DEVELOPMENT OF ENVIRONMENTALLY FRIENDLY LIGHTWEIGHT BLOCK FROM WASTE PAPER

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Abstract

The high consumption of natural resources, such as sand, gravel, clay and wood attributed to the building construction industry, coupled with the need for affordable housing and environmentally sustainable building materials has led to studies on the possibilities of producing alternative building materials from wastes. Considering the gaps in the level of research efforts till date, this study was conducted to determine a suitable mix proportioning process for the production of lightweight building block from postconsumer waste paper using waste additives as binder in the place of the more traditional hydraulic binder. The laboratory experimentation carried out involved the processing of waste paper into an artificial lightweight aggregate, designing and preparing trial mixes, moulding of trial specimen and subjecting trial specimen to compressive strength test at 28days curing age. It was found that at the appropriate mixture of waste paper, sand and waste additive (binder), the trial specimen displayed an average compressive strength ranging from a highest of 2.07MPa to a lowest of 1.3MPa, this strength satisfies the minimum standard strength requirement for non-load bearing masonry block. This result thus indicates the possibilities of producing an environmentally friendly, non-load-bearing, lightweight building material with less use of natural resources. Future work will entail, the moulding of trial block specimen using the hydraulic press to apply equivalent compactive effort and subsequent selection of final mix composition will mark the end of this preliminary experimentation. The main experimentation will involve, the moulding of the proposed lightweight blocks to be tested in accordance with relevant standards.

Keywords: Wastepaper, old newsprint, compressive strength, non load bearing, lightweight aggregate, block.

1. Introduction

The growth of civilization, population and increased standard of living has led to rapid growth of civil engineering construction. This situation directly or indirectly increases the demand for aggregate and other natural resources required for the production of building material. For instance, concrete which is a major building material and the most widely used substance after water [1] consumes a considerable amount of raw material (Fig 1) and energy for its production.50% of global aggregate consumption has been attributed to the building construction industry [2]. All this phenomenon indicate that the creation of the built environment is gradually becoming a threat to the natural environment.

![Figure 1. Estimated percentage quantity of raw material contained in standard concrete mixes M10, M15 (IS456:2000) (having equivalent strength with ST2 and ST3 (BS5328:2:1991)) and mix for Masonry block (BS 2028:1975) respectively. (Source: Estimated by Author)](image-url)
The need to promote and achieve environmental sustainable construction is paramount, considering the prediction of 70% global growth of construction market by 2025 [3] and the environmental impact of building construction (fig 2).

The prediction that “what we build, what we build with and how we build it will soon be transformed by a number of environmental considerations” [4] is already becoming a reality, as various studies to develop alternative building materials from wastes such as paper, wood glass, metal textile etc. have been conducted with desirable conclusions (table 1). Some of the building materials previously produced from waste paper are; fibre cement composite, wall panel, composite panel, thin cement sheet, low density board and papercrete which is made from mixture of waste paper , sand, cement, water and other optional material. This papercrete can be used for several application such as block [21], plastering mortar [22], lightweight concrete [18] etc.

However, extensive literature review has shown that, building material produced from waste paper suffers high water absorption, thickness swelling and low strength with increasing paper fibre content. This drawback of strength reduction is observed to be due the contradiction that exist between the hygroscopic properties of paper fibre and the moderate water requirement of cement hydration, which means that the high water cement ratio resulting from increasing paper content lowers the strength of the building material concerned. The utilization of considerable quantity of cement to improve the strength properties offset the environmental friendliness of this building materials.

To address this problems, there is need to investigate the possibilities of developing building material from waste paper without the use of hydraulic cement as binder.

Therefore, as part of research experimentation to develop an environmentally friendly, lightweight, non load bearing building block from wastepaper with the use of waste additive as binder. This study was conducted to determine a suitable mixture proportioning process for the production of the block.

2. Experimental Details

2.1. Materials

The materials used includes waste paper (old newsprint), waste additive (binder), water, and admixture.

2.2. Preparation of materials

The waste paper were shredded (fig 3a) and scientifically processed into an artificial lightweight aggregate with particle gradation ranging from 4mm to 0.125mm (fig 3b).
4. Testing Specimen

From the trial mixtures, trial block specimen of size 50mmx50mmx50mm (fig 4) were molded, following the recommendation of BS EN772-1:2011(section 7.1) [23] that a cube specimen could be used as representative sample for testing of masonry block. The specimen were subjected to curing and drying in open air in the laboratory for 28days. To simplify this process of selecting an efficient mix composition for the block, compressive strength was considered as the benchmark parameter, this is due to the intrinsic importance of compressive strength in the structural design of concrete structures [24].

3. Result and Discussions

3.1. Strength properties of the test specimen

The compressive strength of the trial block specimens were tested at 28days curing age in a mortar compression testing machine at a loading rate of 2400N/S. The highest average compressive strength obtained was 2.07MPa, and the highest individual compressive strength was found to be 2.18MPa. The average strength obtained was higher than (and satisfies) the minimum strength specified by BS EN 772-1:1992, Ghana building code, New Zealand code, Nigeria building code for non load bearing masonry block (table 2).

The trial block specimen displayed a ductile mode of failure unlike the brittle failure mode usually displayed by concrete. Based on the comparison of strength of specimen containing 20% binder and the specimen containing 0% binder(control), the binder was responsible for 28.6% strength increase (fig5a and fig5b).
3.2. Other observation from trial block specimen

Shrinkage was observed on the trial block specimen at 28 days curing age, and the addition of admixture in the component of trial specimen II eliminated the mold growth observed in the trial specimen I.

3.3 Future Work in progress

In order to finally select an efficient mix composition for the proposed block, future experimentation will deal with the optimization of method of application of compactive effort, from the tamping method presently used to use of hydraulic press. This is expected to:

- Enable the determination of a suitable water content
- Address the shrinkage problem.
- Enable the application of equivalent compactive effort to all the specimen, which will enhance the accuracy of the specimen properties and shed more light on the influence of sand content on the specimen strength.
- It may also enhance the strength of the specimen

The moulding of trial block specimen using the hydraulic press to apply equivalent compactive effort and subsequent selection of final mix composition will mark the end of this preliminary experimentation and the beginning of the main (second section) experimentation.

4. Conclusion

Considering the desirable compressive strength displayed by the tested specimen, it is a clear indication that by using appropriate mix proportion of the constituent material involved in this experimentation, an environmentally friendly, non load bearing, lightweight block with desirable strength properties can be produce with the use of less natural resources.
References


[25]. Standard new Zealand “specification for non load bearing block” NZs42984798, 1998


