# Study of recycled polyethylene plastic waste as binder in building block for greener construction

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Charles K Kankam
Kwame Nkrumah University Of Science and Technology

Bismark K. Meisuh

Jonathan Sasah
Accra Technical University

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Charles K. Kankam[a], Kwaku Ansa-Asare [a], Bismark K. Meisuh*[b] and Jonathan Sasah[c]

[a]*Department of Civil Engineering, MountCrest University College, Kanda, Accra, Ghana*

[b]*Department of Civil Engineering, Ho Technical University, P. O. Box HP 217, Ho, Ghana*

[c]*Department of Civil Engineering, KAAF University College, P. O. Box WU 177, Kasoa, Ghana*

**Corresponding author's mail: bisuh2004@yahoo.com*

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## Abstract

Plastic production has overtaken most man-made materials including metals and has long been under environmental scrutiny. Most plastic wastes are accumulated in landfills, natural environment and oceans. It is estimated that with the current trend of global production and waste management, approximately 12000 million metric tons of plastic waste will accumulate in landfills and in the natural environment by the year 2050. Plastics have very poor recycling rates, and their inherent menace is most pervasive in low-income, developing countries. This paper presents results of study on plastic waste as binder in mixtures of sand (fine aggregates) to produce building blocks for construction. Melted polyethylene plastic was mixed with sand (sandplast) in different proportions of 1:1, 1:1.5, 1:2, 1: 2.5 and 1:3 (plastic: sand). Test results include compressive, tensile and impact strengths, stress-strain response, fire resistance, water absorption and permeability of sandplast. The optimum mix ratio for the compressive, tensile and impact strength was 1:2. The compressive and tensile strength of sandplast blocks ranged from 4.8 to 7.4 $N/mm^2$ and 3.3 to 7.2 $N/mm^2$ respectively. These are greater than the respective values for sandcrete blocks produced in Ghana that generally vary from 1.4 to 3.5 $N/mm^2$ and 0.1 to 0.3 $N/mm^2$. The static modulus of elasticity of sandplast averaged approximately 89.0, 311.5 and 197.7 $N/mm^2$ for mix proportions of 1:1, 1:2 and 1:3. At temperatures below 80$^o$C the strength properties and stability of sandplast blocks remained unchanged. When immersed in water, sandplast blocks were found to be insoluble in water. The coefficient of permeability of sandplast averaged 4.6 x $10^{-4}$, 8.2 x $10^{-4}$ and 21.8 x $10^{-4}$ cm/sec for mix proportions 1:1, 1:2 and 1:3 respectively.

*Keywords: Plastic, Recycle, Binder, Sand, Sandcrete, Strength, Durability*;

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## 1. Introduction

Provision of adequate housing is one of the most intractable challenges that face low-income nations [1,2]. Approximately half of the world's population lives in mud houses. In tropical countries, mud in the form of laterite (weathered soil) contains silicates and aluminates of iron and other chemical elements that make it partially cementitious [3,4]. The problem of mud as building material is that because it is generally sun-dried and un-stabilized, it is very prone to erosion under the scouring action of rain [5,6]. Rendering of mud walls with mortar made from Portland cement and sand is adopted occasionally to improve the durability of mud buildings.

Sandcrete is a building block that is prepared from a mixture of Portland cement and sand in Ghana, Nigeria and other countries in West Africa. Ideally, the constituents of sandcrete blocks are mixed in definite proportions and compressed at very high pressure by means of electric press. However, the pressing is commonly done manually and the sandcrete blocks are moulded using inadequate mixing water that leads to improper hydration of the cement; the resulting products are therefore inferior. Sandcrete is therefore most often unsuitable for load-bearing columns and is mainly used for walls. As material for walls, its strength is less than that of fired clay bricks, but sandcrete is considerably cheaper. The high cost of Portland cement, an extremely energy-intensive product, is beyond the reach of the majority of people who cannot afford several hundreds of sandcrete blocks and other related materials that are required to complete a simple housing unit. This situation has resulted in a severe housing shortage for the average worker and a large percentage of the population are homeless [7,8].

Due to the increasingly high cost of cement, this study aimed to investigate melted plastic waste as binder in sand (fine aggregate) mix to produce building blocks. Plastics' largest global market is packaging, facilitated by a global shift from reusable to single-use containers. They are non-biodegradable inorganic materials that accumulate rather than decompose in landfills, natural environments and oceans. As of year 2015 approximately 6300 million metric tons of plastic waste had been generated and it was estimated then to grow to 12000 million metric tons by 2050 if the current production rate and waste management trends continued [8]. In high-income, developed countries, some amount of recycling (9%) and destructive thermal treatment (12%) of plastic waste are done, whereas virtually all plastic wastes generated in low-income developing nations accumulate in landfills, natural environment, rivers and oceans.

Polyethylene is the most common polymer product that is used for the manufacture of plastic materials in West Africa. In spite of their extensive and purposeful usages, they pose serious environmental problems and their improper disposal makes them a primary source of environmental nuisance including choked drainage channels. Many waste management organizations in developing countries are therefore making frantic efforts to find economical ways to re-cycle plastic wastes. This study finds an appropriate engineering use to re-cycle polyethylene plastics in the building construction industry.

### *1.1. Properties of polyethylene*

Polymer is made up of macromolecules and may be naturally-occurring as in wood cellulose, proteins of living organisms and natural rubber; it may also be produced artificially by chemical synthesis such as plastic, synthetic rubber, chemical fibres and varnishes [9]. Polyethylene is a thermoplastic polymer that is formed from the ethylene monomer and its polymerization is carried out at either high or low pressure. Under high pressure, it is carried out at a temperature of 220 to 280ºC in the presence of a small amount of oxygen as catalyst, and the resulting product has a low density. Ethylene polymerization at low pressure is conducted in a solution such as petrol at a temperature of 60 to 80ºC in a reactor and a mixture of tri-ethyl-aluminium and titanium tetrachloride as catalyst. Polyethylene produced at low pressure is more resistant to organic acids and solvents but less elastic [10]. Polyethylene is used worldwide for diverse plastic products and possesses the following attractive characteristics [11]:

(i) High mechanical strength that exceeds the strength of wood, glass and ceramic;
(ii) High thermal properties;
(iii) High chemical stability and resistance;
(iv) Excellent electrical insulation properties over a wide range of frequencies;
(iv) High toughness and moderate tensile strength;
(v) High flexibility and good processability;
(vi) Low cost.

Polyethylene can be classified on the basis of its density as either low or high, and bonding structure as branched or linear. Tables 1(a, b, c) summarize the physical, thermal and elastic properties of polyethylene. In general, properties of polyethylene involving small deformation such as modulus and creep depend on its density, while those for large deformation such as tensile strength and creep rupture depend on molecular weight and branching. The behaviour of polyethylene under applied stress is visco-elastic. Its deformation is initially largely elastic and recovery is virtually complete with 5% strain, which may be taken as safe operating limit for design purposes[12].

## 2. Experimental Procedure

The properties of polyethylene plastic binder-sand mixes that were investigated include compressive and tensile strength (modulus of rupture), impact resistance, stress-strain response, fire resistance, permeability and water absorption.

### *2.1 Materials and preparation*

Polyethylene plastic and ordinary pit sand were used as binder and fine aggregates respectively to cast sandplast blocks for the various tests. Batching of the materials for all mix ratios was done by volume. The polyethylene plastics were melted in covered steel pots and measured volumes of sand were poured into the molten plastic and mixed thoroughly into a uniform paste. Different mix ratios of 1:1, 1:1.5, 1:2, 1:2.5 and 1:3 (plastic: sand) were investigated.

**Table 1a**: Physical properties of polyethylene [12]

| Specific gravity | | Melting point °C | Refractive index | Resistivity (ohm cm) | |
|---|---|---|---|---|---|
| Low-density | High-density | | | Low-density | High Density |
| 0.92-0.94 | 0.94-0.95 | 110-130 | 1.51-1.52 | 1017-1019 | 1015-1016 |

**Table 1b**: Thermal properties of polyethylene [12]

| Specific heat (cal/g °C) | Conductivity (cal/s cm °C) | | | | Coefficient of linear expansion (/ °C) | |
|---|---|---|---|---|---|---|
| | Low-density | | High density | | Low-density | High density |
| 0.55 at 20 °C rising to 0.70 at 120-140 °C | 8.4 x 10 $^{-4}$ at 0 °C | 7 x 10 -4 at 50 °C | 10 x 10 $^{-4}$ at 0 °C | 8.7 x 10 $^{-4}$ at 50 °C | 1.7-2.2x10$^{-4}$ | 1.3-2x10$^{-4}$ |

**Table 1c**: Elastic properties of polyethylene [12]

| Specific gravity | 0.92 | 0.94 | 0.95 | 0.96 |
|---|---|---|---|---|
| Elastic modulus (kN/mm$^2$) | 15.4 | 63.0 | 77.0 | 126.0 |

The hot mixture was poured into moulds and compacted in layers using a broad base compacting rod. Each test specimen was left to cool and dry for approximately one hour before de-moulding. De-moulding of the specimens did not require greasing of the inner surfaces of moulds since polyethylene as thermoplastic possesses characteristics that allow easy removal when it solidifies during cooling [13].

### *2.2. Test specimens and testing*

The compressive strength and modulus of rupture tests were carried out on fourteen 100 mm cubes in accordance with BS 1881-116 [14] and eleven 100×100×500mm prisms of sandplast specimen in accordance with BS 1881-118 [15] respectively. The cubes were tested in a universal compression machine while the prisms were tested in bending with a central point load to obtain the tensile strength. The impact strength of sandplast was determined using specimen 400mm square slabs of 50mm thickness. A spherical steel ball of weight 3.04kg was dropped from a constant height of 0.8m onto the slab that was supported on its base. The total length, maximum depth and maximum width of the cracks that developed in the specimen were measured with the aid of a manually operated crack etection microscope to determine the impact resistance of the slab. Fire resistance was tested using specimen of size 100mm cubes and 100×100×500mm prisms. Eight cubes and prisms were used to study the fire resistance of sandplast in compression and tension, respectively, at different temperatures up to 125$^{o}$C.

The stress-strain properties of sandplast were investigated by testing nine 100×100×500mm prisms in compression. The falling head permeability test was used to determine the permeability of the sandplast block. Nine cylindrical specimens measuring approximately 9.40cm by 11.6cm (diameter and height) were cast in their molten state in cylindrical moulds of a permeameter. The lid of the permeameter was sealed with a rubber gasket and tightly fixed in position with screws. The test was conducted after the sample had cooled to room temperature. Water absorption of sandplast was measured using nine 100mm cubes in accordance with BS 3921 [16]. After cooling to room temperature, the cubes were first weighed, submerged in water and their weights were then recorded over different periods for 28 days.

## 3. Test results and discussions

### *3.1. Density*

The average densities of sandplast measured after 7-days are presented in Tables 2a and 2b. They ranged from about 2075 to 2430 kg/m3 depending on the relative proportion of sand in the mix. This range is generally of the order of the dry density of normal sandcrete prepared from ordinary Portland cement and sand which ranges from 500 to 2100 kg/m3 [17]. In relation to concrete, the density of sandplast falls within the range of lightweight to normal weight [17].

**Table 2a:** Tensile strength (modulus of rupture) of concrete after 7-days at different temperatures for different mix proportions.

| Mix ratio | Average density ($kg/m^3$) | | Average tensile strength ($N/mm^2$) | | Reduction in tensile strength (%) |
|---|---|---|---|---|---|
| | Room temp. 26$^{o}$C | 80$^{o}$C | Room temp. 26$^{o}$C | 80$^{o}$C | |
| 1:1 | 2079 | 2218 | 3.3 | 0.12 | 96.4 |
| 1:2 | 2239 | 2228 | 7.2 | 0.30 | 95.8 |
| 1:2.5 | 2165 | 2265 | 5.4 | 0.24 | 95.5 |
| 1:3 | 2258 | 2285 | 4.8 | 0.12 | 97.5 |

**Table 2b:** Compressive strength of concrete after 7-days at different temperatures for different mix proportions

| Mix ratio | Average density ($kg/m^3$) | | Average compressive strength ($N/mm^2$) | | Reduction in compressive strength (%) |
|---|---|---|---|---|---|
| | Room temp. 26$^{o}$C | 80$^{o}$C | Room temp. 26$^{o}$C | 80$^{o}$C | |
| 1:1 | 2118 | 1992 | 4.8 | 0.2 | 95.8 |
| 1:2 | 2304 | 2215 | 7.4 | 1.4 | 81.1 |
| 1:2.5 | 2431 | 2347 | 5.8 | 0.5 | 91.4 |
| 1:3 | 2354 | 2404 | 5.2 | 0.4 | 92.3 |

### *3.2. Tensile and compressive strength*

The results of the tensile and compressive tests at room temperature for the different mix ratios of sandplast are presented in Tables 2a and 2b respectively. The average tensile strength of sandplast ranged from 3.3 to 7.2 $N/mm^2$ which was found to be greater than the values 0.1 to 0.3 $N/mm^2$ generally obtained for normal sandcrete prepared from pit sand and ordinary Portland cement in Ghana and other countries in West Africa [18]. A plot of the tensile strength of sandplast and mix proportions shows a general increase in the tensile strength up to a maximum for a mix ratio of 1:2 (plastic: sand), followed by a general decrease (Fig 1). This general trend is due to the fact that for mix proportions lower than the optimum mix ratio 1:2, the presence of relatively excessive molten plastics required for binding the sand could have led to the formation of micro-cracks during cooling and resulted in reduced strength. Beyond this optimum mix ratio, molten plastic was not enough to bind effectively all the sand particles together and could also result in low compaction and reduced strength.

The average compressive strength of sandplast ranged from 4.8 to 7.4 $N/mm^2$ and the densities averaged between about 2115 and 2430 $kg/m^3$ (Table 2b). The relationship of compressive strength and mix ratio (Fig 2) followed the same trend as that of the tensile strength ranging from 3.0 to 7.8 N/ mm$^2$. The peak value of 7.4N/mm$^2$ was obtained for the mix ratio of 1:2. These values are found to be greater than the compressive strength of sandcrete which ranges from 1.4 to 3.5 N/ mm$^2$ [18]. In comparison, the average compressive strength for normal load-bearing burnt bricks produced in Ghana varies from 11.5 to 26.0 N/mm$^2$ [19,20]. The Ghana Building Code [21] specifies a minimum strength of 2.67 N/ mm$^2$ .The Nigerian Standards [22] on the other hand specifies maximum and minimum limits of 2.5 and 3.5 N/mm$^2$ for non load-bearing and load-bearing walls respectively.

Sandcrete blocks produced by electrically- powered machines can attain compressive strength up to 6.0 N/mm$^2$. The range of strengths specified by BS 6073-2 [23] for concrete blocks is 2.8 to 35 N/mm$^2$, but from considerations of cost the more normal practical limit is about 20 N/mm$^2$, Sandcrete blocks produced by electrically- powered machines can attain compressive strength up to 6.0 N/mm$^2$. The range of strengths specified by BS 6073-2 [23] for concrete blocks is 2.8 to 35 N/mm$^2$, but from considerations of cost the more normal practical limit is about 20 N/mm$^2$, and the most commonly used blocks fall within a much smaller strength band of 3.5 to 10 N/mm$^2$ [24].

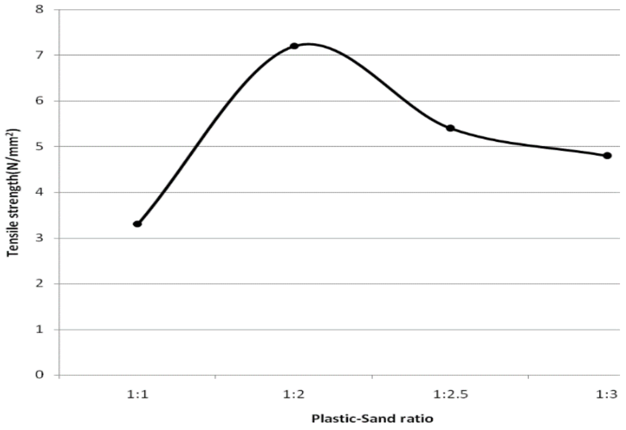

**Fig. 1.** Average tensile strength versus plastic-sand mix ratio

### *3.3. Impact resistance*

Table 3 presents results of the impact resistance test of the sandplast blocks and indicates the total length, maximum depth and maximum width of cracks and the resulting impact resistance. Figure 3 illustrates the effect of the plastic content in the sandplast block on the impact resistance of the product. The impact resistance was computed using the relationship [25]:

**Table 3:** Impact crack resistance

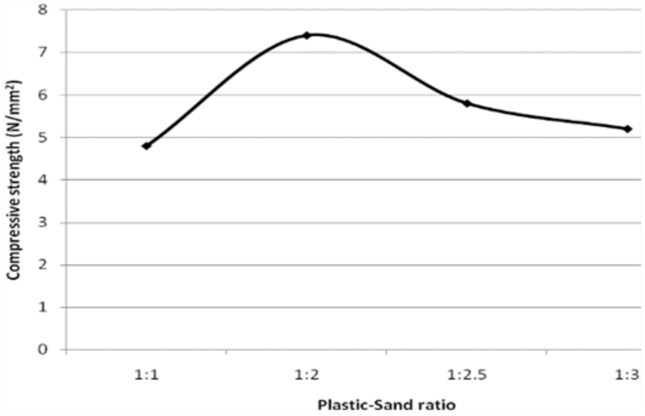

**Fig. 2.** Average compressive strength versus plastic-sand mix ratio

$$Qh = R_u L_c d_c w_c \tag{1}$$

where $Q$ = weight of the falling ball (N); $h$ = height of fall (mm); $R_u$ = ultimate cracking resistance to impact load of the target structure (N/mm$^2$); $L_c$ = total length of all cracks (mm); $d_c$ = maximum crack depth (mm); $w_c$ = maximum crack width (mm).

The average impact resistance of sandplast ranged from 0.61 to a maximum 1.61 N/mm$^2$ for mix ratios from 1:1 to 1:2 (plastic: sand) as shown in Fig 3. As in the case of concrete the impact strength of sandplast is more closely related to the tensile strength than its compressive strength [26]. High impact strength indicates a sufficient bond between the right proportions of binder and sand particles.

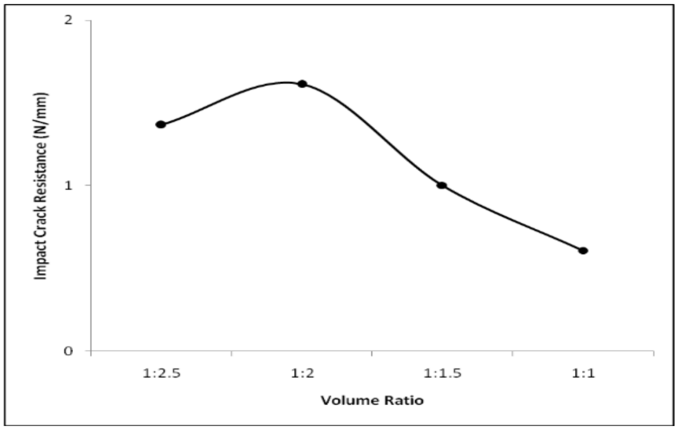

**Fig. 3.** Impact Strength versus mix ratio

| Specimen no. | Mix ratio | Total crack length (mm) | Maximum crack depth (mm) | Maximum crack width (mm) | Impact strength (N/mm$^2$) |
|---|---|---|---|---|---|
| 1 | 1:1 | 670 | 45.3 | 1.3 | 0.61 |
| 2 | 1:1.5 | 665 | 45.0 | 0.8 | 1.00 |

| | | | | | |
|---|---|---|---|---|---|
| 3 | 1:2 | 714 | 46.0 | 0.6 | 1.61 |
| 4 | 1:2.5 | 451.3 | 46.0 | 0.9 | 1.37 |

### 3.4. *Stress-strain relationship*

Typical stress-strain relationships of sandplast for two different mixes are illustrated in Figures 4 and 5. The initial tangent modulus obtained from the stress-strain curves and the static or short-term modulus of three different mixes estimated from Equation 2 are presented in Table 4.

$$E_c = 1.25E_{cq} - 19 \quad (2)$$

where $E_c$ and $E_{cq}$ are the secant and dynamic moduli expressed in kN/mm$^2$ respectively [26].

From Table 4, the dynamic modulus of elasticity of sandplast averages 86.4, 173.4 and 264.4kN/mm$^2$ for mix proportions 1:1, 1:3 and 1:2, respectively. The static modulus also varied in the same order of 89.0, 197.7 and 311.5 kN/mm$^2$ for mix proportions 1:1, 1:3 and 1:2, respectively. In comparison, the modulus of elasticity for sandcrete (sand and oPc) produced in Ghana ranges from 5.0 to 30.8 kN/mm$^2$ [19,20]. The short-term modulus of elasticity of concrete generally ranges from 21 to 42 kN/mm$^2$ for compressive strength of 20 to 60 N/mm$^2$ [26].

The estimated values of the modulus of elasticity of the three sandplast mixes are much greater than that of concrete. The modulus of elasticity for polyethylene plastics is greater than that of plain concrete, and polyethylene serving as binder in fine aggregates most probably contributed to its higher value. Sandplast with mix ratio of 1:3 (plastic: sand) produced the highest modulus of elasticity, followed in order by mix ratios 1:2 and 1:1. The high modulus of elasticity of sandplast particularly for the mix ratios 1:2 and 1:3 relative to sandcrete and even concrete mixes manufactured with Portland cement is an indication of the high strength and low deformation of sandplast.

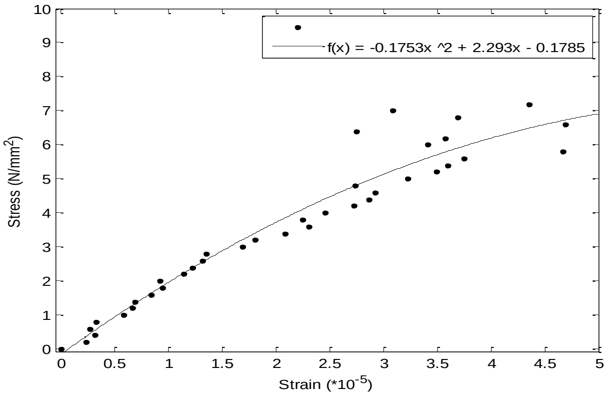

**Fig. 4**. Stress-Strain relationship for sandplast mix (1:2)

**Table 4:** Dynamic and static modulus of sandplast mixes

| Mix ratios | Dynamic modulus, $E_{cq}$ (kN/mm$^2$) | Static modulus, $E_c$ (kN/mm$^2$) |
|---|---|---|
| 1:1 | 86.4 | 89.0 |
| 1:2 | 264.4 | 311.5 |
| 1:3 | 173.4 | 197.7 |

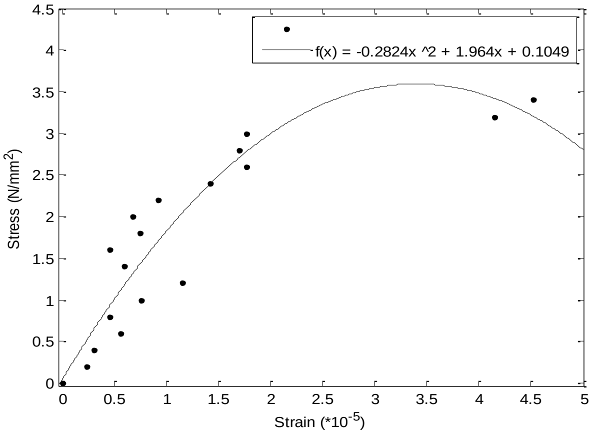

**Fig. 5.** Stress-Strain relationship for sandplast mix (1:3)

### 3.5. *Fire resistance*

Tables 2a and 2b present the tensile and compressive strength characteristics at two different temperatures. The strengths of the sandplast specimens at room temperature (approximately 26°C) are presented in the tables for comparison. In order to assess the influence of heat on the durability or resistance to physical decomposition of the sandplast blocks, the average percentage reduction in strength is calculated for both tensile strength and the compressive strength at 80°C. The percentage values obtained were 96.3 and 90.1 reduction in tensile and compressive strengths respectively. The tensile strength is found to decrease more than the compressive strength with increasing temperature. This sudden change in the strength characteristics of this component can be attributed to the effect of heat on polyethylene plastics. The strength-mix ratio profiles of the sandplast material remained approximately the same for temperatures below 80°C. However, the reductions in tensile and compressive strengths at 80°C averaged 96.3 and 90.1 percent respectively.

Table 5 presents the deformation characteristics of sandplast specimens at temperatures up to 125°C. The sandplast blocks remained intact with no visible cracks upon heating up to a temperature of 80°C for mix ratios of 1:2 and 1:3. Blocks of these ratios developed cracks at a temperature of 100°C and started decomposing beyond 120°C. It is observed from the results that the fire resistance quality for the mix ratio 1:2 is intermediate between that of 1:1 and 1:3. This shows that the resistance to heat depends on the amount of polyethylene plastics bonding with the sand. The results show that the sandplast blocks can hardly withstand environments with temperatures beyond 80°C. For normal ambient temperatures of under 50°C that generally prevail in the hot tropical countries where sandcrete is a common construction material, the strength and durability of sandplast will be adequate and efficient substitute for sandcrete or burnt brick.

### *3.6. Permeability and water absorption*

The results of the permeability tests are presented in Table 6 and typical water absorption curves are shown in Figure 6. From the table the average coefficient of permeability of the plastic-to-sand ratio of 1:3, 1:2 and 1:1 is 0.00218 cm/s, 0.000816cm/s and 0.00046 cm/s, respectively. These values fall within the range of medium permeability as shown in Table 7. The permeability of the sandplast block was found to increase with increasing sand-to-plastic ratio. This was due to the fact that the increased volume of sand in the 1:3 plastic-to-sand mix resulted in less binder and increased pores in the mix. Similarly, the mix ratio 1:2 contained more sand and free pores than the 1:1 ratio and consequently produced higher permeability.

The water absorption of sandplast block varies between 0.26 and 6.6 percent by weight (Fig 6). In comparison, water absorption values of sandcrete block below 7% are regarded as low, while those above 12% are high [27]. The recommended maximum value of water absorption for sandcrete block is 15% [28]. Also the water absorption of calcium silicate brick varies between 6 and 16 percent by weight [29].

The increasing volume of sand in the blocks reduces the effect of the plastic as a binder and increases the pores in the specimen. The relatively high coefficient of permeability could be attributed to increased shrinkage in the specimens since there was relatively less aggregate content which was expected to provide stability as normally obtained in normal ordinary Portland cement concrete. Therefore, non-uniform contraction results in increased shrinkage of specimen which would likely lead to micro-cracking of specimen and hence result in increased water absorption.The sandplast blocks prepared from the different mix proportions of 1:1, 1:2 and 1:3 did not show any signs of disintegration of the constituents due to the fact that the constituent materials are insoluble and inert either chemically or physically in water.

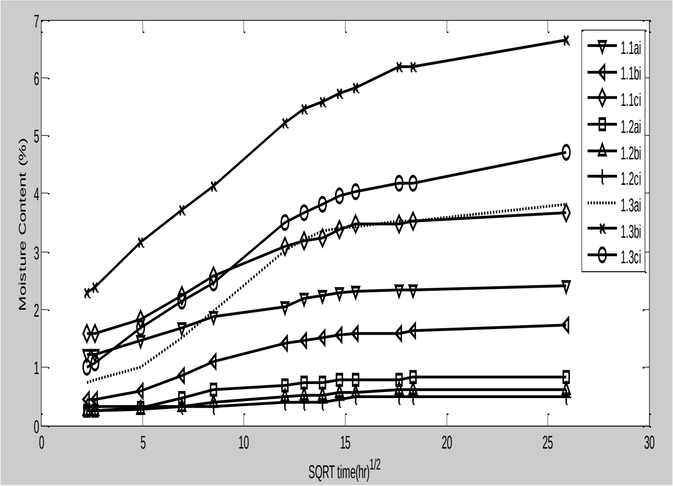

**Fig. 6**. Water absorption of different sandplast mixes (1:1, 1:2 and 1:3 are sandplast mix ratios)

**Table 5:** Observed conditions of sandplast specimens at various temperatures

| Temperature (°C) | Mix Proportion (molten plastic:sand) | | |
|---|---|---|---|
| | 1:1 | 1:2 | 1:3 |
| 60 | Visible cracks | No cracking. Samples remain intact | No cracking. Samples remain intact |
| 80 | Very hot particles started breaking off | Still intact, but very hot | Still intact, but very hot |
| 100 | Melting initiated taking place | Cracks developed | Cracks developed |
| 120 | Half of material almost melted | Melting starts | Cracks developed, but no melting |
| 125 | Completely melted | Decomposed and melted | Particles broke and melting started |

**Table 6:** Permeability of sandplast

| Specimen no. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Mix ratio | 1:1 | 1:1 | 1:1 | 1:2 | 1:2 | 1:2 | 1:3 | 1:3 | 1:3 |
| Coefficient of permeability, k $\times 10^{-3}$ (cm/s) | 0.46 | 0.388 | 0.532 | 0.818 | 0.764 | 0.877 | 2.18 | 2.158 | 2.199 |

**Table 7:** Classification of degree of permeability [24]

| Degree | High | Medium | Low | Very low | Practically impermeable |
|---|---|---|---|---|---|
| Coefficient of permeability, k | over 1000 | 10 - 1000 | 0.1 – 10 | 0.001 – 0.1 | below 0.001 |

$\times 10^{-6}$ (m/s)

## 4. Conclusions

Plastics are non-biodegradable material that constitutes a source of menace to the environment and society in several developing countries when they are disposed of indiscriminately and in a haphazard manner after they have been used. Polyethylene plastic wastes were melted and used as binder in sand in place of ordinary Portland cement to produce building blocks. Sandcrete (sand and Portland cement) blocks are commonly used in building construction in several developing countries, particularly West Africa.

Four different mix proportions of sandplast 1:1, 1:2, 1:2:5 and 1:3 (plastic-to-sand) were used to investigate the tensile strength, compressive strength, impact strength, stress-strain behaviour, fire resistance, permeability and water absorption. The optimum mix ratio turned out to be the 1:2 mix which gave the highest strength in tension, compression and impact resistance. The tensile, compressive and impact strengths of sandplast were found to be generally greater than for sandcrete. Its static modulus of elasticity which ranged from 89.0 to 311.5 $\text{kN/mm}^2$ was greater than for sandcrete. For temperatures below about 80°C sandplast blocks manufactured from sand and polyethylene remained composed and their physical properties remained useful for practical application. Sandplast was found to be insoluble in water, and did not decompose in it just like its constituent materials of sand and polyethylene plastic.

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