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Use of spent earth in production of garden tiles

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Use of spent earth in production of garden tile

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Abstract

Bleaching earth is an adsorbent used in edible oil refinery process. After using bleaching earth, the residues are called spent earth. The spent earth has no proper disposal method rather than landfilling which results severe environmental problems. In this study use of spent earth in production of garden tiles has been examined. Two experimental series have been suggested: use of spent earth as an alternative for (i) sand and (ii) cement. Measuring compressive strength and water absorption capacity is suggested to determine the quality of the produced garden tiles. This study reveals that 45 % cement and 40% sand can be replaced when the spent earth is considered as an alternative for cement and sand separately. These replacements yield 22 % and 45 % reduction in cost and CO_2 emission respectively.

Key words

Spent earth, Garden tile, Compressive strength, Water absorption value

1.Introduction

Edible oil (Palm oil) refinery process consists of 3 steps to covert crude oil to edible condition. They are degumming, bleaching, and deodorizing. In bleaching step, to adsorb gum particles (Phospotide), impurities, moisture and some color pigments, bleaching earth is directly added to crude oil. After processing, bleaching earth is called spent earth. A detailed description on bleaching earth can be found underneath.

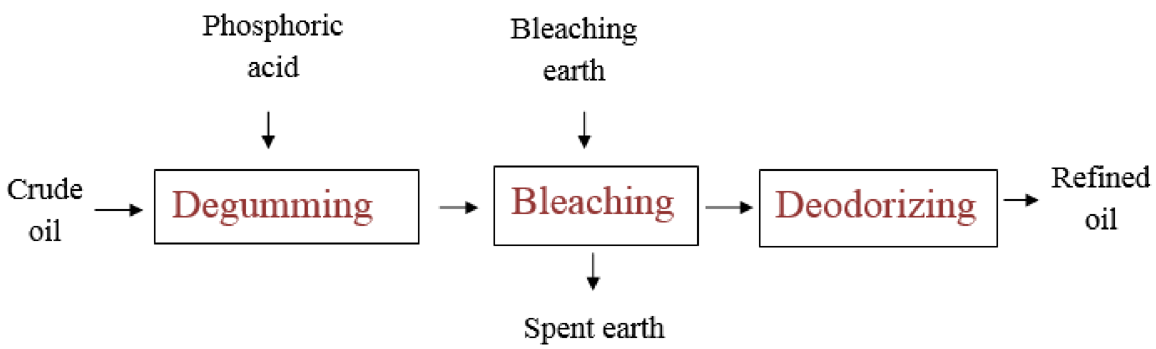

Figure 1. Generation process of spent earth

Bleaching earth (fuller's earth) is a clay material that has a capability to decolorize liquid or oil mined in Asia, England and the US obtained from earth. Attapulgite ($(Mg,Al)_2Si_4O_{10}(OH)\cdot4(H_2O)$), kaolinite ($Al_2Si_2O_5(OH)_4$) and montmorillonite ($(Na,Ca)_{0.33}(Al,Mg)_2(Si_4O_{10})(OH)_2\cdot nH_2O$) clays are the most common substances found in bleaching earth. In its raw state, the clay mostly contains Aluminum silicate family. In addition, this clay contains iron, magnesium and calcium. Clay deposits resemble soil and can range in color from buff or tan to yellow or pure white. It is highly absorbent and typically has a smooth, greasy feel. Table 1 shows the general composition of bleaching earth.

Table 1. General composition of bleaching earth (Taiko,1998)

Chemical composition	Percentage(%,by mass)
SiO_2	55-80
Al_2O_3	5-20
Fe_2O_3	2-10
MgO	0-8
CaO	0-5
Na_2O	0-2
K_2O	0-2

Applications of spent earth are very limited. Most of the times spent earth is directly disposed of in landfills. There are environmental concerns with the continued use of landfills. Moreover, the necessity to dispose of the spent bleaching earth as within a day is problematic with respect to safety, transportation, and timing. As a result, many attempts to find a safe and economic use for spent earth have been contemplated. For over fifty years, numerous ideas for economic utilization of the spent bleaching earth have been explored including inclusion in some liquid animal feeds. These methods have not proven to be satisfactory because of the spontaneous combustion hazard in handling. Loha and James (2013) describe the possibility of use of spent earth as an organic fertilizer while Smallwood and Norman (2014) highlight its application as an animal feed in order to enhance the health and nutritional level of feed supplements. Another application of spent earth is use them in production of construction materials. Production of a porous brick from sawdust, spent earth, compost and marble residue is reported by Deliche-Quesda,, FACorpas Iglesias, L perez. 2012.In addition Wachira et al. (2012) reported a study on production of a cementitious material by using rice husk, broken bricks, spent earth and dried calcium carbide residues. So far all the studies performed to produced building materials by using spent earth combined spent earth with various other waste materials. None of the studies reported use of spent earth as the sole substitute for cement and sand in production of building materials. Hence in this study we focus on use of spent earth in production of garden tiles

2.Materials and methods

2.1. Preparation of materials

Spent earth was crushed and sieved if necessary in order to obtain a uniform grain size. Sand and cement were purchased from local market. Sand was sieved from four meshes and used the compositions shown in Table .2

Table.2 Sand composition

Square mesh size (mm)	2.0-1.6	1.6-1.0	1.0-0.5	>0.5
Sieve residue (%)	7	25	40	28

2.2. Preparation of specimens

According to the sand and cement ratio of a commercially available garden tile Cement: Sand: Water ratio was considered as 1: 3: 0.485 (ASTM 109/C109M)

Size of a specimen was 5cm×5cm×5cm (ASTM 109/C109M). The entire series of experiments was performed in triplicates. Following two series of experiments conducted.

Series A

Amount of cement was kept as a constant.

Amount of sand was replaced by spent earth

Sand percentage(%)	Spent earth percentage(%)	Weight of Sand(g)	Weight of Spent earth(g)	Weight of water(g)	Weight of cement(g)
0	100	0	659	106.5	219.7
20	80	131.8	527.2	106.5	219.7
40	60	263.6	395.4	106.5	219.7
60	40	359.4	263.6	106.5	219.7
80	20	527.2	131.8	106.5	219.7
100	0	659	0	106.5	219.7

Series B

Amount of sand was kept as a constant.

Amount of cement was replaced by spent earth

Cement percentage (%)	Spent earth percentage (%)	Weight of cement (g)	Weight of spent earth (g)	Weight of water (g)	Weight of sand (g)
0	100	0	219.7	106.5	659
20	80	43.94	175.76	106.5	659
40	60	87.88	131.82	106.5	659
60	40	131.82	87.88	106.5	659
80	80	175.76	43.94	106.5	659
100	100	219.7	0	106.5	659

Using stainless steel mixing bowl, mixture was mixed. First, water and cement were added after that added the sand quantity to the mixer. After prepare mortar first layer was spared and applied 16 tamps using tamping rod. Next, 2nd layer was introduced and applied 16 tamps using tamping rod and gave good finish look for top of the tile. Each mold was placed on a horizontally in the moist-air cabinet. After 24h demolded the specimens and stored in moist-air cabinet until doing strength testing. For the better removing tile from the mold, required good oil layer to inside the mold. (ASTM 109/C109M)

There are 5 age of specimens for strength tests, 24h ,48h ,72 h ,7days and 28 days, have used 28-day strength testing. For the calculation.

Figure 2. Mixing bowl, moist-air cabinet & tile preparation

2.3 Analysis of physical properties

Following properties were measured according to British standards.

(i) Compressive strength (BS EN 1338:2003)
Compressive strength values were measured using universal testing machine Load was applied on 50mm×50mm area until a fraction occurs.

Compressive strength Rc (MPa) $=F_c/2500$

F_c is Maximum load at fracture, (N)

2500 is the area of the auxiliary plates (50mm×50mm)

Figure 3: Universal testing machine

(ii) Water absorption value (BS 6717-1:1993)

Specimens were immersed in potable water at a temperature of (20 ± 5) °C.(The minimum period of immersion shall be three days). Before each weighing wiped the specimen with the cloth which has been moistened and squeezed to remove any excess of water. (The drying is correct when the surface of the concrete is dull).
Each specimen was placed in inside the oven in such a way that the distance between each specimen was at least 15 mm. Specimens were dried at a temperature of (105 ± 5) °C until it reached constant mass M2. (BS 6717-1:1993)

$$W_a = \frac{M_1 - M_2}{M_2} \times 100\ \%$$

M_1 is the initial mass of the specimen (g);
M_2 is the final mass of the specimen (g).

3. Results and Discussion

3.1.1 Compressive strength

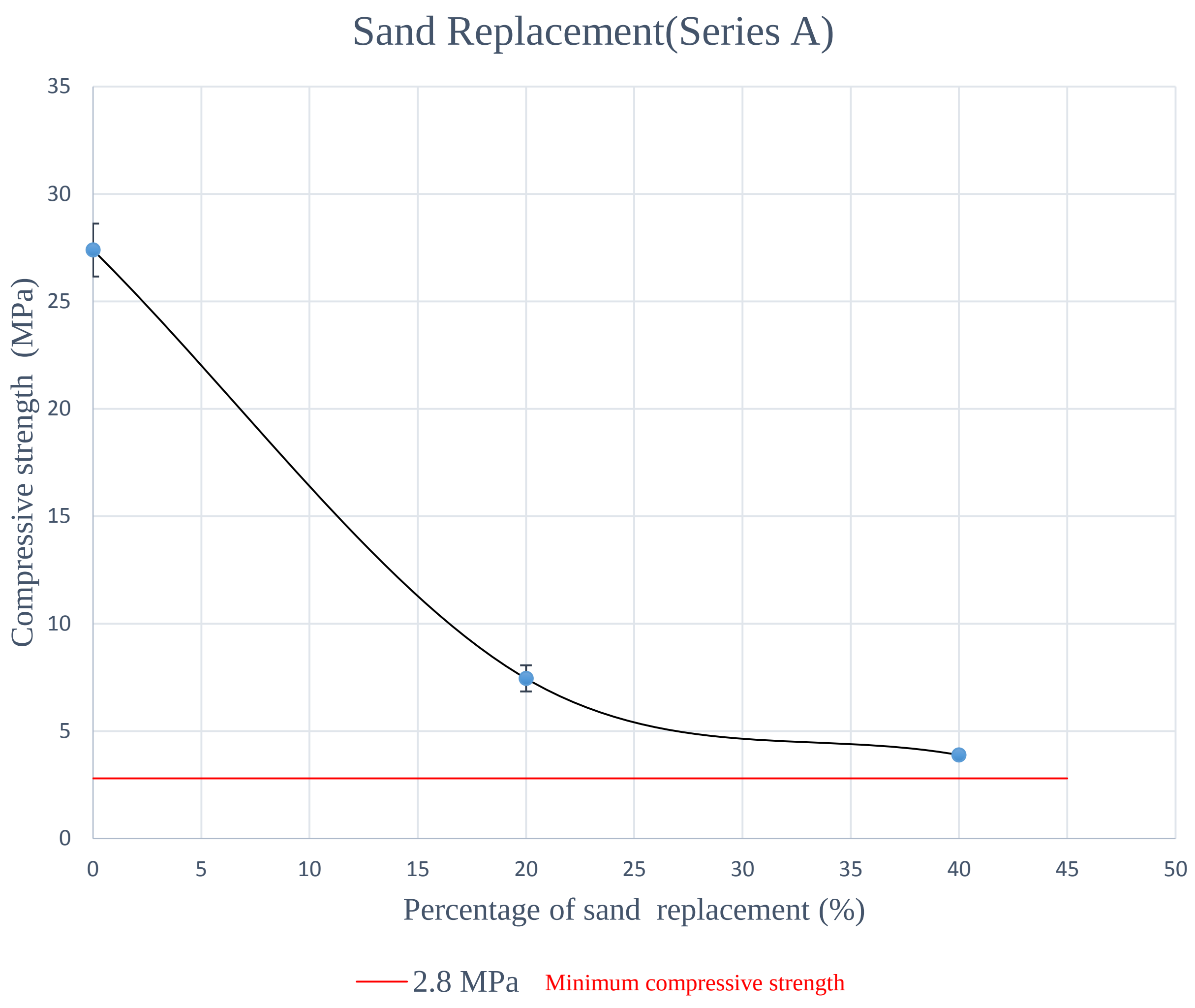

Figure.4 Compressive strength value of series A

Minimum compressive strength value of garden tile > 2.8 MPa (BS 6073)

According to BS 6073, 40 % of sand can be replaced by spent earth.

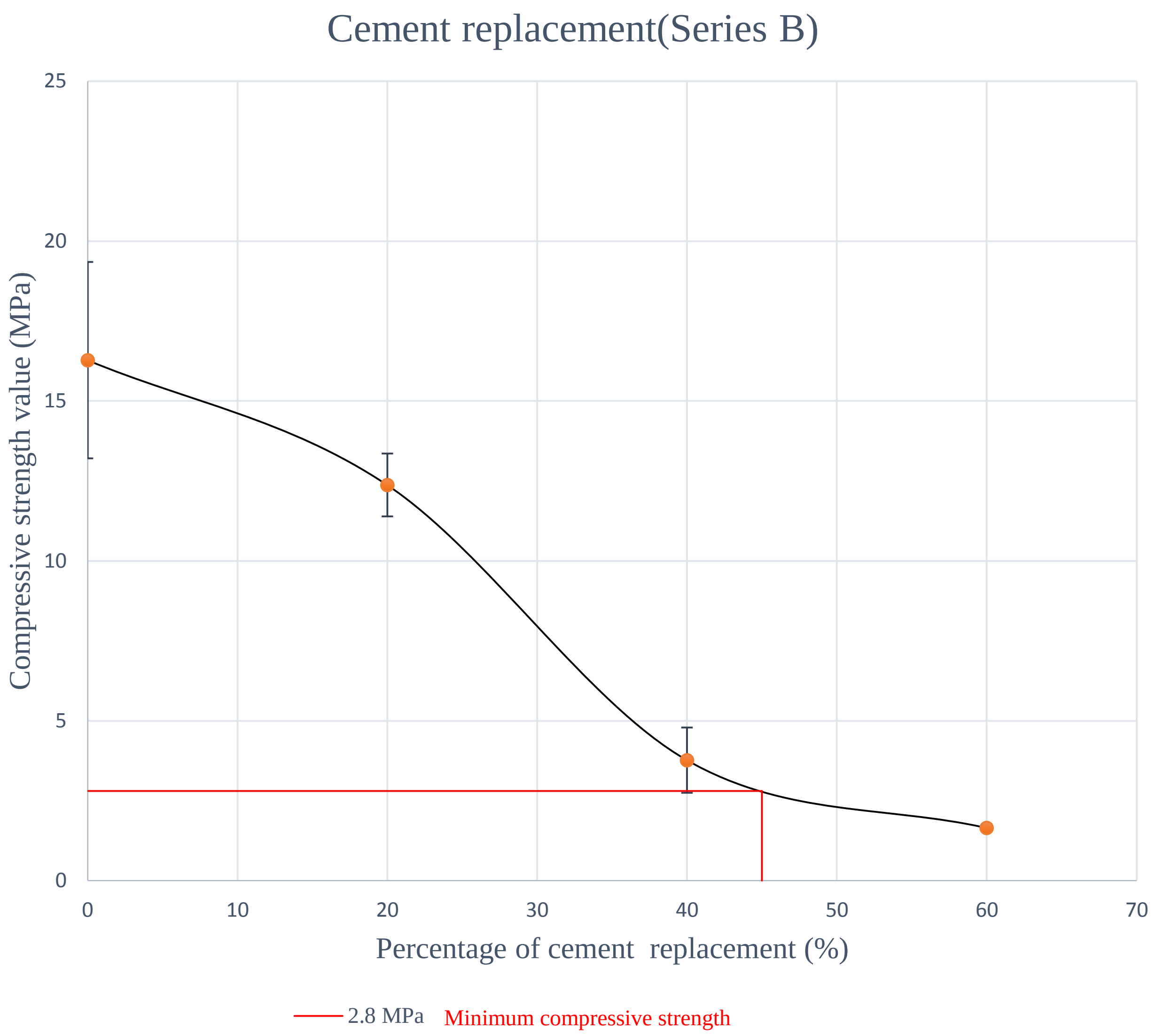

Figure.5 Compressive strength value of series B (Sand constant, Cement replacement)

Minimum compressive strength value of garden tile > 2.8 MPa (BS 6073)

According to BS 6073, 45 % of sand amount can be replaced by spent earth

Some specimens (100% and 80% of sand and cement replacements) were not properly demolded and also those were affected by a fungi attack.

Figure 6.Fungus attack and demolding process

3.1.2 Water absorption value

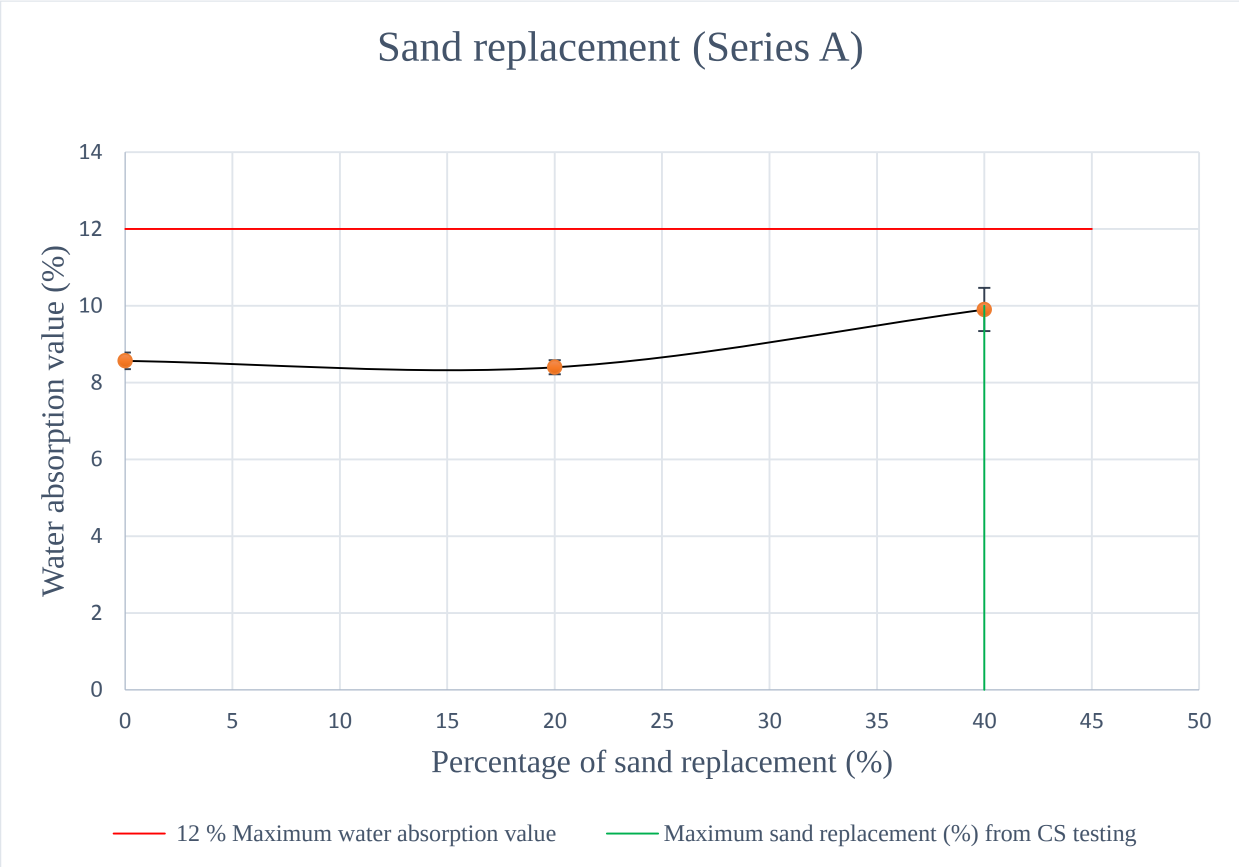

Figure 7. Water absorption level of series A

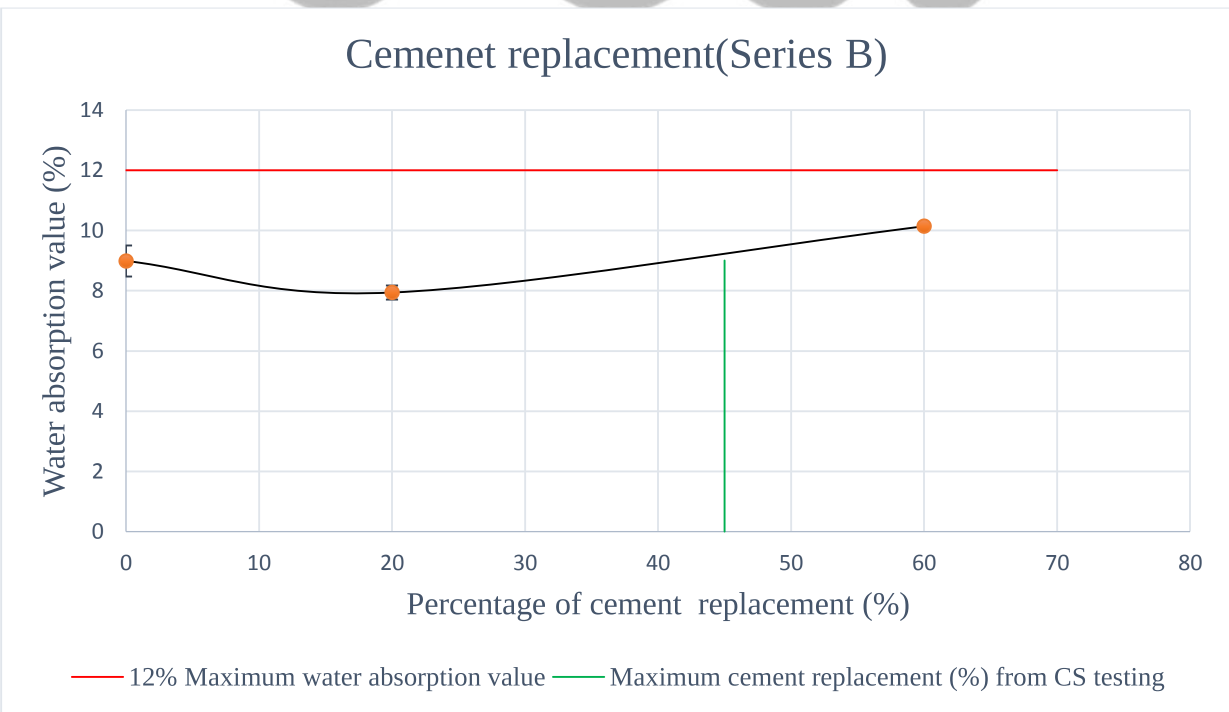

Figure.8 Water absorption level of series B

According to BS 5628 - 1: 2005, Maximum water absorption value of garden tile < 12 %
Maximum sand & cement replacement percentage obtain from compressive strength are in acceptable range in the water absorption value measurement.

It was assumed that the fungus grown on the specimens due to the residual oil content. Hence oil extraction was carried out to investigate the residual amount of oil as explained by IS 10640:2011. It was identified that residual oil content of spent earth is 24% which is a good substrate for fungus.

Figure 9. Soxhlet apparatus & hexane vaporization process

Figure 10. Extracted oil quantity

3.2. Environmental impact reduction

Considering 200 mm length,100 mm width & 80mm height of garden tile with 1:3 cement to sand ratio (average weight is 3.5kg) the reduction of CO2 emission was calculated for optimal cement replacements as follows.

Cement quantity = 0.875 kg
Sand quantity = 2.625 kg
Amount of CO_2 release by a garden tile cement quantity = 0.875×1kg CO_2/1kg of cement (Nielson,2008)
Amount of CO_2 reduction from spent earth replacement = 0.875×0.45 =0.394 kg/tile

In addition to the emission caused by cement manufacturing, extraction of sand also causes environment degradation such as river bank damage, bio diversity changes, water pollution etc. These type of environmental burdens can also be minimized as 40 % sand can be replaced with spent earth in a garden tile.

3.3. cost reduction

For above considered garden tile 22& reduction in cost can be achieved. The results are summarized in Table .3

Table. 3 Approximate cost calculation

Materials	Garden tile without spent earth	Garden tile with 45 % cement replacement	Garden tile with 40 % sand replacement
Cement	Rs.20.00	Rs.9.63	Rs.20.00
Sand	Rs.26.25	Rs.26.25	Rs.15.75
Spent earth	-	Rs.20	Rs.00.53
Total cost	Rs.46.25	Rs.36.08	Rs.36.28
Percentage reduction of cost		$\frac{10.17}{46.25} \times 100 = 22\ \%$	$\frac{9.97}{46.25} \times 100 = 22\ \%$

3.4 Conclusion

- 45 % of cement and 40% of sand can be replaced by spent earth (satisfy the research hypothesis)
- O_2 emission related to cement production can be reduced by 45% per tile by using spent earth.
- 22% of cost reduction can be achieved.
- Instead of 1:3 Cement: Sand ratio used in this study, another set of experiments with low cement to sand ratios should be carried out to find out the influence of spent earth on strength value.
- Instead of varying only the sand and cement amounts, water flow should also be varied.

4.Acknowledgement

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