EFFECT OF NEEM GUM POWDER ON DURABILITY PROPERTIES OF CONCRETE

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ABSTRACT

This study investigates the influence of neem gum powder (NGP) as a natural admixture on the durability and microstructural properties of grade 20 concrete. The durability of concrete structures in aggressive environments is a persistent challenge in civil engineering, often leading to reduced service life and increased maintenance costs. This research is aimed at enhancing concrete's resistance to chemical attack by introducing neem gum powder as an admisture. Neem gum powder was incorporated into fresh concrete mixes at varying dosages of 0.2%, 0.4%, 0.6%, 0.8%, 1.0%, and 1.2% by weight of cement. The methodology included durability evaluation through immersion of concrete cubes in 1% and 5% sulfuric acid (H_2SO_4) solution for 90 days, and microstructural characterization using visual and microscopic analysis. Results indicated that acid resistance decreased with increasing NGP dosage, with weight loss rising from 15.69% in the control mix to 25.67% at 0.4% NGP addition. However, the microstructure revealed that pore spaces initially decreased with NGP addition, reaching optimal densification at 0.4%, beyond which pore spaces increased. Based on these findings, it is recommended that NGP be used at a dosage not exceeding 0.4% to improve microstructure without compromising durability in acidic environments.

Keywords: Neem Gum Powder; Durability; Microstructural Effect; Acid Resistance

1 INTRODUCTION

Concrete remains the most widely used construction material globally, including in Nigeria, due to its versatility, strength, and availability. However, growing infrastructural demands, environmental concerns, and the need for durable construction materials have driven research into the use of natural and sustainable additives to improve the long-term durability and microstructural performance of concrete [1]. Particularly in tropical environments, durability issues such as sulphate attack, acid degradation, permeability, and microcracking often compromise the lifespan and structural integrity of conventional concrete [2, 3]. In recent years, the integration of natural admixtures and agro-based materials into cementitious systems has gained attention as a sustainable approach to enhance concrete durability. Gum-based biopolymers such as Gum Arabic have demonstrated water-reducing capabilities, improved bonding, and better resistance to chemical attack, leading to enhanced concrete performance in aggressive environments [4]. Similarly, powdered additives from Neem tree by-products, including Neem seed husk ash, have shown promise as pozzolanic materials that contribute to long-term strength and sulfate resistance due to their reactive silica and alumina content [5, 6]. Building on these insights, Neem gum powder, derived from Azadirachta indica, presents a largely untapped natural resource with potential to function as an organic admixture in concrete. Preliminary compositional analysis of Neem gum powder conducted in this study indicated a significant presence of silicon dioxide (SiO_2), calcium oxide (CaO), and aluminum oxide (Al_2O_3), which are well-known contributors to cement hydration and durability development [7]. SiO_2 improves matrix density and reduces permeability; CaO enhances strength development; and Al_2O_3 contributes to setting time acceleration and chemical resistance [8, 9]. Additionally, the gum's organic matrix may play a role in modifying the microstructure by filling pores or altering hydration pathways. Microstructural examination using Scanning Electron Microscopy (SEM) has become increasingly vital for evaluating the internal morphology of cement composites and understanding the distribution and formation of hydration products. Natural admixtures such as Neem gum are hypothesized to refine pore structure, increase compactness, and influence the formation of C-S-H gel, thereby improving both mechanical integrity and chemical resistance [10, 11]. Durability, on the other hand, is a function of both chemical composition and internal microstructure. Therefore, understanding how Neem gum affects both becomes critical to determining its viability as a sustainable admixture. Several studies have investigated natural and industrial waste admixtures like rice husk ash, groundnut shell ash, coconut shell ash, and fly ash, reporting improved resistance to sulphate and acid attacks, reduced chloride penetration, and better microstructural densification [12, 13]. However, limited attention has been given to Neem gum powder, particularly in relation to its durability performance under aggressive media and its influence on concrete microstructure. Therefore, this study aims to evaluate the durability properties of concrete incorporating Neem gum powder with particular focus on resistance to acid as well as sulphate attack. Furthermore, microstructural characteristics are analyzed using Scanning Electron Microscopy (SEM) to assess the impact of Neem gum on pore refinement, matrix densification, and hydration product morphology. The goal is to determine the potential of Neem gum powder as a cost-effective and eco-friendly admixture for enhancing the longevity and resilience of concrete structures, particularly in corrosive or tropical environments.

2 MATERIALS AND METHODS

2.1 Materials

Cement: The cement used in this study is regular Portland cement called Dangote 3X, with a strength grade of 42.5N. It was made by Dangote Cement Plc and bought from a local dealer near the Gyadi-Gyadi roundabout in Kano.

Fine Aggregate: The fine aggregate used in this study is river sand collected from the Challawa River in Kano State.

Coarse Aggregate: The coarse aggregate used is crushed granite with a maximum size of 20 mm. It was sourced from a quarry in Bunkure Local Government Area, Kano State.

Neem Gum: Neem gum was collected from neem trees (Azadirachta indica species) found within the Yola metropolis in Adamawa State, Nigeria.

Water: Clean, drinkable water that meets the required standards [14] was sourced locally in Kano and used for mixing and curing the concrete cubes in this study.

2.2 Methods

2.2.1 Neem Gum Powder

Neem gum from neem trees was collected and air-dried at room temperature for three days to lower its moisture content from 30% to 10%. After drying, it was ground into powder using a mortar and pestle, then passed through a 75 μm sieve.

2.2.2 Durability Test

Concrete cubes cured for 90 days was used to carried out the test. The samples was immersed in concentrated Sulphuric acid solution (H_2SO_4) of 1%:5% concentration for 90days. The samples cubes cured for each percentage addition of Neem gum was taken, air dried and weighed before being immersed in

H_2SO_4 solution. The resistance of concrete containing each percentage of Neem gum to the acidic solution was determined in terms of the weight retained after its immersion in H_2SO_4 in accordance with [15].

2.2.3 Microstructural Effect of Nem Gum Powder on Concrete

Crushed concrete was used to determine the effect of the load impacted on it. Normal Concrete and concrete with optimum percentage of neem gum were used to understand the micro-structural effect of the neem gum in concrete.

3 RESULTS AND DISCUSSION

3.1 Durability Test Result of NGP Concrete

The durability of the concrete was determined and the effect on Neem Gum Powder as an admixture in the concrete is presented in the Figure 1. The results show the weight of concrete retained decreased with increase in NGP content. In case of the control mix there was about 15.69% reduction in weight of the concrete and 25.67% reduction in NGP concrete of 0.4% addition. The observed trend showed that NGP concrete have no better resistance against acidic solution. At 1.0 % and 1.2 % addition of NGP, the concrete disintegrates when placed in the cured tank as shown in Figure 2, making the concrete unsound. This could be attributed to the presence of Potassium Oxide and chlorine at these percentages in the concrete which leads to the formation of alkaline that weaken the concrete constituent bond.

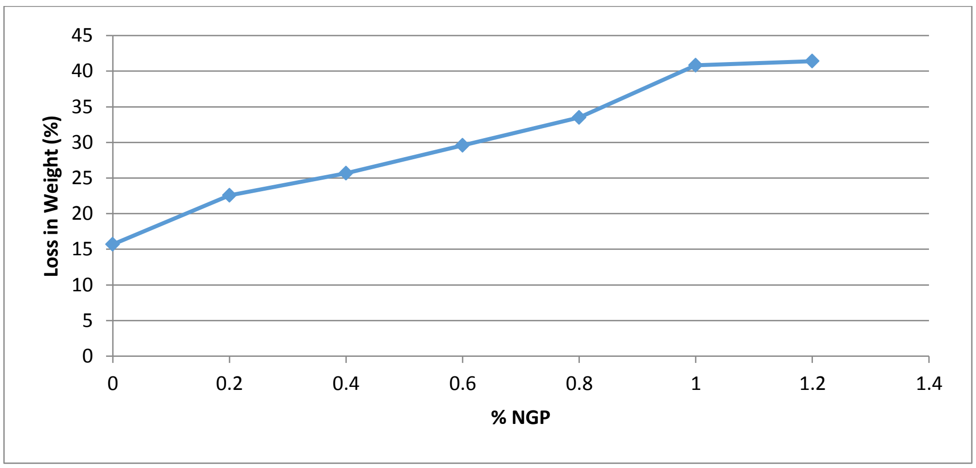

Figure 1. Durability Test Result

Figure 2. Disintegrated concrete cubes with NGP content of 1% and 1.2% during curing

3.2 Microstructural Effect of NGP On Concrete

From the results of the scan electron microscopy presented in Fig 3 to 9, it was observed that the pore spaces of the concrete decreases with an increase in the Neem Gum Powder (NGP) content and subsequently above the optimum addition of 0.4%, the pore spaces started increasing. This could be attributed to the higher alkali content in mixes with higher NGP content, which is in agreement with [16], who found out cement pastes with high alkali content to be more porous. However, this did not affect the compressive strength of the Concrete at later ages. This could be due to the effect of SiO_2 and CaO contained in the powder, which counteract the effect of alkalis and sulphate on portland cement system as established by [17].

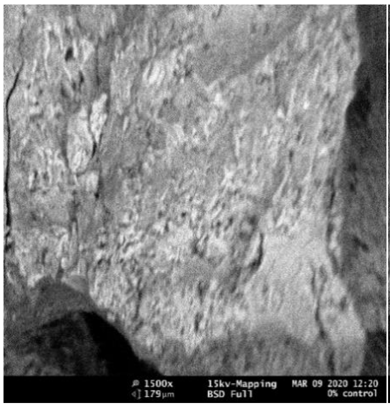

Figure 3. 0% NGP

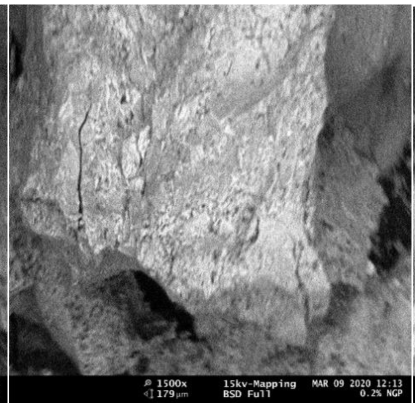

Figure 4. 0.2% NGP

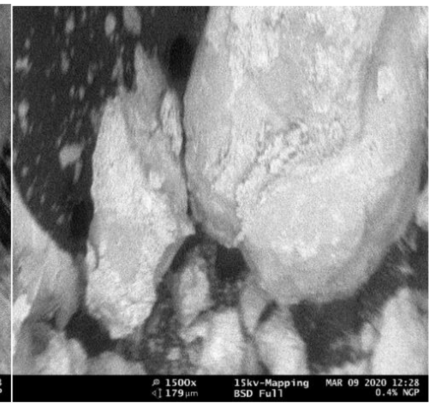

Figure 5. 0.4% NGP

Figure 6. 0.6% NGP

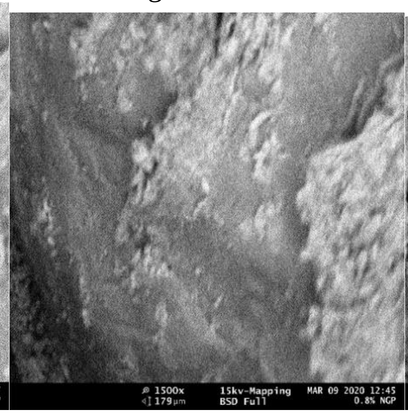

Figure 7. 0.8% NGP

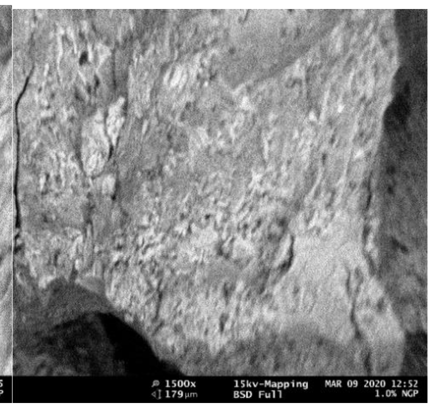

Figure 8. 1.0% NGP

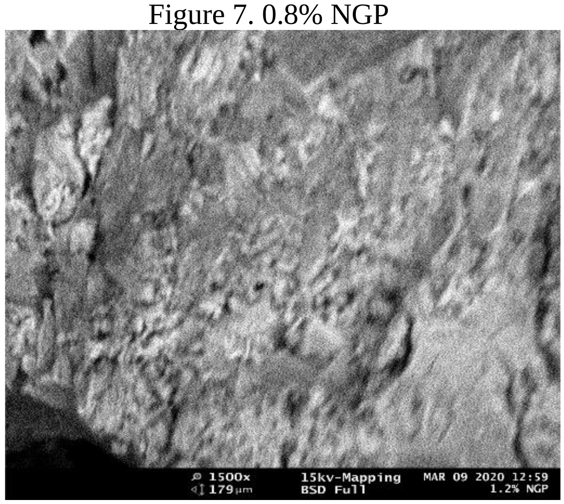

Figure 9. 1.2% NGP

4 CONCLUSIONS

The effect of neem gum powder as an admixture in the durability properties of concrete was investigated on grade 20 concrete and the following conclusions were made; that: Neem Gum Powder can be classified as a mineral admixture with a combined SiO_2, Al_2O_3 and Fe_2O_3 percentage of 45.78 %. Above 1.0% of the neem gum powder in the concrete, the cured cubes disintegrate due to the presence of potassium oxide and sulfur trioxide in the powder. Percentage of Loss of weight of the concrete increases with increase in the Neem Gum powder. The powder has no positive effect on the durability of the concrete. The addition of neem gum powder has decreased the porosity of the microsture of concrete at 0.2 -0.4 % increment, but from 0.6%-1.2% increment, the pore spaces in the concrete increase.

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