



(RESEARCH ARTICLE)



## Modification of concrete mortar using polyurethane resin

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### Abstract

This paper presents an experimental investigation carried out to study the effects of non-water soluble Polyurethane Resin used in the modification of concrete mortar. The non-water soluble Polyurethane Resin (PU) was obtained from Fursa Industry and Tech Limited. The non-water soluble PU was used for this study do to its availability and low cost. Additives such as; Sulphur and Calcium Oxide responsible for binding and curing were used. Concrete mortar cubes of 50 x 50 x 50 mm respectively were produced with grade 42.5 Ordinary Portland Cement from Dangote Cement Limited. The ordinary Portland Cement was partially replaced with 0% (control), 15%, 25% and 35% non-water soluble Polyurethane Resin respectively. The influence of partial replacing Ordinary Portland Cement with non-water soluble Polyurethane was checked by testing the concrete mortar cubes for compressive strength test at 7, 14 and 28 days respectively after casting and curing. It was observed that the addition of Polyurethane Resin as OPC partial replacement leads to considerable increase in compressive strength at 25% and 35% in comparison to the compressive strength of the control sample. The improvement in compressive strength was not significant beyond 35% Polyurethane replacement of OPC and was there accepted as the optimum percentage replacement

**Keywords:** Polyurethane; Resin

### 1. Introduction

Developments in civil engineering and industrial growth have created a continual demand for building materials with new and improved performance attributes. Nowadays, requirements to be met by construction materials include not only strength features but also chemical resistance, resulting from the increasing contamination of the natural environment, leading to the need to protect and increase the durability of building structures. Unfortunately, cement manufacturing consumes large amount of energy amounting about  $7.36 \times 10^6$  kJ per ton of cement (Tarun, 1996). Also, approximately 1 ton of CO<sub>2</sub> is released into the atmosphere during the production of 1 tonne of cement (Min-Hong, 2001). Thus partial replacement of Portland cement in mortar / concrete with Polymer.

Polymer modified concrete is an innovative and modern material that satisfies all the strict requirements of durability and chemical resistance, while offering high mechanical strength. On the other hand all efforts are made in other to reduce demand on cement as a result of the enormous amount of carbon dioxide release during manufacturing. It has been estimated that the manufacturing process of OPC produce 7% of the global CO<sub>2</sub> emission (Suleiman et al, 2012). This trend is adding 1.6 billion tons of CO<sub>2</sub> into the atmosphere (Mehta, 2003).

Concrete mortar made with Ordinary Portland cement has been a popular construction material in the world for the past 170 years or more. However, due to the low tensile strength, delayed hardening, high drying shrinkage, and low

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chemical resistance, this study focuses on how to reduce these disadvantages by partial replacement of Ordinary Portland Cement with non-water soluble polyurethane resin. This can be achieved by investigating the impact of non-water soluble polyurethane on the compressive strength of concrete mortar and the mortar's water absorption, when used as partial replacement of ordinary Portland cement. Due to its excellent bonding ability, high workability and high resistance to aggressive environments, Polymer Modified Concrete finds applications in overlays of industrial floors and rehabilitation of deteriorated bridge decks. Non-water soluble polyurethane resin was obtained from Fursa Tech and Industry, Abuja Nigeria.

### 1.1. Aim and Objectives

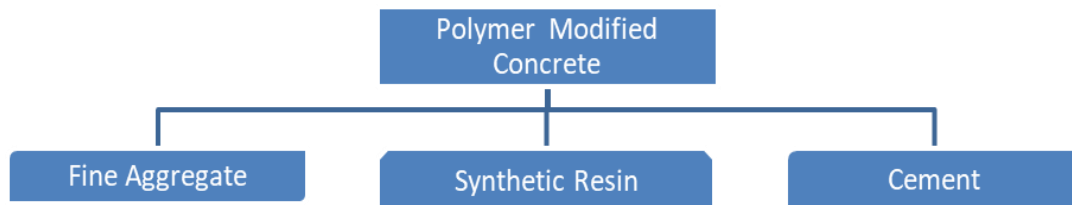
The aim of this research was to investigating the effects of non-water soluble Polyurethane Resin used in the modification of concrete mortar. The objectives of the study includes:

- To determine the impact of non-water soluble polyurethane resin on the compressive strength of concrete mortar.
- To determine the optimum partial replacement of ordinary Portland cement with non-water soluble Polyurethane resin in concrete mortar

## 2. Material and methods

### 2.1. Materials

The grade 42.5 Dangote Ordinary Portland cement was sourced here in Abuja and used for the study. The study was performed using Polyurethane resin non-water soluble purchased from Fursa Tech and Industry Limited, Abuja. Binding and curing additives were also purchased from Aba Market, Abia state Nigeria. Fine aggregate used was river sand and passed through sieved 2mm and retained in 90 microns sieve.



Aggregate mixture: Including a hardener responsible Ordinary Portland Cement  
Sand passing sieve 2mm for binding and curing time

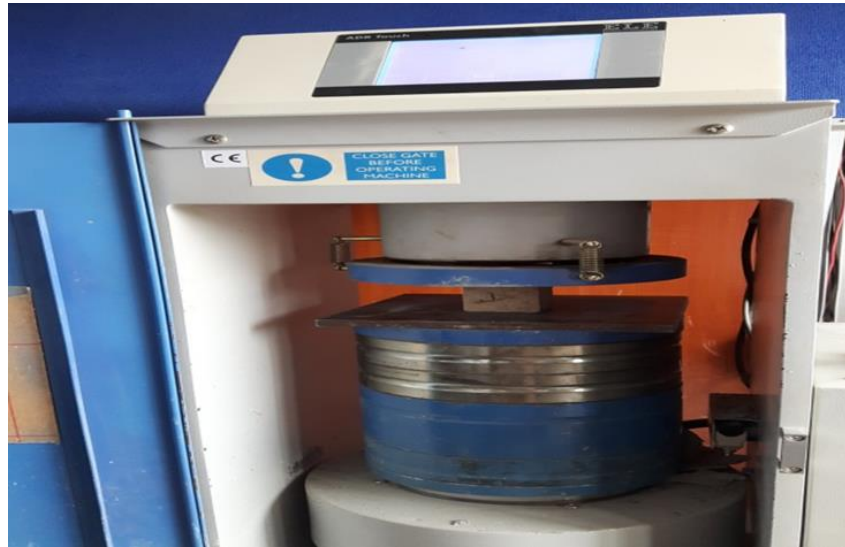
### 2.2. Preparation of Mortar Cubes

Previous research by Chmykov (2005) established 35% as the optimum PU resin content that produce optimum compressive strength of concrete. In this study, the compressive strength of concrete mortar for up to 35% Polyurethane partial replacement of ordinary Portland cement was investigated. Eight blended Polyurethane modified mortar cube in 50mm x 50mm x 50mm sized moulds were prepared in the order of 0%, 15%, 25% and 35% by mass of polyurethane. 35% water to Polyurethane resin/ordinary Portland cement binder by mass used. For all the mixes 1:6 mix ratio of binder to fine sand was used.

Water was added and mixed until the mixture is of uniform color. The mixing lasted about 3 minutes. Immediately after mixing, the mortar was poured into the cube mould and prodded with the help of the rod. The mortar was prodded 20 times in about 8 sec to ensure elimination of entrained air. Then the cube moulds were allowed to cure at room temperature of  $27 \pm 2^\circ \text{C}$  and 90% relative humidity for 24 hours. After 24 hours the cubes were removed from the mould and immediately submerge in clean water till testing. The cubes were subjected to a uniform loading at the rate of 2.4kN/sec. Test was conducted for 3 cubes and recorded the average value as the test result for 7 days, 14 days and 28 day compressive strength. The summary of mix proportion for each cement mortar is presented in Table 1.

**Table 1** Experimental Design

Mix (%)	Water (g)	Sand (g)	OPC (g)	PU (g)
0	120	1062	211	0
15	120	1062	180	31
25	120	1062	160	51
35	120	1062	140	71

**Figure 1** Compressive Strength test on mortar

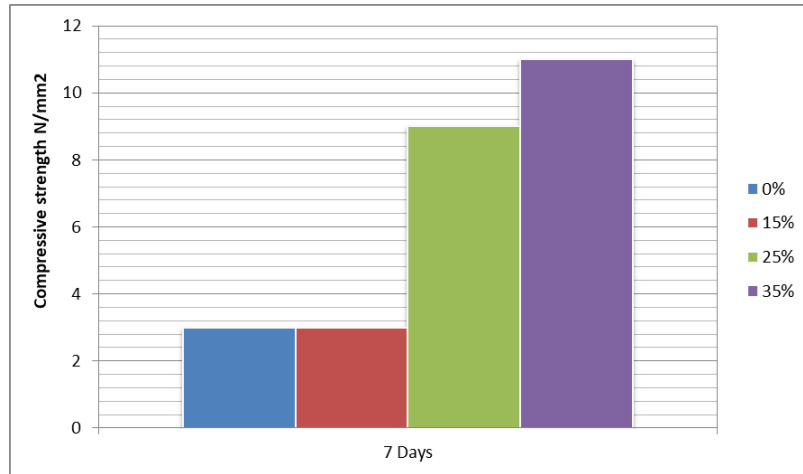
### 2.3. Compressive Strength Test

The prepared specimens were cured for 7 days, 14 days and 28 days each and were tested for compressive strength, according to BS 1881-116:1983 using universal testing machine as shown in Figure 5. Three samples of each category (Table 2) were prepared and the stress at failure was measured

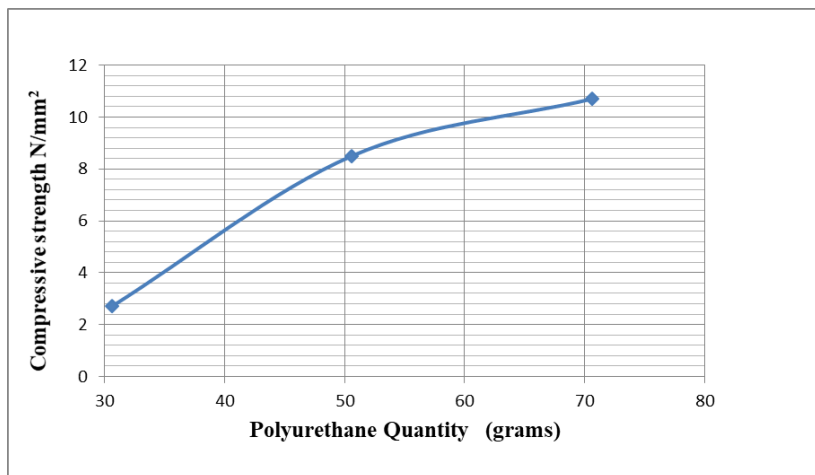
## 3. Results and discussion

### 3.1. Compressive Strength Test

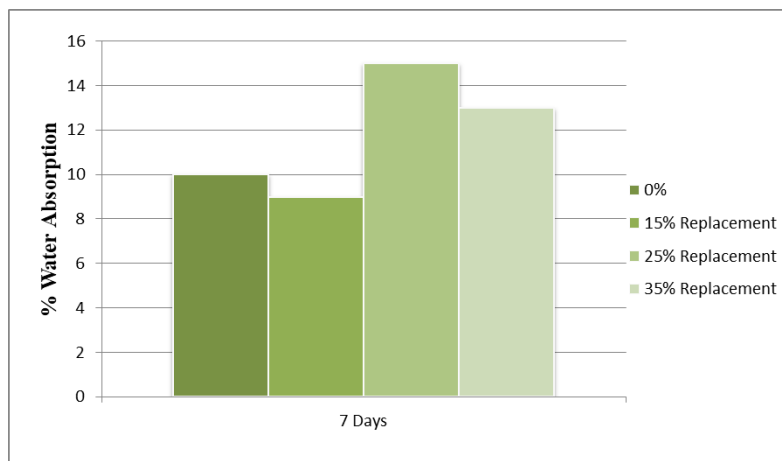
The compressive strength of Polymer modified as listed in table 2, has been graphically presented in figure 2. All the mixes for 15% PU replacement of OPC at 7 days compressive strength, no PMC achieved maximum strength compared to the 0% (control sample) that had 3 N/mm<sup>2</sup>. Test results showed that the 7 days compressive strength of 25% PU replacement of OPC rose to 9 N/mm<sup>2</sup>, higher than the 0% (control sample) at 3N/mm<sup>2</sup>. Similar trend was observed for 35% replacement. The maximum compressive strength of 11N/mm<sup>2</sup> was attained at 35% Polyurethane replacement of OPC. This trend shows that the addition of PU as partial replacement of Ordinary Portland Cement has negligible effect on the compressive strength of mortar at 15%. However, at higher percentage replacement beyond 15%, the compressive strength for all the mixes are higher than the control samples. These results further confirm the similar previous studies which concluded that Polyurethane resin of hydrophobic class, when mixed with concrete increases its compressive strength significantly [2]



**Figure 2** Percentage Replacement of PU Resin in OPC at 7 Days



**Figure 3** Compressive strength vs quantity of PU



**Figure 4** Water Absorption

#### 4. Conclusion

Based on the results of the investigation conducted on different PU modified mortars made with various level of cement replacement and cured for 7 days period, the following conclusions can be drawn. The use of non-water soluble polyurethane resin for the replacement of ordinary Portland cement in concrete mortar was found to increase the compressive strength with increase percentage replacement

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#### Compliance with ethical standards

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##### *Disclosure of conflict of interest*

Authors declare that they do not have conflict of interest.

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