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The study of the effect of polyethylene and polyvinylchloride on the physico-chemical properties of Portland cement.

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ABSTRACT: *The goal of this research work is to develop a better way of handling the problems caused by the failures of cement concrete structures by forming cement-polymer composites and identifying the best composite for targeted product. Polyvinylchloride(PVC) and Polyethylene(PE) were ground into fine powder of 2.55mm mesh size and were compounded with Portland cement at various concentrations of 0.0%, 0.1%, 0.5%, 1.0%, 3.0%, 7.0% and 25.0% of pure Portland cement. Physico-chemical properties of the cement-polymer composites produced were analysed and the results obtained were compared with pure Portland cement which served as the control. The results show that abrasion resistance and hardness of the composites increased, except at some concentration while water imbibition, electrical and thermal conductivities of the composites decreased as the polymer concentrations increased. It is observed that 7.0% concentration of both polymers gave the best composites when hardness and abrasion resistance is required. 7.0% PE concentration gave the best PE composite for electrical conductivity and water imbibition while 25.0% PVC concentration gave the best PVC composite for electrical conductivity and water imbibition.*

KEYWORDS: *Composites, Concrete, Polyethylene, Polyvinylchloride, Portland cement.*

I. INTRODUCTION

The term cement was derived from the Latin word Caementum meaning anything that binds or unite two bodies together .It may be defined as powdered ceramic material which when mixed with water, sets and develops adhesive and cohesive properties that enables to bind up into a compact mass[1]. Portland cement is a hydraulic cement that when combined with water, hardens into a solid mass. Interspersed in an aggregate matrix it forms Portland cement concrete (PCC) [2].The use of cement can be traced back to Egyptian, Roman and Indian builders who used different types of cementing materials like gypsum, lime, etc, in their ancient constructions[3]. It was not until the nineteenth century that Joseph Aspdin developed Portland cement by firing limestone which contained some clayey soil to a very high temperature. This led to the production of cement with superior hydraulic properties [3] Concrete, which Portland cement is a major part of it, is made up of sand or stone, known as aggregate, combined with cement paste to bind it. The greater proportion of concrete is aggregate which is bulky and relatively cheaper than the cement. As much of the constituents of concrete come from stone, it is often thought that concrete has the same qualities and will last forever [4]. In recent years this concept has been changed. Many investigations have shown that concrete does not perform as well as it was expected due to the effect of many factors which contribute to or cause the deterioration of concrete structures [5].These factors can be due to poor manufacture or a very aggressive environment which leads to low flexural strength, low failure strain, susceptibility to frost damage and low resistance to chemicals [6]. In certain situations, these problems can be solved by using materials which contain organic polymers or resins, instead of or in conjunction with Portland cement [6]. Polymers are large class of materials consisting of small molecules (monomers) that can be linked together to form long chain, thus they are known as macromolecules. They mainly have light weight, are tough, have low modulii and high strength to weight ratio [7]. These polymers offer the advantages of high strength, improved durability, good resistance to corrosion and reduced water permeability. There are three principal classes of composite materials containing polymers. These are; polymer impregnated concrete (PIC), polymer modified concrete (PMC) and polymer concrete (PC) [8]. In this work, we reported the effect of polyethylene and polyvinylchloride on the physico-chemical properties of Portland cement.

II. EXPERIMENTAL

Materials

Dangote brand of Portland cement obtained from Eke market, Awka, Nigeria was used for this research. The polyethylene plastic bags and polyvinylchloride pipe samples were sourced from waste dumps, roadsides, gutters and streets at Awka , Anambra state, Nigeria. The PE bags were washed with water and detergent, dried and taken to a lumping machine, where they were heated to lumps. The PVC pipe samples were

also washed with water and detergent, dried and cut into smaller sizes. Both the PE lumps and PVC samples were ground separately using Ferm FMS-200 grinding machine of model: 31010 and speed: 31m/s, to fine powder of 2.55mm mesh size. Portland cement was accurately weighed in a cuboids' shaped mould using electronic balance of model: LC 120005 and the mass was found to be 756g. The weighed cement was then missed with 200ml of water in a plastic container and introduced into the cuboids' shaped mould made of wood and lined with polyethylene sheets. It was allowed to set for 24 hrs. This slab was removed from the mould and was taken to be 100% cement and served as the control. From 756g of dry cement, 0.1%, 0.5%, 1.0%, 3.0%, 7.0% and 25.0% concentrations of polymers were calculated for each cement-polymer composite and the ratio was based on pure cement. These various concentrations of the polymers were mixed with the dry cement until they were evenly distributed in the cement. Water was added in aliquots until a homogenous paste was formed. The mixing was carried out in a plastic container and care was taken to avoid over watering by maintaining an appropriate water/cement ratio. The paste was then poured into the mould. It was kept under a temperature of 25^0C for 24hrs to set. After setting, the composites were removed from the mould and cured for 2 weeks. Curing was carried out by immersing the composites fully in water to develop full strength [9]. After curing, the composites were taken out to be air dried for 2 days and kept for analysis.

Method

The following parameters were determined on the cement-polymer composites produced; electrical and thermal conductivities, hardness, abrasion resistance and water imbibitions. The electrical and thermal conductivities were determined using ASTM, (2009) method [10], the water imbibition was determined using the NIS, (2000) method [11] while the hardness and abrasion resistance was determined using ASTM, (1999) method [12].

III. RESULTS AND DISCUSSION

Table 1: The results of the physic-chemical properties of the cement-polymer composites.

Filler (%)	Polyethylene (PE)					Polyvinylchloride (PVC)				
	TC (kW/m/^{0}C)	EC (10^{-6} Sm^{-1})	H (HRC)	AR (mm)	WI (%)	TC (kW/m/^{0}C)	EC (10^{-6} Sm^{-1})	H (HRC)	AR (mm)	WI (%)
0.0	0.273	0.55	602	0.138	10.24	0.273	0.55	602	0.138	10.24
0.1	0.167	0.36	462	0.136	6.61	0.315	1.11	477	0.141	1.86
0.5	0.187	0.36	454	0.136	6.15	0.145	0.09	647	0.128	6.56
1.0	0.167	0.33	534	0.135	6.15	0.150	0.44	584	0.132	9.63
3.0	0.172	0.42	633	0.139	14.55	0.205	0.86	694	0.148	7.76
7.0	0.265	0.21	743	0.145	3.44	0.247	0.12	593	0.141	7.61
25.0	0.050	1.50	617	0.739	15.07	0.021	0.02	629	0.162	2.80

TC = Thermal Conductivity, EC = Electrical Conductivity, H = Hardness, AR = Abrasion Resistance and WI = Water Imbibition.

The results of the physic-chemical properties of the cement-polymer composites produced are shown in Table 1. The results of thermal conductivities of the cement-polymer composites are shown in Fig.1, It is generally observed that the thermal conductivities of these composites decreased as the concentration of the polymers increased. The decrease can be attributed to the positive effect of the polymers in preventing ions such as Na^+, Al^{3+}, Ca^{2+}, etc, in the cement from transferring heat energy through the openings in the cement matrix which serves as a medium for heat transfer. This is due to the good adhesion of the cement matrix to the polymer filler [13]. It is observed (fig.2) that the electrical conductivities of the cement-polymer composites decreased as the concentrations of the polymers increased, though the values for PE composites were contrary to this observation. The increase in electrical conductivities for PE- composites at high concentrations is due to the possession of free polar mobile groups at high concentrations, the polymer tends to conduct electricity appreciably at 25% concentration. PVC on the other hand tends to have low electrical conductivity at high concentration due to the presence of chlorine attached to the polymer backbone which prevents free rotation of the polymer chains [14].For hardness (fig.3), it is observed that the hardness of the composites increased when the concentrations of the polymers increased to 7% and thereafter decreased slightly. Hardness is the ability of a material to resist indentations from applied normal loads. Although cement materials have excellent hardness, they are generally brittle and this makes them easily indented when loads are applied. The polymers used acts as a binder which increases the mobility/rheology of the cement-polymer composites. The result is that there is a reduction in both entrapped and capillary voids. Increased binder content means that the individual cement

grains are in close proximity to each other resulting in a denser microstructure in the hardened composites. It is seen that 7% polymer concentration gives optimal increase in hardness of the composites before saturation effects sets in. Abrasion resistance test (fig.4) shows that the abrasion resistance properties of the cement-polymer composites increased as the polymer concentration increased until a definite concentration when the increase in polymer concentration brought about a decrease in abrasion resistance. Abrasion is the ability of a slide to wear or scratch a material [15].Materials such as cement are abraded because of the creation of entrapped voids which result when cement is molded with water and other aggregates. These voids result in cement concrete having inferior abrasion resistance. The polymers act as binders by reducing both the entrapped air and void in the cement matrix. 7% polymer concentration gives optimal increase in abrasion resistance of the composites before saturation effect sets in. It is observed (fig.5) that the water imbition of the cement-polymer composites decreased as the concentrations of the polymers increased, except for PE at 25% concentration which had a high increase in water imbibitions. Cement when mixed with water, creates entrapped voids which is a result of trapped air introduced during mixing operation. This makes the cement material to imbibe water when used in constructions under water. The polymers in the composites helps to fill the voids and pores inherent in native cement paste and so reduce the effective area over which flow can take place.7% polymer concentration gives effective decrease in the water imbibitions of the PE composites before saturation effect sets in.

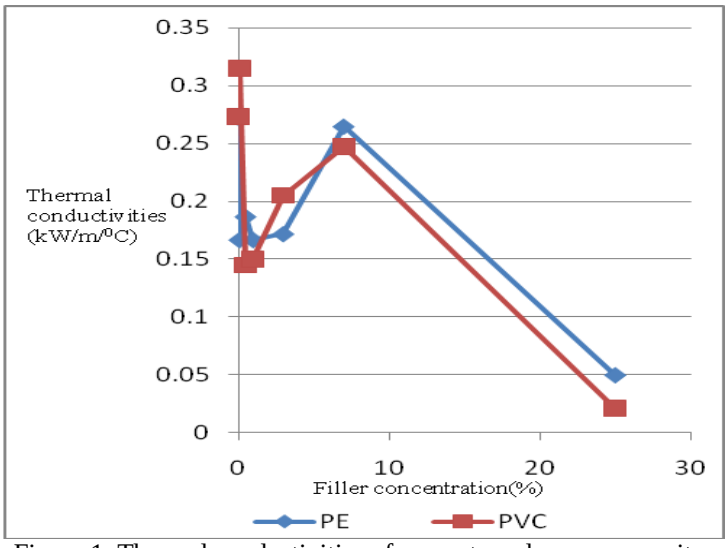

Figure 1: Thermal conductivities of cement - polymer composites

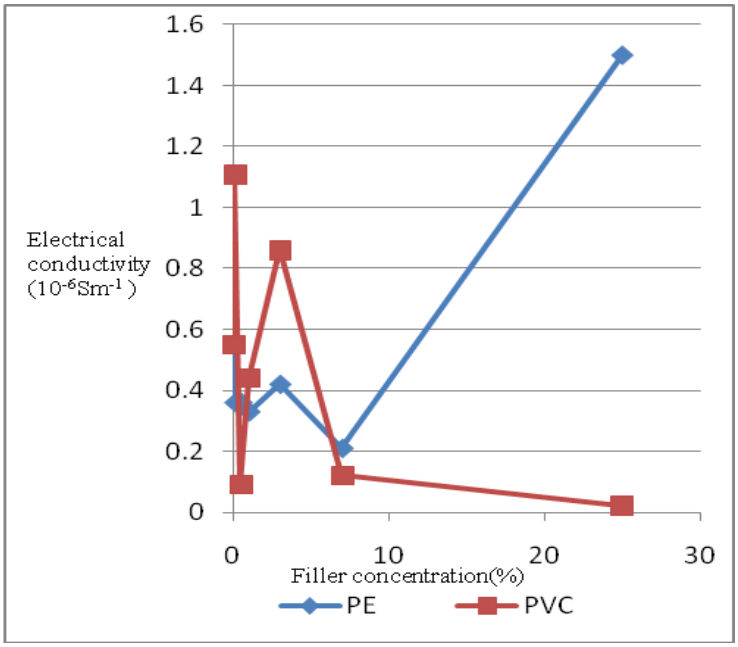

Figure 2: Electrical conductivities of Cement - Polymer composites

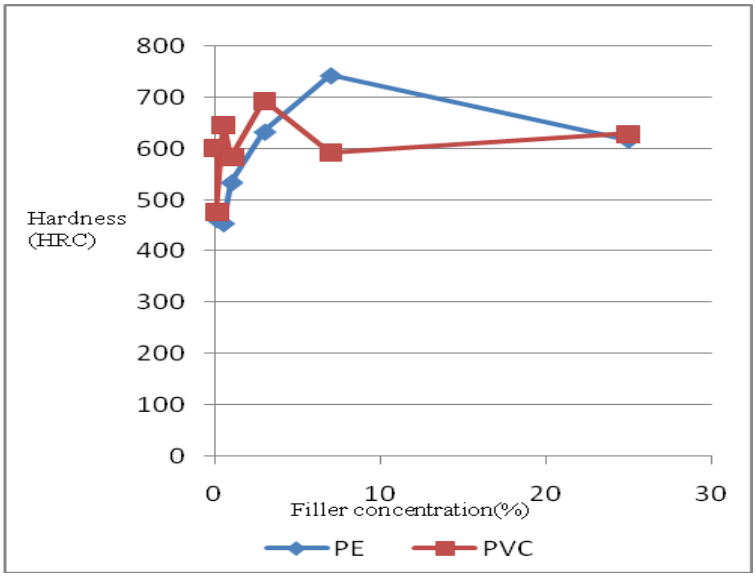

Figure 3 Hardness of Cement - Polymer composites.

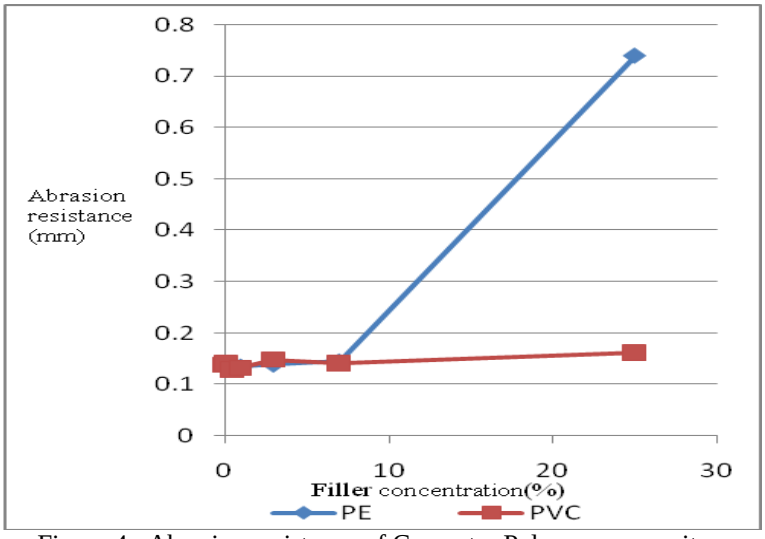

Figure 4: Abrasion resistance of Cement – Polymer composites.

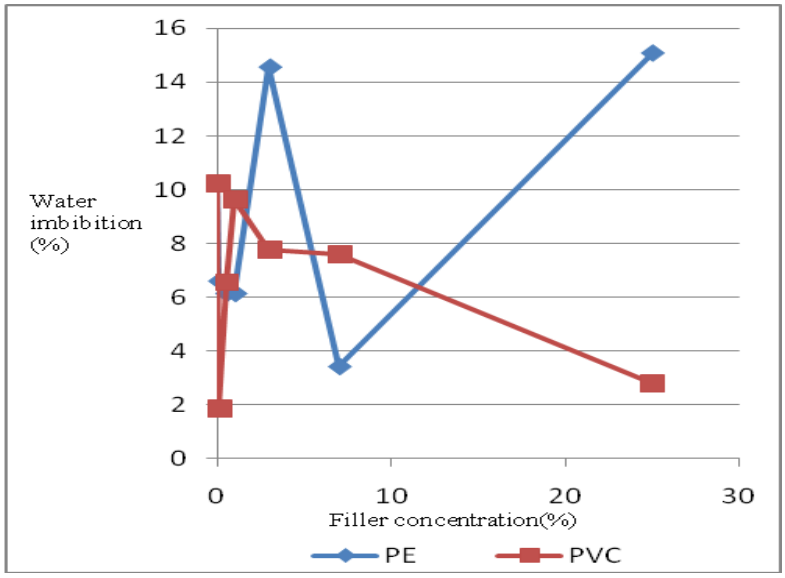

Figure 5: Water imbibition of Cement - Polymer composites.

IV. CONCLUSION

It is concluded from this investigation that 2.5mm mesh size of polyethylene and polyvinylchloride powder can be used as fillers or rein forcers for Portland cement. The results of the physico-chemical properties showed variations in properties of the cement-polymer composites produced with increasing polymer concentration. The study showed that the composites will help: in controlling heat conduction in cement buildings, in reducing electric hazards associated with cement buildings, in reducing the rate at which under water cement constructions imbibe water and in the production of cement materials that will be hard enough to resist indentation and wear and tear through abrasion at optimal polymer concentrations.

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