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"Experimental Study on Manufacture of Tiles with Egg Shell, Waste Plastic and White Cement"

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Abstract: *Human activities often generate solid wastes such as plastics and egg shell wastes. Disposal of this waste is usually a problem. The aim of this study was to investigate the feasibility of using plastic and egg shell wastes together with white cement in the production of floor tiles. The waste is collected from kitchens and waste disposal facilities. The materials were cleaned and dried; and plastics were shredded while egg shells were crushed. Waste materials were then mixed with white cement in different proportions. Compressive strength tests were carried out to determine the suitability of using such solid waste in making floor tiles. Crushed egg shells passing through the 1.2 mm sieve and shredded plastics with an average diameter of 1 to 2 mm were used. Cubes were cast and cured for 28 days. The compressive strength of the cubes was tested using a universal testing machine. The study found that addition of up to 50% cement resulted in a more than 10 fold increase in the compressive strength of the cast cubes. Addition of plastics decreased the compressive strength of the cubes, while the addition of egg shells had an insignificant effect on their compressive strength. Increasing the quantity of plastics and egg shells resulted in elevated water absorption, while larger quantities of cement resulted in reduced water absorption. Increasing the quantity of egg shells and plastics has resulted in reduced density. With the presence of plastics, abrasion resistance increased and the tiles became less brittle. It is concluded that egg shells can be used as filler material in the manufacture of floor tiles. Because of the tendency of plastics to reduce the compressive strength of tiles, they should be used cautiously. The study has established that waste of plastic and egg shell waste in the manufacture of floor tiles is a viable waste reduction option. However, further studies are necessary to establish the chemical interactions involved in floor tile production systems where household and industrial wastes such as plastics and egg shells are waste*

Key Words: *TWW,CKD, Egg shells, Waste Plastic etc.*

1. INTRODUCTION:

In the growth of the population, increasing urbanization, and rising standards of living due to technological innovations have contributed to an increase in the quantity of a variety of solid waste generated by industrial, mining, domestic and agricultural activities. Globally, the estimated quantity of solid waste generation was 12 billion tons in the year 2002. Many authorities and investigators have been working to have the privilege of reusing the wastes in environmentally and economically sustainable ways. The utilization of solid waste in construction materials is one of such innovative efforts. Previous studies indicated that the egg shell waste samples were rich in $CaCO_3$ (50.7%) and may be used as an alternative raw material in the production of wall tile materials. The use of floor tiles in construction is for decorative, protection and aesthetic purposes. The core material mostly used to produce floor tiles is clay, which may be glazed to improve the tile properties. Fabricated ceramic tiles in India using blast furnace slag with 0.1–2.5% water absorption. Tiles have to have a degree of impact resistance. Impact resistance of ceramic tiles is important for their life in service. Floor tiles are expected to sustain many types of loads, some of which may be static, but impact loads also occur. Impact loads provide the most method for breakages on walls (Harrison and Ralph, 1988). The effect of water absorption on clay roofing tiles was studied and it was stated that the relationship between the water absorption and frost resistance of brick products cannot be precisely defined. Water absorption capacity identifies the nature of the ceramic body in regard to internal structure, which is related to mechanical strength (measured by modulus of rupture and breaking strength) and also other characteristics that affect ceramic tile durability (particularly in unglazed tiles), such as resistance to deep abrasion, stain resistance, and resistance to frost/thaw cycles, as well as to dimensional quality .For glazed tiles intended for flooring, European standard EN 14411 makes it compulsory to state the abrasion resistance class of the glazed surface as a whole (glazes and decorations), after performance of the standard test according to ISO 10545- 7 (1999). In an effort to eradicate solid waste, this study focuses on using solid waste in the form of egg shells and raw construction.

2. LITERATURE REVIEW:

- **Rebeiz** showed that the resins based on recycled PET can be used to produce a good quality of precast concrete (Rebeiz, 2007). Many studies have been conducted on the use of scrap tire/rubber in mortar and concrete, and a research work has been published

- **Siddique a review paper (2008)** on the use of recycled plastic in concrete (Siddique, Khatib & Kaur 2008). In the other study, Choi et al. (2005) investigated the effect of plastic waste (PET bottles) as aggregate on properties of 12 concrete. The results obtained in this study showed that these wastes could reduce the weight by 2–6% of normal weight concrete and the compressive strength was reduced up to 33% compared to that of normal concrete

- **Batayneh et al. (2007)** have shown, in their work that the decrease of compressive strength was in function of increase in the content plastic content. For a 20% substitution of sand by the waste, the compressive strength was reduced up to 70% compared to that of normal concrete.

- **Remadnia et al., 2009, Yazoghli-marzouk et al. 2007)** have also studied the use of consumed plastic bottle waste as sand-substitution aggregate within composite materials for building applications. These authors showed that the density and compressive strength were decreased when the PET aggregates exceeded 50% by volume of sand. Also, It was found that the addition of plastic waste (fractions < 10%) in volume inside of cementitious matrix does not imply a significant variation of the concrete mechanical features.

- **Haly and Gill, (2004)** did a study on compression and deformation performance of concrete containing postconsumer plastics. It was observed that specimens containing plastics failed at lower compressive loads as compared with those made of conventional concrete. The decrease in strength may be attributed to the weak bond between plastics and cement or the weak strength of the plastic. The effect of reducing the compressive strength of concrete by the plastic aggregates is due to the fact that plastic particles aggregates do not have the compression qualities of the conventional coarse aggregates. Despite the lower compressive loads, these specimens underwent considerable 13 deformations and did not experience brittle failure. At failure, most of the specimens were reduced to two pyramids in the vertical direction with the top one being upside down.

- **Al-Jabir et.al (2009)** investigated the properties of hollow sand Crete blocks made with cement kiln dust (CKD) as an additive and as a replacement for ordinary Portland cement. They observed that when CKD was used as a replacement for cement, the compressive strength and density of blocks generally decreased with higher replacement levels of cement by CKD. However, when CKD was used as an additive, within the investigated levels, an improvement in the compressive strength of up to 54% was observed.

3. MATERIALS & METHODOLOGY:

Determination of the optimum proportions of the waste materials for maximum strength of building tiles This involved collecting the wastes, cleaning, drying, crushing and grinding them, determining the density of the ingredients and determining the volumes of the respective moulds that were used in the study.

Collection and processing of plastics. Plastics is collected especially from hospitals and other dumping sites, and were washed and shredded into pieces of 1 mm average diameter. Plastic is a strong material and it is resistant to both chemical and physical attacks, making it hard to disintegrate. It is also resistant to the penetration of water, which is why it is considered one of the major threats to the fertility of our soils. This has made it a suitable component in this material since it increases the water penetration resistance of the material. Plastics also increase the bonding in the composite material. Plastics were mainly used as fill materials to increase the bulk.

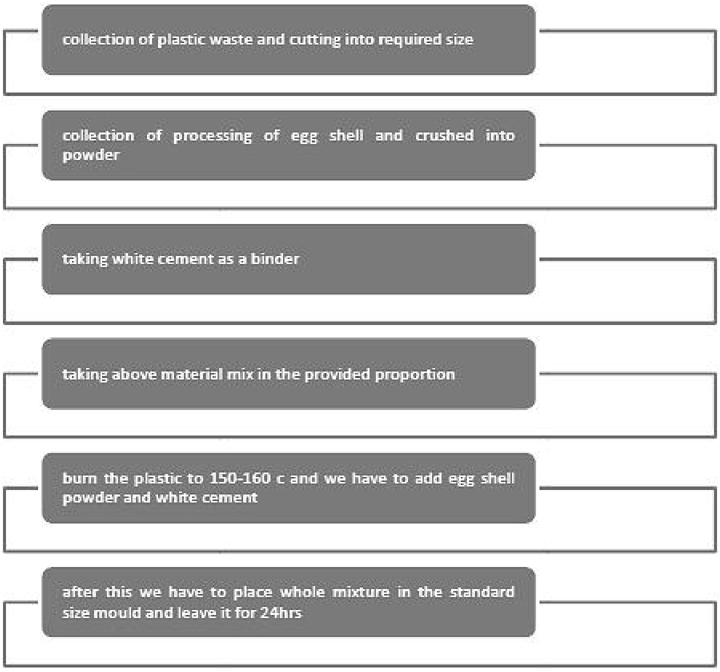
Collection and processing of egg shells. The egg shells were obtained from poultry farmers and hotels; they were subjected to thorough cleaning involving soaking in water for 24 hours, allowing easy removal of dirt and membranes during cleaning .The major component of egg shells being calcium carbonate, which makes them a very important material .The egg shells are resistant to water penetration, making their combination with plastics suitable for their use. Egg shells were first put in boiling water for 5-10 minutes to remove the membrane and then sun dried for 3-4 days and then some were pounded using a motor and pestle and others crushed using a milling machine. The pounded egg shells were sieved through a 1.2mm sieve. The egg shells were used to increase the bulk and reduce the use of other materials.

White cement as a binder is a third component that binds the plastics and egg shells to make a material which is resistant to water penetration. In this case, white cement was used to bring out the colours of plastics and egg shell respectively. White hydraulic cement is a good ingredient because it is resistant to water infiltration and will increase the strength of the material. White cement is basically used for aesthetic properties. However, the common ordinary Portland cement (OPC) can be used. Clean drinking water was used for mixing the ingredients.

Fig 1.Plastic waste

Fig 1.1 Egg shells

Fig 1.2 White cement



Charts: 1 Flowchart of Methodology

Use of white cement as a binder to make building tiles Physical and chemical properties of white cement
a) Appearance: A fine powder ranging in colour from off-white to white
b) Odour: No distinctive odour
c) Boiling/melting Point: Melting point >1200ºC
d) Vapour pressure: Not applicable
e) Specific gravity: 3.0 – 3.2
f) Flash point: Not applicable
g) Flammability limits: Not applicable
h) Solubility in water: Slight, reacts on mixing with water forming an alkaline (caustic) solution (pH >11)
i) Particle size: Up to 50% of the fresh dry material may be repairable (below 10 microns) Contact with cement mixed with water or body fluids (for example sweat or eye fluid) or with concrete or mortar should be avoided as it may cause irritation, dermatitis or burns. If such contact occurs, the affected area should be washed without delay with plenty of clean water. In case of eye contact rinse immediately with clean water and seek medical advice.

Preparation of Mould and Specimen Casting

Making of the tiles moulds of different sizes (300x300x10mm, 200x200x10mm and 180x180x10mm) were used to make these tiles (Table 3.12). The mixture of white cement, plastics and crushed egg shells was hand compacted into the moulds and the surface finished smooth using a steel float and then the tiles were left to set and dry in the moulds for 24-48 hours before they were removed and let too dry at room temperature. The mixture was made fairly plastic to enable proper compaction manually. Three moulds of 200x200x10mm, one mould of 300x300x10mm and one mould of 180x180x10mm were used in the study.

Fig 1.3 Moulds for tiles casting

Fig 1.4 Tiles casted

Specimen Casting ; Mixing plastics, egg shells and cement and casting tiles; the densities of plastics, white cement and egg shells were 400 kg/m3, 1,440kg/m3, and 1,290kg/m3, respectively. For the production of building tiles, crushed plastics, crushed and pounded egg shells and white cement were mixed in different quantities. Commercial production of these tiles should aim at minimizing the cost of production. In order to manufacture the tiles, the below given ratios are used in making the tiles . The maximum compressive strength attended ratio should be noted. The ingredients (cement, plastics, crushed and pounded egg shells and water) were weighed using a measuring scale and then mixed in a trough and then cast, in already prepared moulds and vibrated using a vibrator and then left in the mould for 24 hours after which they are demoulded and cured for 28 days. The cubes were subjected to testing on a compressive strength testing machine and the results were obtained and recorded below.

Cement: plastic: eggshell	Cement (kg)	Plastics(kg)	Eggshells(kg)
(1:1:0)	0.94	0.26	0.00
(1:1:1)	0.62	0.17	0.56
(1:1:2)	0.47	0.13	0.84
(2:1:1)	0.94	0.13	0.42

Table 1. Quantities (kg) of different materials in each ratio

4. RESULT & DISCUSSION:

The effect of cement plastic and egg shell on compressive strength of tiles after 7 days of curing. Among all the mixing ratios that we have casted the ratio, **(2:1:1)** has attended highest compressive strength, we have observed this after testing in compressive testing machine and by calculation, that is given below The formula for obtaining compressive strength is given by

F=P/A
Where, F is compressive strength of specimen
P is the maximum applied load by newton
A is the area of cross sectional of the specimen

- **TRIAL - 1**

Now, calculation of load for the ratio **(1:1:0)**
We have attended load of 12.5KN on the ratio **(1:1:0)**
Therefore F=P/A
F= 12.5KN/ (30cm*30cm)
We know that 1KN =1000N
1CM = 10MM
F= (12.5*1000) / (300*300)=0.14N/mm^2
Therefore compressive strength is equal to 0.14N/mm^2

- **TRIAL – 2**

Now, calculation of load for the ratio **(1:1:1)**
We have attended load of 11KN on the ratio **(1:1:1)**
Therefore F=P/A
F= 11KN/(30cm*30cm)
We know that 1KN =1000N
1CM = 10MM
F= (11*1000) / (300*300)=0.13N/mm^2
Therefore compressive strength is equal to 0.13N/mm^2

- **TRIAL –3**

Now, calculation of load for the ratio (1:1:2)
We have attended load of 15.25KN on the ratio (1:1:2)
Therefore F=P/A
F= 15.75KN /(30cm*30cm)
We know that 1KN =1000N
1CM = 10MM
F=(15.75*1000) / (300*300)=0.18N/mm^2
Therefore compressive strength is equal to 0.18N/mm^2

- **TRIAL – 4**

Now, calculation of load for the ratio **(2:1:1)**
We have attended load of 15.25KN on the ratio **(2:1:1)**
Therefore F=P/A
F= 16KN/(30cm*30cm)
We know that 1KN =1000N
1CM = 10MM
F=(16*1000) / (300*300)=0.19N/mm^2
Therefore compressive strength is equal to 0.19N/mm^2

5. CONCLUSION:

The compressive strength of tiles increases with increasing cement content. Compared to plastics and egg shells, cement contributes most significantly to the compressive strength of tiles, which decreases with increasing quantity of plastics. Addition of egg shells does not significantly affect the compressive strength of tiles. Plastics have a tendency to reduce the compressive strength of tiles. Hence, they should be used cautiously. The presence of plastics seemed to enhance abrasion resistance. The presence of plastics in tiles under study enhanced impact resistance as they resisted impact due to a falling steel ball weighing 438g.

Water absorption decreased with increased amounts of cement. However, plastics and egg shells had no significant effect on water absorption of the tiles. The most appropriate mix in the study was that which gave a compressive strength of 17.9 N/mm^2, a water absorption rate of 11.4% as well as tiles that are resistant to impact and abrasion. The density of tiles increased with the increase in the quantity of cement. Cement was the major contributing material to the density of cubes. The density of cubes decreased with increased plastic quantity. The effect of egg shells and plastics on the density of the cubes was very insignificant. Economically, the tiles made using cement, plastics and egg shell mixture are affordable (Kgs 535 per m^2) compared to (Kgs. 900 to 1500) for ceramic tiles available commercially and the production process is cheap since it does not involve more expensive industrial equipment. Wastes (plastics and egg shells) are the major materials that are needed to manufacture for the tiles.

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