STRUCTURAL BEHAVIOUR OF FIRE-DAMAGED REINFORCED CONCRETE BEAMS RETROFITTED WITH BAMBOO FIBRE LAMINATE

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

AUGUST, 2023

ACCEPTANCE

This is to attest that this dissertation has been accepted in partial fulfilment of the requirements 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, Nigeria.

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DECLARATION

I, **AKIN-ADENIYI, AYOMIDE JOHN (20PCI02280)** declare that this dissertation is a representation of my work and is written and was carried out by me under the supervision of Dr. Paul O. Awoyera of the Department of Civil Engineering, College of Engineering, Covenant University, Ota, Nigeria. I attest that this dissertation has in no way been submitted either wholly or partially to any other university or institution of higher learning for the award of any degree. All information cited from published and unpublished literature has been duly referenced.

AKIN-ADENIYI, AYOMIDE JOHN

Signature and Date

CERTIFICATION

This is to certify that the research work titled **"STRUCTURAL BEHAVIOUR OF FIRE-DAMAGED REINFORCED CONCRETE BEAMS RETROFITTED WITH BAMBOO FIBRE LAMINATE"** is an original work carried out by **AKIN-ADENIYI, AYOMIDE JOHN** and meets the requirements and regulations governing the award of a Master of Engineering (M.Eng) degree in Civil Engineering from the Department of Civil Engineering, College of Engineering, Covenant University, Ota, Nigeria and is approved for its contribution to knowledge and literary presentation.

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Prof. Akan B. Williams
(Dean, School of Postgraduate Studies) **Signature and Date**

DEDICATION

I dedicate this research work to the Almighty God, the source and giver of wisdom, knowledge and understanding whose grace and mercy kept me throughout this program. I also dedicate this research work to my parents, siblings, and friends whose words of encouragement kept me pushing even up until the end of this program.

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LIST OF ABBREVIATIONS

RC – Reinforced Concrete

FRP – Fibre Reinforced Polymer

NFPA – National Fire Protection Association

RCJ – Reinforced Concrete Jacket

GFRP – Glass Fibre Reinforced Polymer

AFRP – Aramid Fibre Reinforced Polymer

CFRP – Carbon Fibre Reinforced Polymer

NSM – Near Surface Mounted

EBR – Externally Bonded Reinforcement

BFRP – Bamboo Fibre Reinforced Polymer

SDG – Sustainable Development Goals

ASTM – American Society for Testing and Materials

NDT – Non-destructive Test

PDT – Partially Destructive Test

RH – Rebound Hammer

CS – Compressive Strength

UPV – Ultrasonic Pulse Velocity

RN – Rebound Number

PVA – Polyvinyl Alcohol

PP – Polypropylene

HDPE – High Density Polyethylene

LDPE – Low Density Polyethylene

PVC – Polyvinyl Chloride

PALF – Pineapple Leaves Fibre

KFRP – Kenaf Fibre Reinforced Polymer

BFCP – Bamboo Fibre Composite Plate

ITZ – Interfacial Transition Zone

ABSTRACT

Fire occurrences in building is becoming increasingly frequent as a result of accidents, the presence of combustible items in buildings, particularly residential buildings, and other potential sources of fire. When there is a fire occurrence in a building, the structural integrity of such building is affected. In order for such building to be habitable again, it has to either be strengthened or rebuilt. The common practice for fire-damaged buildings is to be abandoned or demolished, whereas such buildings could be assessed and strengthened for it to regain its initial load carrying capacity. Several studied have investigated methods for strengthening reinforced concrete (RC) beams impaired by fire using synthetic FRP composites but little or no studies has been done on the usage of natural FRP composite to strengthen a RC beam impaired by fire. This study investigated the usage of bamboo fibre laminate to retrofit a fire damaged RC beam and the structural behaviour of the beam was observed. Eight RC beams were designed, cast, and reinforced normally. Two of the beams were the control samples. The remaining six beams were exposed to three different temperatures (400, 600 and 800 °C) in pairs of two. One out of each pair was retrofitted with bamboo fibre laminate. Subsequently, each beam underwent testing until failure, with loads increasing in 0.5 tons increment. The outcomes revealed that the utilization of bamboo fibre laminate had the capability to enhance both the ability to carry load and deflection characteristics of a beam that had been impaired by fire. For beams exposed to 400 °C the load-carrying capacity returned to that observed in the control beam and the deflection was increased by 48.78% in relation to the control beam. In the case of beams exposed to 600 °C, the bamboo fibre laminate increased the load-carrying capacity by 29.5% beyond that of the unstrengthened fire-damaged beam but 5% less than the control beam. The deflection was also increased by 39.37% relative to the control beam. When considering beams exposed to 800 °C, the bamboo fibre laminate increased the ability to carry load by 37% beyond the unstrengthened fire-damaged beam but 10% less than the control beam. The deflection was also increased by 4.83% relative to the control beam. This study demonstrated that bamboo fibre laminate is a viable alternative for strengthening fire-damaged beams instead of using synthetic fibres.

Keywords: RC beam; bamboo fibre; fibre reinforced polymer; impaired, fire, fire-damaged beam; strengthening; load-carrying capacity.