Cogent Engineering
Volume 8, 2021 - Issue 1

Submit an article Journal homepage

CIVIL & ENVIRONMENTAL ENGINEERING

Permeable pavements for storm water control incorporating nano clay

Busari Ayobami

,Ndambuki Julius

,Sadiku Emmanuel

,Jacques Snyman

,Kupolati Williams

,Amu Olugbenga

Marinella Giunta

Article: 1817254 | Received 22 Apr 2020, Accepted 07 Aug 2020, Published online: 06 Jul 2021

- https://doi.org/10.1080/23311916.2020.1817254

In this article

- Abstract

Formulae display: MathJax ?

Stormwater affects the economic situation of the environment, changes the land use, which also affects the ecosystem. Consequently, this affects the pavement condition of the road and lead to both structural and functional pavement defects. In a bid to proffer solution to the harmful effects of stormwater and reduce the cost of pavement construction in track with sustainability, this research utilized nano clay in the development of permeable concrete. The nano clay was used as a partial replacement for cement. It was dehydroxylated at 720°C; the characterization and particle geometry was done using the XRF equipment. The de-hydroxylated nano clay was used as a partial replacement for cement at 5, 10, 15, 20 and 25%. Correspondingly, six samples of concrete were developed. The mechanical properties (compressive and flexural strength) of the permeable concrete was assessed at 3, 7, 14, 21 and 28 days. Additionally, the porosity of the concrete was determined using Archimedes principle. The result of the research showed that using nano clay replacement at 15% gave a flexural strength of 4.01MPa. This is lower than the required specification of 4.27Mpa—4.5MPa for pavement construction at 28 days and 4.5Mpa and above for airfield pavement. The porosity test using Archimedes principle showed a satisfactory result. This proves the efficiency of the concrete for stormwater control. Therefore, this concrete is recommended for use in the design and construction of low axle or low trafficked road for stormwater control and aquifer recharge based on the flexural strength.

Keywords:

sustainable roadspermeable concretenano claytransportationporosityConcrete

1. Introduction

The negative effect of stormwater is encompassing. It can destroy properties and harm the life of man and animal through the impact of storm surge. This could also be in the form of snow or heavy rainfall. It affects the economic situation of the environment, changes in land use which also affects the ecosystem. Consequently, this, to a large extent, affects the pavement condition of the road and leads to both structural and functional pavement defects. In a bid to proffer a solution to this problem, the permeable pavements were developed as a form of open-graded road.

Permeable pavements are also known as porous or pervious, gap-graded or enhanced porosity concrete pavements; it originated in Europe about four decades ago (Ghafoori & Dutta, 1995a, 1995b, 1995c). The first construction was like a form of grass or open aggregate

pavements. Other developments involved the use of concrete technology (ACPA: American Concrete Pavement Association, 1999; Ghafoori & Dutta, 1995a). The research of Hein and Smith (2011) avowed that interlocking concrete block pavers were also adopted in the design of this special type of pavements. The most popular application of this type of concrete is in the design and construction of roads. However, some researcher has used it as a structural material in the construction industry. Other applications of this concrete involve the construction of parking lots, sidewalks, pathways, tennis courts, patios etc.

From the environmental perspectives, Brattebo and Booth (2003), Collins et al. (2008), and TRCA (2008) asserted that the design of this pavement could be effective in pollutant removal such as nitrogen, phosphorous, total suspended solids. However, it is not effective in the removal of salts, metals, nutrients etc. The research of Tennis et al. (2004) stated that the principle behind the operation of this concrete is by capturing rainwater when it seeps into the ground. This helps in groundwater recharge meeting up with the European Protection Agency (EPA).

There are two main factors involved in the design of pervious concrete, which are the hydraulic properties and mechanical properties. The research of the authors in Table 1 showed previous research on the use of permeable concrete by varying some notable characteristics using sustainable materials and purpose.

Table 1. Batched samples

Previous Studies on pervious concrete

Table

The choice nano clay was adopted in this research because of its unique pozzolanic ability infrastructural development (Ayobami et al., 2018; Busari et al., 2019) and useful life cycle ability Praticò et al. (2020) with satisfactory global energy requirement (Nanjegowda & Biligiri, 2020).

Nano clay is said to be one of the most efficacious pozzolans in the concrete industry. It is deliberately fabricated and not solid waste material. It is regarded as an anhydrous calcined clay formed from heating mineral kaolinite clay (Aiswarya et al., 2013; Ayobami et al., 2018; Hisham, 2010; Pacheco et al., 2011). Nano clay was used in this research for the development of sustainable, cost-effective permeable pavement for stormwater control.

However, the hydraulic properties of permeable concrete can also be affected by the testing methods as avowed by (Borst & Brown, 2014; Li et al., 2013; West et al., 2016).

This research aims to utilize a sustainable, naturally occurring supplementary cementitious material in the development of porous concrete for sustainable pavement construction for stormwater control.