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International Journal of Engineering Research and Technology (IJERT)

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Chatibi youness, PhD, Mathematics Department, ENSAM/Moulay Ismail University, **Morocco**.

Area of Research Interest: Fractional Calculus, Method of Resolution of Fractional Differential Equations and Applications.

Dr. Diego Bellan, Professor, Department Of Electronics, Information And Bioengineering, Politecnico Di Milano, Piazza Leonardo Da Vinci 32, 20133, Milan, **Italy**.

Area of Interest : Power Quality, Electromagnetic Compatibility

Dr. Liew Pay Jun, Senior Lecturer, Department Of Manufacturing Process, Faculty Of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, Durian Tunggal, Melaka, **Malaysia**.

Area of Interest : Electrical Discharge Machining, Machining, Micro/Nano Machining, Nanofluid

Jong-Wook Lee, Electrical & Computer Engineering, Ajou University, Worldcupro 206, Yeongtong-gu, 16499, Geonggi-do, **South Korea**.

Area of Interest: I Device structure and materials for sub-0.5V voltage operation, I Scaling-down enabling technology, I Low-power, high-speed devices and circuits.

Dr. Ishita Roy, Upward Bound STEM TRIO, Long Beach City College, Los Angeles, California, **United States of America**.

Area of Interest: Civil Environmental Engineering, Environment Engineering, Energy

Dr. Nanaji Yerramsetti, Department of Chemistry & Biochemistry, Texas Tech University, Lubbock, Texas, **USA**.

Area of Interest: Organic synthesis, asymmetric synthesis, Organo-metallic chemistry

Prof. Dr. Ashok K. Singh, University of Nevada, Las Vegas (UNLV), William F. Harrah College of Hospitality, Las Vegas, Nevada, **USA**.

Area of Interest: Applied Statistics, Bayesian Inference, Spatial and Temporal Analysis of Data, Structural Equations Modeling, Panel Data Analysis

Mohammad Amin Horiri Ardebili, Civil Environmental and Architectural Engineering (CEAE), University of Colorado at Boulder, Colorado, Boulder, **USA**.

Area of Interest: Concrete dams; Fluid-structure-interaction; Earthquake engineering; PBEE; Special structures

Giripraseth Gururajan, Bartlesville Technology Center, ConocoPhillips Company Oklahoma, Bartlesville, **USA**.

Area of Interest: Polymer, Vibrational Spectroscopy, Electrospinning, Polymer characterization.

Goutam Ghoshal, Department of Research and Development, Company: Acoustic MedSystem Inc, Savoy, Illinois, **USA**.

Area of Interest: Biomedical ultrasound, therapeutic ultrasound, high-intensity focused ultrasound, signal processing, ultrasound imaging, computational mechanics, solid mechanics, image-guided intervention, acoustic, ultrasonic non-destructive testing, mechanical stress analysis

Dr. Dong-Chan Kim, Department of Biomedical Laboratory Science, Gimcheon University, Gimcheon City, Gyeongbuk Province, **South Korea**.

Area of Interest: Molecular Pharmacology, Neuropharmacology, Natural Herb Pharmacology

Dr. Sulalit Bandyopadhyay, Department of Chemical Engineering, Norwegian University of Science and Technology (NTNU), Trondheim, Trøndelag, **Norway**.

Area of Interest: Synthesis, characterization and functionalization of nano-particles, development of nanoparticle based hydrological tracers, drug delivery, bioimaging, nanosystems in drilling fluids and enhanced oil recovery, nanogels, polymeric nanoparticles, polymerization, colloids and interfaces.

Dr. Siamak Hoseinzadeh, Islamic Azad University, Division Mechanical Engineering, Tehran, **Iran**.

Area of Interest: Green House, Zero Energy, Building Material, Building Energy Efficiency, PCM Nanocomposites, Thin Films, Synthesis, Structural, Optical and Electrical properties, Smart Material and Devices, Electrochromic and Thermochromic Devices.

Dr. Basim Abu-Jdayil, Chemical & Petroleum Engineering Department, UAE University, Al Ain, Abu Dhabi, **UAE**.

Area of Interest: Rheology, Fluid mechanics, Composite materials, EOR

Prof. Abdullah M. Al-Shaalun, EE department, College of Engineering, King Saud University Riyadh, **Kingdom of Saudi Arabia**.

Dr. Joni Welman Simatupang, School of Engineering, President University, Cikarang, Bekasi-17550, **Indonesia**.

Area of Interest: Electrical Engineering, Semi Conductor Technology, Opto Electronic Devices, Optical Networks, Electrical Sensors, Design and Fabrication of Semiconductors and optoelectronic devices.

Sameer Chand Pudaruth, Computer Science and Engineering Department, University of Mauritius, Reduit, Moka, Port Louis, **Republic of Mauritius**.

Area of Interest: Multimedia, Computer Vision, ICT in Education, Software Engineering

Mohd Hafiz bin Jali, Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100, Melaka, **Malaysia**.

Area of Interest: Control system, Signal Processing, Rehabilitation, Human assist technology. Pattern Recognition, Robotic.

Rajeev Ahuja, Physics Department, Uppsala University, Box 530, 751 21 Uppsala, **Sweden**.

Area of interest: Computational Materials Science, Electronic Materials, Spintronics, High pressure, Dynamics.

S.A. Soliman, Electrical Engineering Department, University of Qatar, P. O. Box 2713 Doha, **Qatar**.

Area of Interest: Applications of State Estimation to Electric Power Systems, Fuzzy and Neural System Applications to Electric Power Systems.

Vincenzo Niola, Professor, Department Of Industrial Engineering,, University Of Naples Federico II – Engineering Faculty, Naples, **Italy**.

Area of Interest : Mechanics, Robotics, Diagnostics Of Mechanical Systems, Non-Linear Analysis Of Mechanical Systems, Vibrations, Tribology

Rose Farahiyah Munawar, Senior Lecturer, Department Of Engineering Materials, Faculty Of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, **Malaysia**.

Area of Interest : Nanotechnology, Environmental And Green Materials, Cellulose Derivatives, Materials Characterization And Materials Science & Engineering

Ruqa Alsabah, Lecturer, Department Of Computer Science, Freha Campus, Kerbala University, Kerbala, **Iraq**.

Area of Interest : Internet Of Things & Big Data Analysis, Wireless Communication 4G, 5G And Beyond, Microwave Remote Sensing, Space-Borne – Airborne Platforms And Calibration And Validation Measurements.

Dr. Asim Datta, Associate Professor & Head, Dept. Of Electrical Engineering, Mizoram University (A Central University), Tanhril, Aizawl-796004, Mizoram, **India**.

Area of Interest : Electrical Power Systems, Renewable Energy Sources, Embedded Systems

Pranav Mahamuni, Research Assistant, Department Of Mechanical Engineering, Stony Brook University, Stony Brook, New York, **United States Of America.**

Area of Interest : Mechanical Engineering - Cad/Cam, Product Design, Rapid Prototyping, Finite Element Analysis

Dr. Diego Bellan, Professor, Department Of Electronics, Information And Bioengineering, Politecnico Di Milano, Piazza Leonardo Da Vinci 32, 20133, Milan, **Italy.**

Area of Interest : Power Quality, Electromagnetic Compatibility

Dr. Claudia Espro, Assistant Professor, Department Of Engineering, Contrada Di Dio, 4^o Piano, Blocco C, 98166 Messina, **Italy.**

Area of Interest : Heterogeneous Catalysis And Development Of Novel Catalytic Green Processes. Catalytic Conversion Of Natural Gas And Light Alkanes Into Intermediates, Fuels And Chemicals Of Higher Added Value. Conversion Of Renewable Biomass For The Production Of Bulk Chemicals, Electrochemical Sensors

Dr. Massila Kamalrudin, Deputy Dean, Associate Professor, Faculty of Information Technology and Communication , Institute of Technology Management and Entrepreneurship, Universiti Teknikal Malaysia Melaka, **Malaysia.**

Area of Interest : ICT, software engineering

Dr. Nilamadhab Mishra, Assistant Professor, School Of Computing, Debre Berhan University, Ministry of Education, Government of Ethiopia, **Ethiopia.**

Area of Interest : Encompass Network Centric Data Management, Data Science: - Analytics and Applications, CIoT Big-Data System, and Cognitive Apps Design & Explorations.

Dr. Liew Pay Jun, Senior Lecturer, Department Of Manufacturing Process, Faculty Of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, Durian Tunggal, Melaka, **Malaysia.**

Area of Interest : Electrical discharge machining, machining, micro/nano machining, nanofluid

Dr. G.PARAMASIVAM , Associate Professor, Department Of Computer Science, KG COLLEGE OF ARTS AND SCIENCE, Tamilnadu, **India.**

Area of Interest : Image processing, Computer Network

Dr. Ch. Swapna Priya, Assistant Professor, Department Computer Science And Engineering, Vignan's institute of Information Technology, Visakhapatnam, Andhra Pradesh, **India.**

Area of Interest : Image processing, Pattern recognition deep learning, machine learning

Dr. K. Sangeetha, Assistant Professor, Department Of Computer Science & Engineering, SNS College of Technology, Coimbatore, Tamilnadu, **India.**

Area of Interest : Theory of computation, Computer Networks, Advanced Computer Architecture, Operating Systems, Computer Programming, Network Security, Object Oriented Analysis and Design and Data Base Management System

Dr. Deepali Gupta, Professor And Head, Department Of Computer Science & Engineering, Maharishi Markandeshwar University, Sadopur, Ambala, **India.**

Area of Interest : Computer Engineering & Information Technology, Software Engineering, Genetic Algorithms and Cloud Computing

Dr. Ghassan Fadhil Smaism, Associate Professor, Department of Mechanical Engineering, University of Kufa, Faculty of Engineering, Kufa, P.O. Box: 21, Najaf Government, **Iraq.**

Area of Interest : Enhancement Heat Transfer, Renewable Energy, Fluid Mechanics, Thermal Nanofluid Flow, Power Generation, Solar Energy, CFD.

Dr. Darshankumar Chandrakant Dalwadi, Associate Professor, Department of Electronics and Communication Department, Birla Vishvakarma Mahavidyalaya Engineering College, Post Box No. 20, **India.**

Area of Interest : Digital Communication, Wireless Communication and M Tech Information Theory and Coding

Jong-Wook Lee, Electrical & Computer Engineering, Ajou University, Worldcupro 205, Yeongtong-gu, 16499, Geonggi-do, **South Korea.**

Area of Interest : I Device structure and materials for sub-0.5V voltage operation, I Scaling-down enabling technology, I Low-power, high-speed devices and circuits.

Mohd Hafiz bin Jali, Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100, Melaka, **Malaysia.**

Area of Interest: Control system, Signal Processing, Rehabilitation, Human assist technology, Pattern Recognition, Robotic.

Timon Rabczuk, Chair of Computational Mechanics, Bauhaus University Weimar, Marienstrasse 15, 99423 Weimar, **Germany.**

Hacene Mahmoudi, Vice Rector for Animation, promotion of scientific research, Hassiba Benbouali University, B.P. 151, Chlef, **Algeria.**

Mircea Cristian DUDESCU, Technical University of Cluj-Napoca, Faculty of Mechanical Engineering, Departament of Mechanical Engineering, B-dul Muncii 103-105, 400641 Cluj-Napoca, **Romania.**

Area of interest: mechanics of materials, experimental mechanics, mechanical testing, structural analysis of MEMS.

Rajeev Ahuja, Physics Department, Uppsala University, Box 530, 751 21 Uppsala, **Sweden.**

Area of Interest: Computational Materials Science, Electronic Materials, Spintronics, High pressure, Dynamics.

Shigeru Aoki, Department of Mechanical Engineering, Tokyo Metropolitan College of Technology, Shinagawa-ku, Tokyo 140-0011, **Japan.**

Area of Interest: Random vibration, Seismic response of mechanical system, Approximate analysis of nonlinear vibration.

G.Q. Chen, Department of Mechanics and Engineering science, Peking University, Beijing 100871, **China.**

Area of Interest: CFD (Computational fluid dynamics), energy and resources engineering, and systems ecology.

Anna Laura Pisello, Department of Engineering, CIRIAF – Interuniversity Research Center, University of Perugia, **Italy.**

Dr. Jahar Sarkar, Department of Mechanical Engineering, IIT (BHU) Varanasi, UP-221005, **India.**

Area of Interest: Energy, Thermal & Fluid Engineering.

Verena Kantere, Centre Universitaire d' Informatique, University of Geneva, Bâtiment A, Route de Drize 7, 1227 Carouge, **Switzerland.**

B.T.F. Chung, Department of Mechanical Engineering, University of Akron, Akron, Ohio 44325, **USA.**

Area of Interest: Heat Transfer with Phase Changes, Optimum Design of Extended Surfaces, Radiative Heat Transfer System.

Marcelo J.S. De Lemos, Departamento de Energia - IEME, Instituto Tecnológico de Aeronáutica - ITA, 12228-900 São José dos Campos S.P. - **Brazil.**

Area of Interest: Turbulence Modeling, Porous Media, Combustion In Porous Media, Numerical Methods, Finite Volume.

Dimitris Drikakis, Head of Aerospace Sciences Department, Cranfield University, School of Engineering, Cranfield, MK43 0AL, **United Kingdom.**

Area of Interest: Computational Fluid Dynamics, Aerodynamics, Turbulence Gas dynamics, Computational Nanotechnology.

A.S. Al-Harthy, Department of Civil, Surveying and Environmental Engineering, University of Newcastle, Callaghan, NSW 2308 **Australia.**

Area of interest: Concrete material and durability, Recycling construction materials, reliability assessment of structures.

S.Z. Kassab, Mechanical Engineering Department, Faculty of Engineering, Alexandria University, Alexandria, 21544 **Egypt.**

Area of Interest : Experimental Fluid Mechanics, Lubrication, Energy, Environment and Pollution.

Bashar El-Khasawneh, Chairman, Industrial Engineering Department, JUST, P.O. Box 3030, Irbid 22110 **Jordan.**

Area of Interest: Design process and manufacturing-related sciences and processes, advanced and parallel kinematics machine tools.

Kazuhiko Kudo, Laboratory of Micro-Energy Systems, Division of Human Mechanical Systems and Design, Graduate School of Engineering, Hokkaido University.

Japan.

Area of Interest: Radiative heat transfer analysis, transient analysis on surface tension.

Carlos Mario Morales Bautista, Calzada Olmeca 105. Cerrada Chiltepec No. 1. Fraccionamiento la Venta, Villa Parrilla II. C.P. 86280. Villahermosa, Centro, Tabasco, Mexico.

Ihab Obaidat, Department Of Physics, College of Science, United Arab Emirates University, P.O. Box 15551, Al Ain, **UAE**.

Area of Interest: Nanomagnetism, Superconductivity

Huihe Qiu, Department of Mechanical Engineering, The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon **Hong Kong**.

Area of Interest: Transport phenomena in microscale multiphase flows, micro sensors and actuators, optical diagnostics and instrumentation

S.A. Soliman, Electrical Engineering Department, University of Qatar, P. O. Box 2713 Doha, **Qatar**.

Area of Interest: Applications of State Estimation to Electric Power Systems, Fuzzy and Neural System Applications to Electric Power Systems

Dimitri V. Val, Dept. of Structural Engineering, Faculty of Civil and Environmental Engineering, Technion - Israel Institute of Technology, Haifa 32000, **Israel**

Area of Interest: structural safety and reliability; analysis, design, and assessment of reinforced concrete and steel structures

Guo-Xiang Wang, Department of Mechanical Engineering, The University of Akron, Akron OH 44325-3903 **USA**.

Area of Interest: Heat and Mass Transfer, Materials Processing, Solidification Theory and Application

Samir Mekid, Mechanical Engineering Department, King Fahd University of Petroleum and Minerals PO Box 155, Dhahran, 31261, **Saudi Arabia**.

Abdul Razak Rehmat, Department of Bioprocess & Polymer Engineering, Faculty of Chemical & Energy Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, **Malaysia**.

Area of Interest: Polymer Processing and Rheology, Biobased Polymer Composite, Microwave Processing of Polymer

V.R. Mudinepelli, Department of Physics, National Taiwan Normal University, Taipei, 11677, **Taiwan**.

Damodar Maity, Civil Engineering Department Indian Institute of Technology, Kharagpur, West Bengal, **India**.

Area of Interest: Damage Assessment of Structures; Seismic Resistant of Structures; Fluid-Structure Interaction; Sloshing; Concrete Gravity Dam

NG EYK, School of Mechanical & Aerospace Engineering, Nanyang Technological University, 50 Nanyang Avenue, 639798 **Singapore**.

Area of Interest: biomedical engg; computational fluid dynamics and numerical heat transfer

Mohammad Luqman, Chemical Engineering Department King Saud University Chemical Engineering Department, Riyadh, **Saudi Arabia**.

Area of Interest: Polymer Nanocomposites, Polymer/Plastic, Ionomers, Nanocomposites

Mohammad Valipour, Department of Irrigation and Drainage Engineering, College of Abureyhan, University of Tehran, Pakdasht, Tehran, **Iran**.

Area of Interest: Surface and pressurized irrigation, Drainage engineering, Fluid mechanics, Heat transfer in soil media

Najm Obaid Salim Alghazali, Department of Civil Engineering, Babylon University, Hilla, Babylon, **Iraq**.

Area of Interest: Hydraulic Structures, Hydraulics, Engineering Hydrology, Groundwater Hydrology, Dams Engineering

Sushant K. Singh, Earth and Environmental Studies Department, Montclair State University, Montclair, 07043, New Jersey, **USA**.

Area of Interest: Environmental pollution, Environmental management, Environmental toxicology, Environmental policy

Hongseok Choi, Department of Mechanical Engineering, Clemson University, 205 Fluor Daniel Bldg. Clemson, SC 29634 **USA**.

Ling Zhou, National Research Center of Pumps, Jiangsu University, No.301 Xuefu Road, Zhenjiang, Jiangsu 212013, **China**.

Area of Interest : Fluids Engineering, Multiphase flow, CFD (Computational Fluid Dynamics)

International Journal of Engineering Research and Technology (IJERT)

Volume 13, Number 04 (2020)

Contents

Galerkin – Kantorovich Method for the Elastic Buckling Analysis of Thin Rectangular SCSC Plates

pp. 613-619

Michael Ebie Onyia, Eghosa. O. Rowland-Leto and Charles Chinwuba Ike

Palm Oil Bleaching Using Activated Carbon Prepared from Neem Leaves and Waste Tea

pp. 620-624

Furqan Butt, Murtuza Ali Syed, Feroz Shaik

A Proposed Methodology for Detecting Human Attacks on Text-based CAPTCHAs

pp. 625-630

Latifah A. Alreshoodi and Suliman A. Alsuhibany

Effect of Reinforcement Details on Precast Bridge Frames of Bamboo Reinforced Concrete to Load Capacity and Crack Patterns

pp. 631-636

Muhtar, Amri Gunasti, Adhitya Surya Manggala, Ardhi Fathonisyam Putra Nusantara, Hanafi, Agung Nilogiri

Cyclic Performance of Restrained Steel-Concrete Fully Composite Beams Subjected to a Point Load

pp. 637-643

Sarawut Yodmunee, Torkul Kanchanalai and Trakool Aramraks

The Use of Artificial Intelligence in Traffic Violation Data Analysis

pp. 644-652

Mohammed Alshriem

Porosity Measurement of Iron Oxide by Using Computer Vision System

pp. 653-659

Al -Badrawy A., Abo El-Nasr, Alaa Saleh and Abdullah. A. Alshennawy

Characteristics of Object-oriented Soft Concepts in a Soft Context

pp. 660-663

Won Keun Min

Ethno-Design as a Means of Forming Technological and Artistic Competences of Future Technology Teachers and Vocational Educators

pp. 664-667

Akimbek Mederhanovich Muhadiev, Perizat Meiramovna Aitmurkhanova, Baimurat Ermagambetovich Ospanov, Zinidin Nastajevich Isnyazov and Zhalgasbek Zhapparbekovich Belsenbekov

Cellular Automata Implemented on FPGA Based on Totalistic Rules for Deterministic Systems

pp. 668-674

Alexander Bautista-Torres, Edgar Alexander Bautista-Aleman and Helbert Eduardo Espitia-Cuchango

Surface and Intraparticle Diffusion of Crystal Violet Dye on Egyptian Doum Fruit from Aqueous Solutions

pp. 675-685

Ahmed A. Abdel- Khalek, Mahmoud M. Abdel- Hafeez, Reham A. Mohamed and Engy H.Gabrail

Image Denoising Methods for New TVL1 Models with Impulse Noisy

pp. 686-698

Jae Heon Yun

Determining the Physical and Mechanical Properties of Two-Phase Soil for Landslide Slopes of the Northern Tien Shan

pp. 699-705

Algerim Baimakhan, Assima Seinnassanova, Rysbek Baimakhan, Aliman Rysbayeva and Nazgul Moldakunova

Optic Disc and Optic Cup Segmentation Methodology for Glaucoma Detection

pp. 706-714

Mohamed Acuf, Dalia Ali, Ghada Kereem

Multi-criteria Model with a Fuzzy Hierarchical Analysis Process - FAHP, for the Selection of Providers in a Cellular Mobile Telecommunications Company in Colombia

pp. 715-719

Leydy J. Hernández Viveros, Jennifer C. Murcia Rodriguez and Danilo A. López Sarmiento

A Research on the Practice of Developing a Rural 'Magnet' School Model: Theoretical and Applied Aspects

pp. 720-724

B.A. Gazdiyeva, M.V. Tavliy, Z.Ye. Gabdullina, A.A. Akhmetzhanova, G.T. Fatkiyeva

Fuzzy Logic Based Life Cycle Cost Analysis Model for Preventive Road Maintenance by Considering User Costs

pp. 725-733

Dadang Iskandar, Sigit Pranowo Hadiwardoyo, R. Jachrizal Sumabrata

A Study on the Acoustic Variation to Environment Changes in Virtual and Complex Reality

pp. 734-737

SeongGeon Bae

Design of a Motorcycle Frame at an Automotive Company in Indonesia

pp. 738-743

Djoko Setyanto, Arka Dwinanda Soewono, Andi Wibowo and Rugerri Toni Liong

Role of Integrating Business Intelligence Systems and Knowledge Management in Supporting Decision-Making Process in Saudi Electricity Company

pp. 744-755

Fudheh A.AISelami, Ibrahim M.ELEmery and Huda M.Alamoudi

Study on Reducing the Stress of Wearing a Mask through Deep Breathing

pp. 756-761

Zhixing Tian, Bong-Young Kim and Myung-Jin Bae

A Study on Improvement of Special Acoustic Lens Output through Frequency Trimming

pp. 762-767

Bong-Young Kim, Zhixing Tian and Myung-Jin Bae

Current Situation and Issues Regarding the Accessibility of Beijing Daxing International Airport — Beijing Daxing International Airport Opened in September 2019

pp. 768-782

Mizuno Tomomi & Tokuda Katsumi

Theoretical Model of Nanomaterial Heat Content (Energy) During Grain Refinement by Accumulative Roll-Bonding (ARB).

pp. 783-792

M. Pita, M.P. Mashinini, L.K. Tartibu

Novel Compounds for Increasing Women's Breast Size

pp. 793-796

Pyo Song, Seonlin Kim, Dong-Chan Kim

The Future of Engineering Education in South Africa

pp. 797-801

Dr Kehdinga George Fomunyam

Proposal for a Robotic Platform Design for the Control and Monitoring of Physicochemical Parameters in Contaminated Water

pp. 802-806

Jennifer Catalina Murcia, Leydy J. Hernández Viveros , Carlos Arturo Carrasco Henao and Danilo A. López Sarmiento

A Study on the Effect of Wearing Masks on Stress Response

pp. 807-813

Zhixing Tian, Bong-Young Kim and Myung-Jin Bae

A Hybrid Artificial Intelligence Approach to Predict Flight Delay

pp. 814-822

Bashayer Alharbi and Master Prince

Modelling and Analysis of Mini-Fracture Tests in Hydraulic Fracturing

pp. 823-827

Quang Khanh Do, Huynh Nhan Vo and Thi Tam Thanh Nguyen

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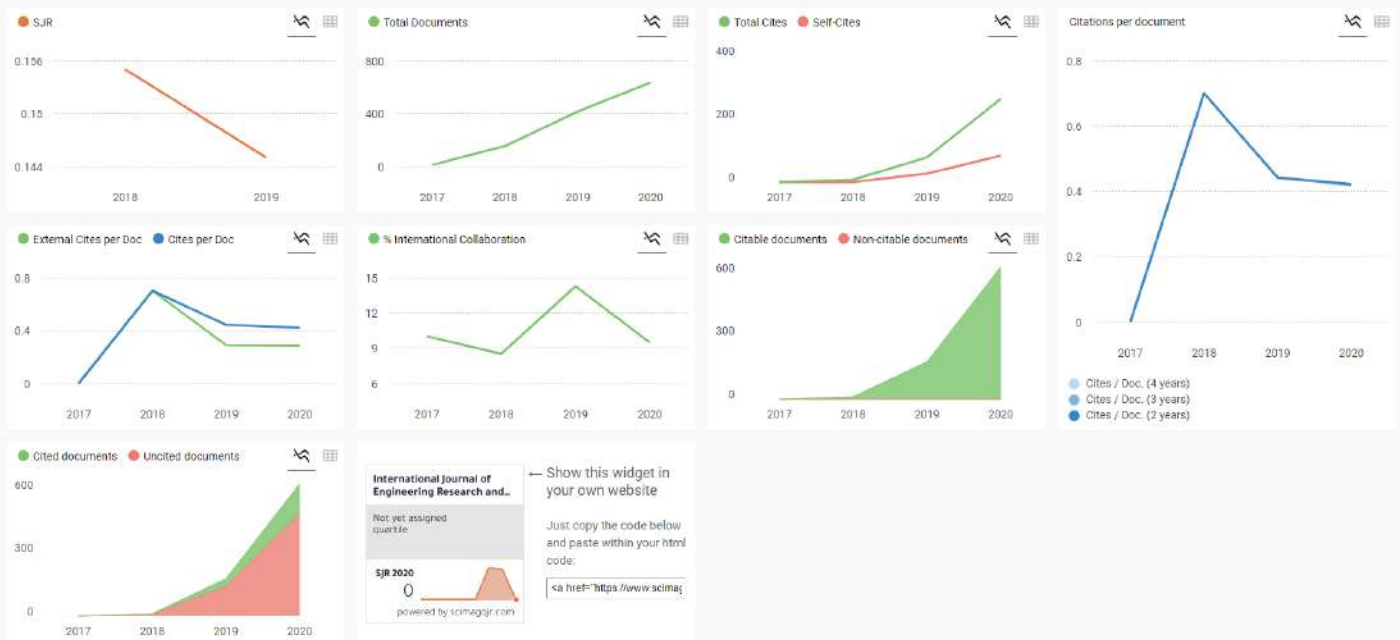
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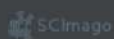
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Effect of Reinforcement Details on Precast Bridge Frames of Bamboo Reinforced Concrete to Load Capacity and Crack Patterns

Muhtar¹, Amri Gunasti², Adhitya Surya Manggala³,
 Ardhi Fathonisyam Putra Nusantara⁴, Hanafi⁵, Agung Nilogiri⁶

^{1,2,3,4,5,6}University of Muhammadiyah Jember, Jember, 68121, Indonesia.

ORCID: 0000-0002-5734-2728 (Muhtar), 0000-0002-9732-5869 (Amri),
 0000-0002-5386-123x (Adhitya), 0000-0001-8183-5875 (Ardhi),
 0000-0002-5616-4384 (Hanafi), 0000-0001-7250-0432 (Agung)

Abstract

Truss structures are usually only considered to accept compressive axial forces and tensile axial forces. Structure node point is assumed to be a joint that cannot receive moments. But it's not the case with truss structures from concrete, large self-weight causes moment, so that "Truss" structures from concrete are called "Frame" structures. This study aims to increase the capacity and crack pattern of the precast bridge frame from bamboo reinforced concrete with different reinforcement variants. Two frames are made with the focus of observation on the underside element of the frame. Frame variations consist of one frame with symmetry reinforcement as the joint frame model or "truss model", one frame with flexural reinforcement as the rigid portal model or "frame model". Testing is done with two load points at the knot on the top side of the frame. The test results show that the bamboo reinforced concrete frame with a rigid portal model or "frame model" has stiffness and higher load capacity than the stiffness of the joint frame model or "truss model". Large self-weight will cause the moment can not be zero on each element, and the knot point behaves elastic clasps. However, a reinforced concrete frame does not fully behave as a rigid portal, this is evidenced by the crack pattern similar to the crack pattern on the "truss model", namely cracking perpendicular to the stem element and propagate across the tensile element.

Keywords: Precast Bridge Frame, Bamboo Reinforced Concrete, Crack Pattern, Truss Model, Frame Model

I. INTRODUCTION

Bamboo as a construction material has been widely used especially in rural areas that produce bamboo. The utilization of bamboo is usually used as a warehouse construction framework, simple house construction, non-permanent bridges, and others. Bamboo as a material renewable and environmentally friendly has been widely researched as a concrete reinforcement by [1], [2], [3], [4], [5], [6], [7], [8], and [13]. The use of bamboo as truss reinforcement has not been much researched. Dewi et al. (2011) [9] examined bamboo as a reinforcement material for simple house horses and his research showed that the cracking patterns that occur are due to the flexural effect.

The main principle of the truss as a load-bearing structure is the arrangement of the truss elements into triangular configurations so that it becomes a stable shape. External load is a centralized load that works at knot points. This external load effect causes pure tensile force and compressive force on each truss element. The truss structure from reinforced concrete has an uncertain element of the knot point so that the compressive force and tensile force are not completely pure axial forces. This is due to the restraint at the knot point and its considerable weight.

Theoretically, the maximum force that can be resistant by every bamboo reinforced concrete frame element is the load that causes the f'_c stress on the concrete. The frame element with area A_g with width b and height h , area of reinforcement of A_b bamboo, then the net area of the cross-section of the bamboo reinforced concrete frame element is $A_g - A_b$. The maximum centric load capacity on a bamboo reinforced concrete frame can be obtained by adding concrete contributions, ie $(A_g - A_b)f'_c$ and the contribution of $A_b f_{yb}$ bamboo. Thus, the maximum centric load capacity, P_o can be stated as follows Equation (1).

$$P_o = (A_g - A_b)f'_c + f_{yb}A_b \quad (1)$$

Centric load causes the pressure to be evenly distributed on the cross-section so that the stress and strain will be the same throughout the cross-section. In reinforced concrete design, the assumption of concrete tensile strength is ignored because the tensile strength of the concrete is small so that the tensile force is fully retained by the reinforcement. However, at elastic loads, before cracking occurs in the concrete, the tensile strength is restraint by the concrete and bamboo reinforcement. So that the tensile capacity of frame elements is calculated by calculating the tensile strength of concrete such as Equation (2) [9], [10].

$$P_o = 0,85f'_{cr}(A_g - A_{bamboo}) + f_{tr}A_{bamboo} \quad (2)$$

where f'_{cr} = concrete tensile stress, f_{tr} = tensile yield stress of bamboo, A_g = Area of cross section of concrete elements, A_{bamboo} = area of bamboo reinforcement.

There are two types of cracks on pure reinforced concrete frame elements, namely primary cracks and secondary cracks [11]. When reinforced concrete elements experience tensile stress, two types of cracks will form. The first type is cracks that are seen on the concrete surface (primary crack), usually occurring at the ends of the trunk, while the second crack does not appear to the concrete surface (secondary crack) as shown in Figure 1. The formation of additional primary cracks continues as the stress increases until the cracking distance approaches twice the thickness of the concrete blanket measured in the direction of the concrete reinforcement center [11].

The crack pattern of a bamboo reinforced concrete frame structure usually has a crack pattern that is almost the same that is perpendicular to the axis of the stem. The initial cracks occur in the element that experiences the greatest tensile force, then the cracks move on the compressive element, along with the load continue to increase cracks approaching the knot point, especially the knot point near the support [9]. The collapse of the entire structure is caused by a combination of the compressive force and the shear force at the support point. The collapse of the knot point causes the frame tensile element and the frame compressive element to be unable to increase the tensile strength and compressive strength to the maximum. And the cracks pattern and collapse of reinforced concrete frame structures still show a bending effect [9].

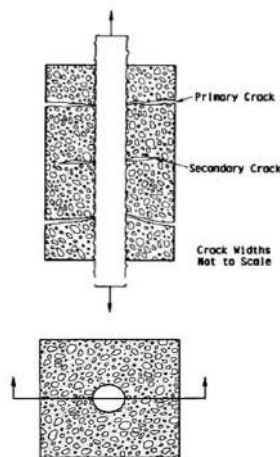


Fig. 1. Primary and secondary cracks in reinforced concrete elements that experience tensile stress [11]

II. MATERIAL AND METHODS

A. Bamboo Reinforcement

Bamboo reinforcement used is petung bamboo species aged 3-5 years. Before use, bamboo reinforcement is treated by immersing it in water for approximately 3 weeks, drying on free air to a moisture content of approximately 12%, cut off according to the planned size and shape, given a first stage waterproof coating, hose-clamp installation, and given a second stage waterproof coating. The type of waterproof

coating used is Sikadur®-752. Hose-clamps used in diameter are $\frac{3}{4}$ " made in Taiwan.

B. Bamboo Reinforced Concrete Frame and Testing Methods

The design of the bamboo reinforced concrete bridge frame was made with a length of 320 cm and a height of 115 cm. Dimensions of the underside element measuring 12 cm x 20 cm, the vertical element and top side element measuring 12 cm x 10 cm, and the diagonal element measuring 12 cm x 14 cm. Hose-clamp spacing of 25 cm is installed only on the tensile element of the underside section of the bridge frame. Tests carried out with a maximum load of 10 tons, adjusting to the loading frame capacity in the laboratory. Strengthening of knot point used \varnothing 6 mm steel reinforcement, while the distribution reinforcement used \varnothing 8 mm steel reinforcement. Dimensions and details of reinforcement of the bridge frame are presented in Figure 2, Figure 3, and Table I.

Bridge frame testing is carried out with static loads at two the knot points of the top side elements. Bridge frames are made as many as 2 pieces with different reinforcement models, namely the rigid portal model "frame" and the joint frame model "truss". The rigid portal model uses the tensile reinforcement and compressive reinforcement, while the truss model uses symmetrical reinforcement on all four sides, as shown in Table I-P.

The bridge frame test is carried out on two supports, namely hinge support and roller support. The load given is a centralized load on two the knot points on the top side of the bridge frame, each spaced $\frac{1}{2}L$ from the support. The loading uses a hydraulic jack and a load cell that is connected to the load indicator tool. The strain gauge is mounted on the bamboo reinforcement at $\frac{1}{2}L$ space from the supports to determine the strain that is occurring. The strain gauge is connected to a 6 digit digital strain-meter with stacking cable. To detect deflection that occurs in the bridge frame, LVDT is installed at a distance of $\frac{1}{2}L$ from the support. The loading is done slowly to get the data accuracy. Load readings on the load indicator are used to control the hydraulic jack pump, deflection readings, and strain readings according to the planned loading stage. The bridge frame testing settings are shown in Figure 4.

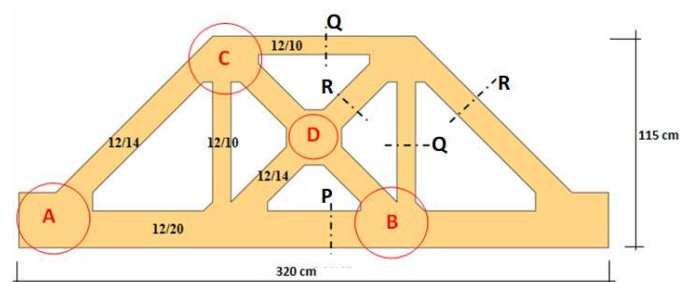


Fig. 2. The dimensions of the bamboo reinforced concrete bridge frame

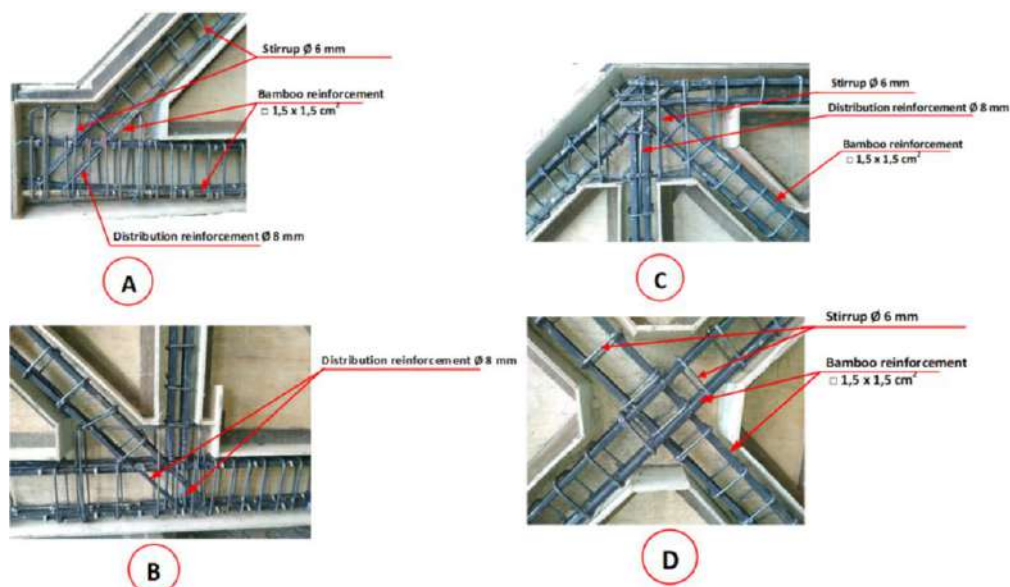


Fig. 3. Reinforcement details of the knot point of the bridge frame

Table I

Reinforcement Details of Bridge Frame

Model	P (shown in Figure 2)	Q (shown in Figure 2)	R (shown in Figure 2)
Rigid portal model or "frame"			
Joint frame model "truss"			

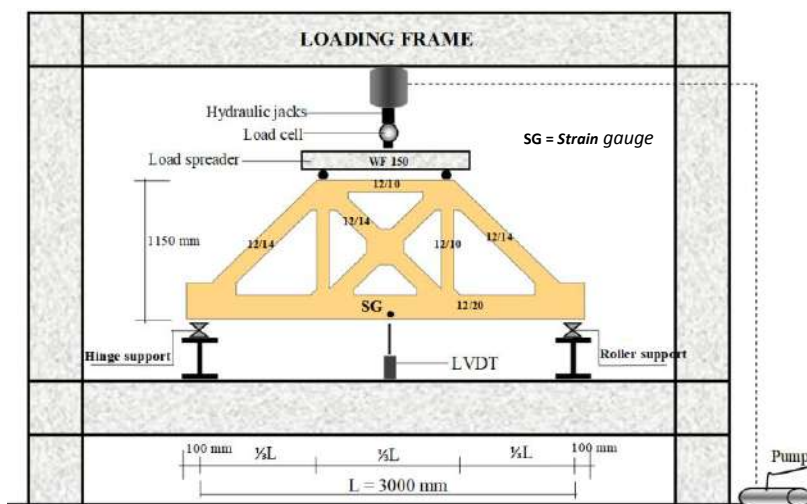


Fig. 4. The setting of the test of bamboo reinforced concrete bridge frame

III. RESULTS AND DISCUSSION

A. The relationship of load (P) vs deflection (Δ) and strain (ϵ)

Figure 5 shows the relationship diagram of load (P) vs. deflection (Δ) of the rigid portal frame. At 0 kg loads up to 7900 kg are linear curves and no cracks have been seen. At an 8700 kg load, the initial crack occurs at the end of the tensile element near the roller support. After the initial crack occurs, the curve is still linear and sloping followed by crack propagation. This is because the bridge frame is a combination of several elements so that if one element is cracked, the rigidity of the frame is still large and the deflection is still small. The load capacity based on theoretical calculations results and test results data is shown in Table II.

At a load of 9500 kg with a deflection of 7.55 mm, the loading was stopped due to a frame maximum loading capacity of 10000 kg. But the curve still shows a linear curve even though the crack has crept up to the top end of the element. After releasing the load slowly, the deflection continues to decreased until 0.64 mm or close to zero, this shows that the bamboo reinforced concrete frame has good energy absorption. Likewise in the load (P) vs strain (ϵ) relationship as shown in Figure 6 shows a linear curve, although it slightly shows deflection that up and down due to the transfer of tensile forces from bamboo reinforcement to concrete.

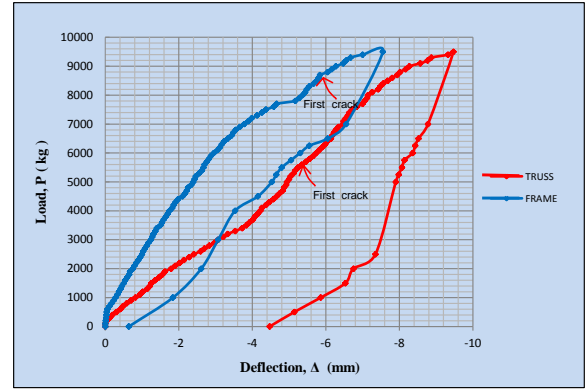


Fig. 5. The relationship of load (P) vs deflection (Δ) of bridge frame

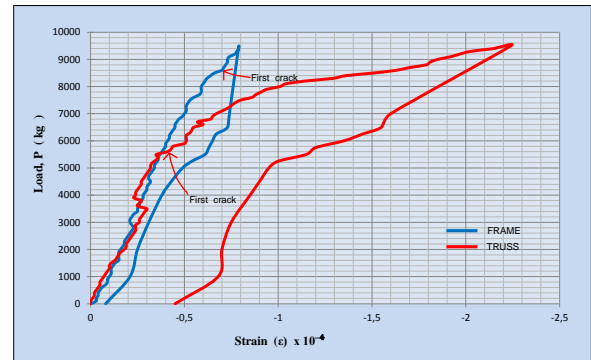


Fig. 6. The relationship of load (P) vs strain (ϵ) of bridge frame

Table II: Data of test results from bamboo reinforced concrete bridge frame

Model	Theoretical results	Experimental results (stoppage of load at 9500 kg)					
	Maximum load, P_o (kg)	Initial crack load (kg)	Stop load (kg)	Deflection		The ratio of the initial crack between experimental / theoretical (%)	Information
				When the initial crack (mm)	When the stopping load (mm)		
Frame Model	42924 (tensile)	8700	9500	5.84	7.55	20.27	The initial crack occurs at the knot point of the roller support
	-46729 (compressive)						
Truss Model	42924 (tensile)	5500	9500	5.24	9.47	12.81	The initial crack occurs at the knot point of the hinge support
	-46729 (compressive)						

Figure 5 and Figure 6 show that a bamboo reinforced concrete frame with a rigid portal model "frame" has stiffness and higher load capacity than the stiffness of the joint frame model "Truss". This is because the reinforced concrete frame

has a large self-weight which cannot be ignored. The facts in the field, a large self-weight will cause the moment can not be zero at the end of each frame element, and the knot point of the frame behaves elastic clasps. Therefore, reinforcement

detail of reinforced concrete frames needs to be reviewed whether there is bending or not. However, reinforced concrete frames do not fully behave as "frames", this is evidenced by crack patterns resembling crack patterns on pure "truss" elements, namely cracks perpendicular to frame elements and cut off frame elements as shown in Figure 7 and Figure 8.

B. The crack pattern of the bridge frame

Figure 8 shows the frame crack pattern with a rigid portal model called "frame" and Figure 7 shows the frame crack pattern with the joint frame model called "Truss". Both crack patterns show the same crack pattern. The initial crack shows crack due to tensile forces, this can be seen in the crack pattern that is perpendicular to the axis of the frame element and cuts the surface of the underside frame element. Shear cracks due to bending have not been seen due to loading stopped at a load of 9500 kg according to the frame loading capacity of 10000 kg. The difference between the crack pattern of the rigid portal model "frame" and the joint frame model "Truss" lies in the crack position, ie the cracks of the "frame" model approach the roller support, while the "truss" model approaches the hinge support. The crack width of the two models when the stopping load is still smaller than 0.3 mm so that the frame can still be used ACI-318 (2014) [12].

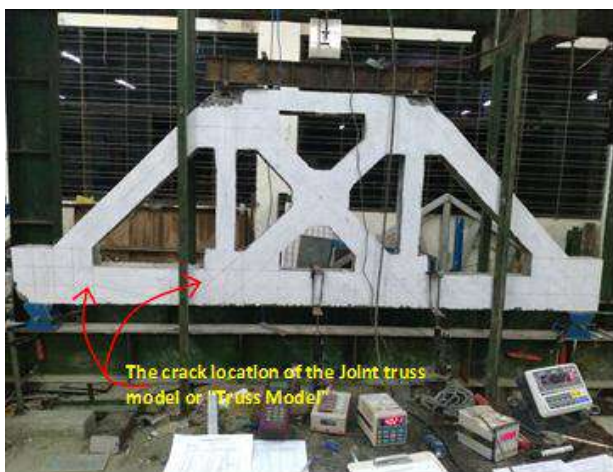


Fig. 7. The crack pattern of the joint truss model or "Truss Model"

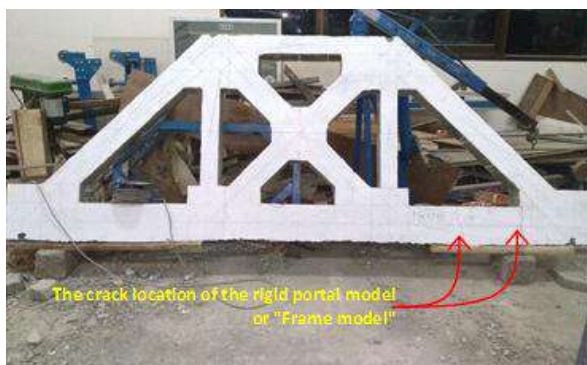


Fig. 8. The crack pattern of the rigid portal model or "Frame model"

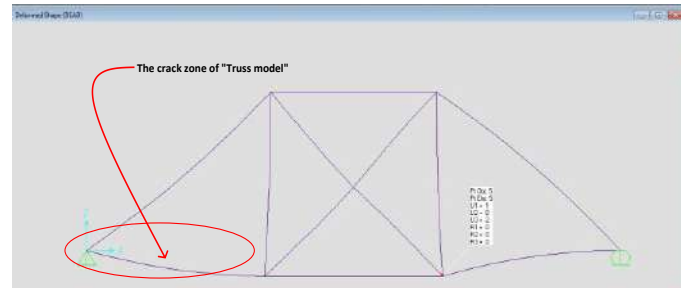


Fig. 9. The deformation of the joint truss model or "Truss Model"

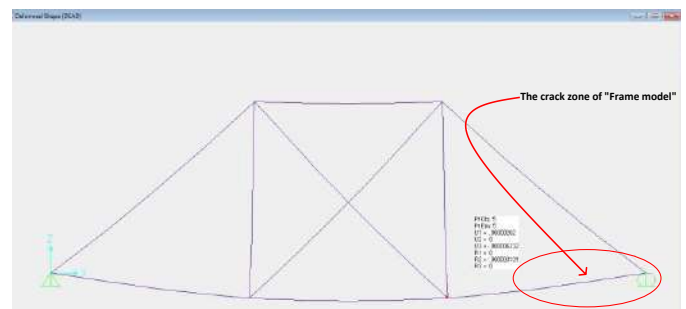


Fig. 10. The deformation of the rigid portal model or "Frame model"

The difference between the two crack locations can be validated with a computer program through the deformation that occurs. The difference deformation and deflection that occur in the two models can be seen in the results of computer program simulations as shown in Figure 9 and Figure 10. The maximum deformation of the "frame" model is on the element or the knot point near the roller support, while the maximum deformation of the "truss" model is at the knot point near the hinge support. Simulation with a computer program on the "truss" model is carried out by releasing the frame element. Another difference from the two frame models is the initial crack load value, the initial cracking load of the "frame" model occurs at an 8700 kg and the initial crack load of the "truss" model occurs at 5500 kg.

IV. CONCLUSION

- From the relationship of load vs. deflection and load vs. strain of the reinforced concrete bridge frame with a rigid portal model or "frame model" has higher rigidity and load capacity when compared to the joint frame model or "truss model"
- The initial crack load capacity of the reinforced concrete bridge frame with frame model is greater until 36.78% when compared to the truss model
- The bamboo reinforced concrete bridge frames with rigid portal models and joint frame models have the same crack pattern and different deformations.
- The application of the details of flexural reinforcement or

double-sided reinforcement, namely tensile reinforcement and compressive reinforcement on a bamboo reinforced concrete bridge frame can increase the load capacity and rigidity of the bridge frame when compared to the symmetry reinforcement model or the truss reinforcement model.

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