EXPERIMENTAL AND NUMERICAL ASSESSMENT OF EXTERNALLY BONDED AND NEAR-SURFACE MOUNTED NATURAL FIBRE COMPOSITES ON REINFORCED CONCRETE BEAMS

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF ENGINEERING (M.ENG) IN CIVIL ENGINEERING IN THE DEPARTMENT OF CIVIL ENGINEERING, COLLEGE OF ENGINEERING, COVENANT UNIVERSITY, OTA, OGUN STATE, NIGERIA

AUGUST, 2022

ACCEPTANCE

This is to attest that this dissertation is accepted in partial fulfilment of the requirements for the award of the degree of Master of Engineering in Civil Engineering in the Department of Civil Engineering, College of Engineering, Covenant University, Ota, Nigeria.

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DECLARATION

I, **EFFIONG, JOHN UDUAK (20PCI02081)** declare that this research was carried out by me under the supervision of Professor Anthony N. Ede of the Department of Civil Engineering, College of Engineering, Covenant University, Ota, Nigeria. I attest that the dissertation has not been presented either wholly or partially for the award of any degree elsewhere. All sources of data and scholarly information used in this thesis are duly acknowledge.

EFFIONG, JOHN UDUAK

Signature and Date

CERTIFICATION

We certify that this dissertation titled "**EXPERIMENTAL AND NUMERICAL ASSESSMENT OF EXTERNALLY BONDED AND NEAR-SURFACE MOUNTED NATURAL FIBRE COMPOSITES ON REINFORCED CONCRETE BEAMS**" is an original work carried out by **EFFIONG, JOHN UDUAK (20PCI02081)**, in the Department of Civil Engineering, College of Engineering, Covenant University, Ota, Ogun State, Nigeria, under the supervision of Professor Anthony N. Ede**.** We have examined and found this research work acceptable as part of the requirements for the award of a Master of Engineering (M.Eng) Degree in Civil Engineering.

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DEDICATION

I dedicate this research work to the Almighty God, the source and giver of knowledge and wisdom, whose sustenance kept through this program. From start to finish, He has sustained me, been the source of strength, and lifted my spirit as I worked on my dissertation.

I also dedicate this research work to my beloved family. I am deeply grateful to my loving parents, and siblings whose words of motivation, wisdom and encouragement taught me the value of perseverance and hard work. Thank you very much.

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LIST OF ABBREVIATIONS

RC – Reinforced Concrete

EB - Externally Bonded

NSM- Near-Surface Mounted

NFRP – Natural Fibre Reinforced Polymer

KFRP – Kenaf Fibre Reinforced Polymer

FRP – Fibre Reinforced Polymer

LDPE – Low Density Polyethylene

HDPE – High Density Polyethylene

ACI – American Concrete Institute

EBR – Externally Bonded Reinforcement

NaOH – Sodium Hydroxide

CFRP – Carbon Fibre Polymer

GFRP – Glass Fibre Reinforced Polymer

SFRP – Sisal Fibre Reinforced Polymer

SFRC - Sisal Fibre Reinforced Concrete

BFRP – Basalt Fibre Reinforced Polymer

ECC – Engineered Cementitious Composite

JFRP – Jute Fibre Reinforced Polymer

IHSCC-CA – Innovative High-strength Self-compacting Non-polymer Cementitious Adhesive

SNSM – Side Near Surface Mounted

FEM – Finite Element Method

HCP – Hybrid Composite Plate

ASTM – American Society for Testing and Materials

UTM – Universal Testing Machine

ABSTRACT

The demand for sustainable and accessible materials is on the increase with drive towards providing and strengthening physical infrastructures to guarantee a more resilient, and sustainable environment. A substantial survey of literature has revealed that most research have concentrated on enhancing reinforced concrete (RC) beams adopting the externally bonded (EB) strengthening or near-surface mounted (NSM) techniques employing synthetic fiber reinforced polymer-based materials. A few studies have found that the use of natural fiber reinforced polymer (NFRP) composites is advantageous as a potential substitute for the utilization of conventional synthetic fibre reinforced polymer (FRP) composites for structural strengthening. The comparison of EB and NSM techniques using NFRP composites is very underexplored. Six beams were cast, and they underwent testing as part of the experiment. Flexural failure was the primary mechanism of failure for these beams. The findings of the empirical investigation show that the NSM kenaf FRP configuration of K-N-2-4 provided the best structural strengthening by increasing the load-carrying capacity by 163.64% and improving stiffness before deformation. This further demonstrates the kenaf FRP composite as a viable option in strengthening RC beams. The un-strengthened and strengthened RC beams were modelled numerically on Abaqus FEA software to correlate the empirical findings, and the numerical analysis' findings on the beams' load-deflection response, yielding load, and crack propagations were in conformity with the results of the experimental research.

Keywords: Kenaf Fibre Reinforced Polymer (KFRP); Externally Bonded Fibre Reinforced Polymer; Near-Surface Mounted Fibre Reinforced Polymer; Failure Mechanisms; Flexural Strengthening