density of concrete was also achieved at optimum replacement of 20%. In conclusion, the use of rice husk should be employed in the production of light weight precast concrete lintel. The study recommended the use of rice husk to achieve concrete that has minimum compressive strength of 20N/mm2, less weight and at optimum replacement with 20% rice husk

Keywords: Fracture Energy Criterion, Concrete Damage Plasticity

1. Introduction

Environmental preservation and responsible usage of resources are currently the main challenges facing sustainability. In concrete work, the main function of fine aggregate or Sand is to produce workability and uniformity in concrete mix due to its well graded nature. According to the British Standard Soil Classification System, the soil having grain size ranging between > 0.075mm < 5.0mm is considered as sand. With the concern rising about the environmental Conservation, the issues of degradation and pollution of Environment have become the hot topic in today's world. As concrete composes the sand as essential constituents, the main source of it is, naturally flowing rivers. The Extraction of huge amount of sand from rivers not only causes the shortage of it but also creates serious problem to the environment. Erosion and failure of river Banks, lowering of river beds and damage of structures situated closer to the rivers are the major adverse effects of it. According to Obilade, (2014), the use of agricultural and industrial wastes to complement other traditional materials in construction provides both practical and Economic advantages. Rice husk is one of the agricultural waste product that is abundant in Nigeria. It is generally indigestible for humans and not recommended for use as animal feed due to its low nutritional value. Additionally, the natural degradation of rice husks is limited due to its uneven abrasive surface and high silica content, making it a potential pollution candidate (Thomas, 2018). Also, accumulation of stock piles of worn-out tyres will not degrade easily to up to a 100 years of time because of the presence of cross-links between the rubber polymer chains. This shows that the huge amount of rice husk, worn-out tyres and saw dust is left unused as waste material annually in Nigeria. On the Other hand, the waste material rice husk (By-product of rice), saw dust and worn-out tyre on burning too causes pollution to the Environment. So, with motive to utilize the rice husk, saw dust and worn-out tyre as an alternative to the sand, this research will perform a comparative analysis of different additives to the production of lightweight precast concrete lintel for mass housing projects without impairing the mechanical properties of the lintels.

More so, the construction activities have been described as labour intensive and dangerous (Jallion and Poon, (2017) According to Dada (2013), Most building project construction in Nigeria relies on labour intensive in-situ construction methods rather than the precast construction method. The output quality in the in-situ construction method is highly dependent on workmanship of construction workers. The construction workers are constantly exposed to excessive site hazard which exposes them to injuries (Orji, Enebe and Onoh, 2016).

In Nigeria, the most popular material used for lintel is reinforced concrete, which may be cast in-situ or precast. Cast in-situ lintel can be constructed to span around the entire length of walls in the building, and are often referred to as chained lintels. On the other hand, they can be constructed to span across the opening concerned without extending far beyond the opening. Precast lintels are often used to span across opening concerned only.

The major benefit of precast lintels includes cost and time saving for the project and contractor because essentially, the idea behind the precast lintel is that the provision of top reinforcement and hanging bars can be neglected for light loaded one span member in bending. Reinforcement are only provided at the bottom of the lintel to take up all the flexural stresses unlike in the cast in-situ lintel (Chained Lintel). Due to the high demand of housing in Edo state, there is a need to fast track construction thereby reducing construction time. In order to improve output and time for project execution, precast construction is advocated in place of the in-situ method of construction but one of the disadvantages of precast items is the difficulty in manual lifting and transportation due to weight. Mobile cranes are usually required to install large pieces of precast items due to its heaviness which makes it imperative for the building contractor to account for crane rentals thereby incurring more contract cost. In response to this problem, this research is carried out in order to reduce the weight of precast concrete lintels through the use of naturally occurring waste products and customized design methods and at the same time, maintaining the mechanical properties of the lintels.

Aim of the Study

The aim of this study is to compare the concrete produced from different additives used in production of lightweight precast concrete lintel, for mass with a view to enhancing mass housing projects delivery in Ekpoma, Edo state, Nigeria.

1.1. Objective of the Study

i. To determine the compressive strength of the lightweight concrete produced from the partial replacement of the sand by rice husk ash, Wood saw dust and worn-out tyre crumbs respectively at 7, 14 and 28 days of curing period respectively.

ii. To compare the bulk density and weight of concrete produced from the partial replacement of rice husk, Wood saw dust and worn-out tyre crumbs respectively at different percentage replacement to that of conventional concrete grade 16.

iii. To determine the optimum percentage of partial replacement of sand by rice husk, wood sawdust, and worn-out tyre crumbs respectively that will produce a concrete of minimum compressive strength of 20N/mm² for structural lightweight concrete.

1.2. Research Methodology

The research design adopted in this study is experimental and comparative, involving a systematic investigation of the effects of the different additives on the properties of light weight precast concrete lintel. The materials such as sand, cement, stone, rice husk, sawdust and worn-out tyre would be collected and prepared. Then the mix design would be carried out using 5%, 10%, 15%, and 20% partial replacement of sand with sawdust, rice husk and worn-out tyre respectively. The next stage is preparation of concrete lintel specimen for each mix design. Various tests would be conducted to determine the compressive strength and bulk density. Comparative analysis would be conducted to compare the test results of different mix designs to determine the optimal additive and proportion that achieved the best performance.

1.3. Result and Analysis

Table 1: Result of Concrete Compressive Strength

Percentages	Fine Aggregate	DAY 7	DAY 14	DAY 28
0%	Sand	15.90	17.22	23.60
5%	Sawdust	16.80	17.89	25.04
	Worn-out tyre	17.00	18.78	25.50
	Rice husk	14.51.	16.21	21.70
10%.	Sawdust	12.98	14.06.	19.44
	Worn-out tyre	14.30.	15.93	21.40
	Rice husk	14.22	15.74	21.10
15%	Sawdust	11.91	13.04	17.72
	Worn-out tyre	11.60	13.90	17.30
	RIce husk	13.91	15.06	20.82
20%	Sawdust	15.61	17.08	23.36
	Worn-out tyre	7.90	9.22	11.80
	Rice husk	13.40	15.91	20.05

Table 2: Bulk Density of Concrete Cube Specimen

Percentages	Fine Aggregate	DAY 7	DAY 14	DAY 28
0%	Sand	2.52	2.46	2.4
5%	Sawdust	2.48	2.37	2.44
	Worn-out tyre	2.45	2.41	2.40
	Rice husk	2.03	2.04	1.96
10%.	Sawdust	2.52	2.43	2.45
	Worn-out tyre	2.41	2.39	2.37
	Rice husk	1.82	1.78	1.69
15%	Sawdust	2.51	2.43	2.4
	Worn-out tyre	2.31	2.29	2.29
	RIce husk	1.67	1.56	1.58
20%	Sawdust	2.41	2.38	2.37
	Worn-out tyre	2.31	2.22	2.18
	Rice husk	1.74	1.63	1.51

1.4. Discussion of findings

From table 1, the strengths of the concrete were observed to be affected by percentage replacement and curing time respectively. The concrete experiment increased in strength with curing age but decreased in strength with percentage replacement. The maximum strength recorded were 25.04, 25.50, and 21.70N/mm2 respectively while the minimum strength were 7.9 and 13.40N/mm2 respectively with Sawdust, worn- out tyre and rice husk respectively. The maximum strength occurred at curing age of 28 days and at 5% replacement with sawdust, worn- out tyre and rice husk respectively while the minimum strength occurred at curing age of 7 days, 15 days, 20 days at 20% replacement with sawdust, worn- out tyre and rice husk respectively.
From table 2, the bulk densities were observed to decrease with increased in percentage addition of sawdust, worn- out tyre and rice husk indicating that the sand density is higher than that of sawdust, worn- out tyre and rice husk. The maximum densities at 7 days with 5%, 10%, 15% and 20% are 2.48g/cm3, 2.52g/cm2, 2.51g/cm3 and 2.41g/cm3 respectively for sawdust and this clearly showed that sawdust is of a higher density than worn- out tyre and rice husk.
The minimum densities at 28 days curing with 5%, 10%, 15% and 20% partial replacement with rice husk are 1.96g/cm3, 1.69g/cm3, 1.58g/cm3 and 1.51g/cm3 respectively and this clearly showed that rice husk is less dense compared to sawdust and worn- out tyre. The result of this study showed that the least density is 1.51g/cm3 with rice husk and at 28 days curing.
Judging from the results of compressive strengths and bulk densities, the optimum percentage of 20% partial replacement of sand with rice husk at 28 days curing correspond to 20.05N/mm2 (Table 1) and 1.51g/cm3 (Table 2) which meets the standard as specified in BS 8110- 2:1985 for structural light weight concrete (300Kg/m3 to 1850Kg/m3).

1.5. Conclusion/Summary

One of the disadvantages of precast lintels is the difficulty in lifting and transportation by hand due to its very dense weight. Installation of precast items using mobile cranes has incurred more contract cost to building contractors due to crane rentals. This is why it is imperative to reduce the weight of precast concrete lintels through the use of naturally occurring waste products and customized design methods. Notably, the partial replacement of sand with rice husk, worn-out tyre and sawdust in the production of reinforced concrete lintel led to:

i. Reduction in the unit weight of the hardened concrete, thereby reducing its self-weight;
ii. A reduction in compressive strength of the hardened concrete.

This application of rice husk, worn-out tyre and sawdust as a partial substitute for sand has the potential to rid the environment of the nuisance associated with indiscriminate rice husk, saw dust and worn-out tyre disposal while also lowering the weight of concrete produced for construction work and at the same time, maintaining the mechanical properties of the concrete produced.

From the experimental analysis, the author found out that 20% replacement of rice husk with sand in cement concrete is a beneficial replacement for production of lintels for structural concreting. The 20% replacement of sand with worn out tyre crumbs and sawdust fell short of this specification due to the following reasons:

1. According to BS81110-2:1985, Lightweight aggregate concrete may generally be designed in accordance with section 2 and 3.1 of BS8110-1:1997. These clauses relate specifically to reinforce lightweight aggregate concrete of grade 15 and above. BS81110-2:1985 states that the structural use of concrete should not be below grade 20. So from the experimental analysis carried out in chapter 4 of this study, 20% replacement of sand with rice husk and saw dust gave a compressive strength of 20.05N/mm2 and 23.36 N/mm2 respectively which is in accordance with the standard specified in BS81110-2:1985. Whereas, 20% replacement of sand with worn-out tyre crumb gave a compressive strength 11.80 N/mm2 which aforementioned is below the recommended standard specified for structural reinforced concrete lintel.

2. The British standard (BS EN 206-1) specify that the density of structural lightweight concrete should be between 0.8g/cm3 to 2 g/cm3 Since one of the main objectives of the research work is weight reduction, it was concluded that only rice husk at 20% partial replacement for fine aggregate met this density requirement according to the design standard.

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