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Studying the Effects of Latex on Compressive Strength of Concrete

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ABSTRACT
This work studied the effects of Latex on Compressive Strength of concrete. The related research works were reviewed before embarking on this work for better understanding. The mixing ratio used was 1:2:4 with water cement ratio of 0.55. Concrete samples were modified at different percentages of latex varying from 0% (control), 2.5%, 5%, 7.5%, 10%, 12.5%, and 15% of the cement constituent. Workability and Compressive Strength of modified Concrete samples were determined. The workability or slump values varied between 10mm and 61mm. The Compressive Strengths were determined at 7, 14, and 28 days of curing. The Compressive Strengths obtained range between 9.10N/mm^2 and 14.00N/mm^2. The Compressive Strength of Latex modified Concrete increased as the latex content and curing ages increase. The results obtained from the tests carried out show that latex improves Workability and Compressive Strength. Latex is recommended as admixture to improve Concrete performance in relation to Workability and Compressive Strength.
KEY WORDS: Improving, Compressive, Strength, Concrete, Latex, Workability

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I. INTRODUCTION

One of the most widely used material is concrete (Sanjith *et al*., 2015). It is a combination of cement, sand (fine aggregate), granite/gravel (coarse aggregate) and water in a designed proportion (Sanjith *et al*., 2015). Concrete has undergone revolution in term of its constituents which has brought increase to its strength performance, this has made normal strength concrete (NSC) to be developed to high strength concrete (HSC) (Paper, 2018).

In recent years the use of polymer in concrete is being enriched by the researches. By the use of polymer, the permeability of concrete can be reduced, workability could be improved and other characteristics can be enhanced to greater extent. Polymer latexes are being increasingly used in the construction industry as modifiers, especially in hydraulic cement concrete and mortar (Paper, 2018).

Portland cement concrete has many desirable properties which allows innovate designs to be carried out on it. It has high compressive strength and weak tensile strength, its weak tensile strength has limited its use. Introducing latex into concrete improves both compressive and tensile strength of concrete (Paper, 2018). latex is defined as a form of polymer system, and it generally consists of a water emulsion of a synthetic plastic or natural rubber (Chynoweth, 1984). The addition of a latex to a shotcrete mixture installs a new set of mechanical properties to the shotcrete and improves its performance as a repair material. In general, Latex Modified Shotcrete is more durable than conventional shotcrete and its improved bond and flexibility makes it a more desirable repair material (Chynoweth, 1984). The Para rubber which is the only tree that can produce the natural rubber latex. The term latex is nothing but a polymer with water-based liquid (Aswathi *et al*., 2017)

Latex was obtained from Hevia Brasiliensis, commonly known as rubber tree. Most rubber trees grow to a height of 50 feet. They require climates that have annual rainfall of about 90 inches and temperatures of about 80^{0}F. Today researchers at the Malaysian Rubber Institute are trying to develop trees with "fatter" stumps to produce more latex (Patel, 2013). Rubber is one of the Agricultural products (cash crop) that Nigeria is known for. The major rubber producing states in Nigeria come from the southern part of the country, where high rainfall is being experienced, although it is also being grown in Abia, Anambra, Akwa Ibom, Rivers, Ebonyi and Bayelsa, it is commercially being grown in Ondo, Edo, Ogun, Delta (Sapele) and Cross River state (Khabet, 2009). It is harvested from the Para rubber tree in the form of latex and others. The rubber tree has a milky sticky secretion, which is obtained as latex, which can be harvested by tapping the rubber tree in a harmless

manner. Due to the solidification of rubber when exposed to air, thin layers of the tree's bark is cut downwardly through the latex vessels where the rubber flows from to the tree trunk in a half spiral, the spiral allows a free flow of the latex to a collecting cup. This is carried out in the early hours of the morning or in the night before the rise in temperature as to allow the latex drip longer before coagulating (Anson, 2001).

Concrete has been modified with different materials by various researchers, among them are;

Kim (2003) studied the properties of polyvinyl alcohol (PVA) modified mortar and concrete with up to 2% polymer by weight based on cement and compared the structure and properties of polymer modified concrete with those without polyvinyl alcohol. The interfacial transition zone and fractured surface were examined with both polarizing optical microscopy and scanning electron microscopy. He concluded that poly vinyl alcohol modified mortar showed slower absorption of water as compared to the unmodified mortar, which was an indication of lower permeability of the latex modified mortar.

Muthukumar and Mohan (2005) studied the mechanical properties and chemical resistance of Furan based latex concretes and concluded that they were cost effective materials for construction in Civil Engineering applications.

Aggarwal *et al* (2007) studied the properties of latex modified mortars using epoxy and acrylic emulsion, and found that these materials had superior strength properties and better resistance to the penetration of chloride ions and carbon dioxide than PMCs based on vinyl acetate, copolymers of vinyl acetate–ethylene, styrene–butadiene, styrene–acrylic, and acrylic styrene butadiene rubber emulsions.

Ray *et al*, (1994) worked on effect of latex and superplasticizer on Portland cement mortar in the fresh state and concluded that water requirement is significantly reduced when Portland cement mortal is modified with latex.

Aswathi *et al*, (2017) studied effect of Natural Rubber Latex as admixtures in concrete. It was concluded that Natural rubber latex increases the strength of normal strength concrete up to 0.9%

II. MATERIALS AND METHODS

MATERIALS

The following materials were obtained and used for this research work:

Fine Aggregate**:**

Locally available river sand was used as fine aggregate. It was got from a local supplier in Ado Ekiti, Ekiti State. This forms a filler for the concrete.

Coarse Aggregate**:**

Granite of 20mm was used as coarse aggregates. It was got from a qurry in Ikere- Ekiti, Ekiti State. Coarse aggregate and Fine aggregates form 75% of the total weight of the concrete.

Cement:

Dangote Ordinary Portland cement of 42.5 grade was used for this project. It was got from local supplier at Ado Ekiti. Cement is the “glue” that binds the concrete ingredients together and is instrumental for the strength of the composite (Henry, 2001).

Latex:

It was obtained from Hevia Brasiliensis, commonly known as rubber tree. It was got from Oghara Efe, Delta State, Nigeria. Ammonia was added to it to keep it in liquid form

Water

Water is an important ingredient of concrete as it actively participates in chemical reaction with Cement. Potable water was generally considered as being acceptable. It was got from local supplier in Ado Ekiti, Hence, clean drinking water available was used for casting as well as curing of the test samples (Russel, 2005).

Ammonia

Ammonium hydroxide, also known as ammonia water, ammonia solution, ammoniacal liquor, ammonia liquor, aqua ammonia, aqueous ammonia, or ammonia, is a solution of ammonia in water. It was got from local supplier in Ado Ekiti. It is also a Cementous material (Roy, 2005). It was added to the latex in order to maintain its liquid form.

III. METHODS

Slump Test

This was done to measure or determine the workability of latex-modified concrete before it sets. It was done according to the prescriptions of ASTM C143-05a. It can also be used as an indicator of an improperly mixed batch. It was carried out at Civil Engineering department, Federal Polytechnic of Ado Ekiti.

Compressive Strength Test

Compressive strength is the ability of material or structure to resist impose loads on its surface without any crack or deflection. It was carried out on hardened conventional and latex modified concrete in accordance with BS 1881-116 [1983]. It was done at different levels of modifications with latex content varying from 0% (control), 2.5%, 5%, 7.5%, 10%, 12.5%, and 15% of cement constituents and corresponding strengths were determined at 7, 14, and 28 days of curing. It was performed at Civil Engineering department, Federal Polytechnic of Ado Ekiti.

Compressive Strength $= \frac{\text{load}}{\text{cross sectioal area}} N/mm^2$ (Chen, 2001).

IV. RESULTS AND DISCUSSION

SLUMP TEST

The Table 1 and Figure 2 below show the slump values of conventional Concrete and Latex Modified Concrete. The addition of latex increases the workability of concrete with positive effect on the strength. This shows that Latex is a suitable admixture that improves the concrete workability. The latex content makes the concrete suitable not just for blinding work but for mass concrete, light and heavy reinforced types of construction.

Table 1: Slump Values of concrete and latex modified concrete

Latex (%)	Slump Value (mm)	Degree of workability	Types of Construction (IS 1199)
0	10	Very low workability	Blinding concrete
2.5	20	Very low workability	Blinding concrete
5	32	Low workability	Mass concrete, lightly reinforced concrete
7.5	38	Low workability	Mass concrete, lightly reinforced concrete
10	43	Low workability	Mass concrete, lightly reinforced concrete
12.5	52	Medium workability	Heavily reinforced section: Bean, Slab, Column, Wall, etc
15	61	Medium workability	Heavily reinforced section: Bean, Slab, Column, Wall, etc

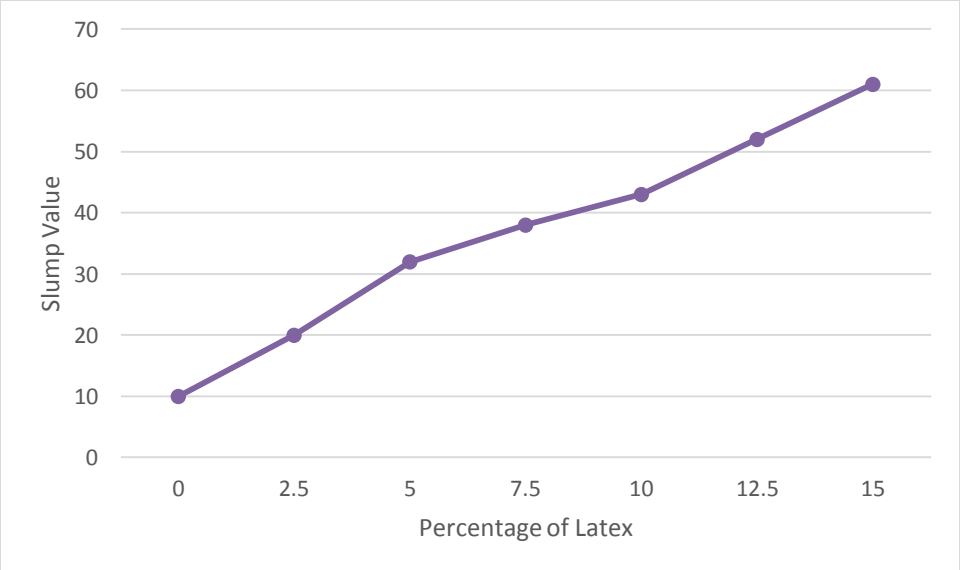

Fig: 2. Slump values of concrete and latex modified concrete

COMPRESSIVE STRENGTH

Concrete samples were modified using latex at different percentages from 0%, 2.5%, 5%, 7.5%, 10%, 12.5% and 15%. These modified samples were cured and tested for compressive strength at 7 days, 14 days and 28 days of maturity. The results obtained show that as the percentage of latex increased, the compressive strengths increased. In addition, there exist a direct relationship between the compressive strengths obtained and the curing ages. These results are as shown in Table 2 and Figure 3. These compressive strength results show that latex improves the strength property of concrete, there exit in latex concrete strength aiding agent. It must be stated here that latex is a suitable admixture in concrete production and it must be added during concrete mixing. Latex has a binding nature; it is suggested here that its cementitious nature be looked into in the future research work.

Table 2. Compressive Strength of Concrete and Latex Modified Concrete

COMPRESSIVE STRENGHT			
Latex (%)	**7days Crushing Strength (N/mm^2)**	**14days Crushing Strength (N/mm^2)**	**28days Crushing Strength (N/mm^2)**
0	**9.1**	**9.2**	**9.3**
2.5	**9.9**	**9.7**	**10**
5	**10.2**	**10.6**	**10.8**
7.5	**11.0**	**11.2**	**11.6**
10	**11.7**	**12.0**	**12.5**
12.5	**12.7**	**12.9**	**13.1**
15	**13.6**	**13.9**	**14.0**

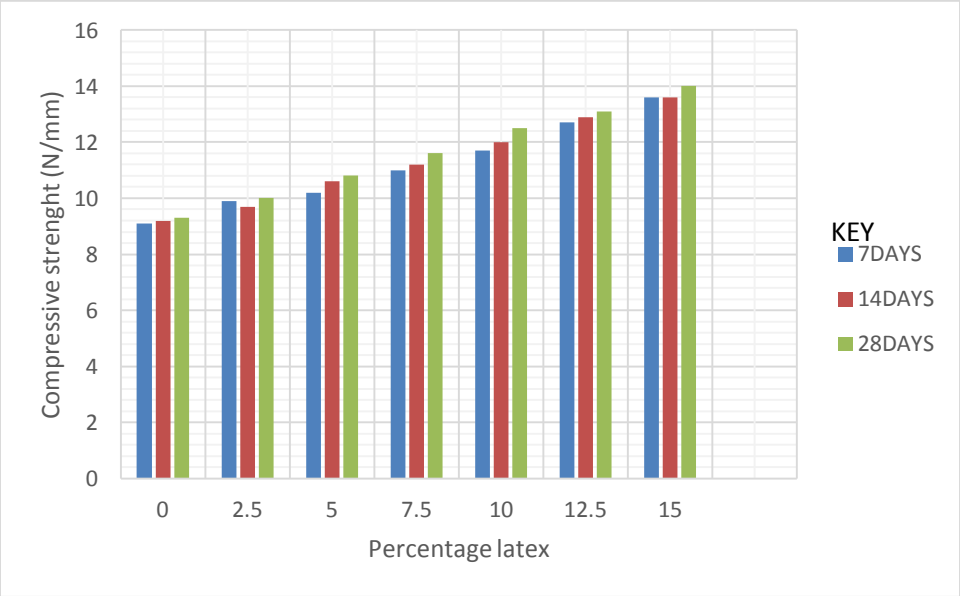

Fig. 3 Compressive values of concrete and latex modified concrete

V. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following conclusions are drawn based on the result obtained:

- addition of latex increased the slump values of the concrete.
- It improves the construction values of concrete
- addition of latex increased compressive strength; the percentage increase varied according to the curing ages. The percentage increases are 5.05%-33.08%, 5.15%-33.81% and 7%-33.6% for 7, 14 and 28 days respectively

Recommendations

The following are recommended:

- Latex is recommended for use in concrete as an Admixture in order to improve its performance in relation to workability and compressive strength.

- Addition of 15% of latex to modified concrete is recommended
- Percentage of latex greater than 15% is recommended for future research work.
- Addition of latex reduced water requirement of concrete
- The cementitious nature of latex should be studied in future research work
- Plantation of rubber latex should be encouraged individual and government so as to generate employment and income

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