

**IN THIS ISSUE**

Omicronvirus Data  
Analytics

Experimental Study of  
Vibrations

Development of New  
Profile of Teeth

Determination of Model  
Parameters



London  
Journals Press



IMAGE: OBSERVATORY WITH STAR  
TRAILS ON MOUNTAINS FOR  
CLEAR SKY

[www.journalspress.com](http://www.journalspress.com)

**LONDON JOURNAL OF  
ENGINEERING RESEARCH**

Volume 22 | Issue 5 | Compilation 1.0

Print ISSN: 2631-8474  
Online ISSN: 2631-8482  
DOI: 10.17472/LJER





London Journal of Engineering Research

Volume 22 | Issue 5 | Compilation 1.0

## PUBLISHER

London Journals Press  
1210th, Waterside Dr, Opposite Arlington Building, Theale, Reading  
Phone:+444 0118 965 4033 Pin: RG7-4TY United Kingdom

## SUBSCRIPTION

*Frequency:* Quarterly

Print subscription  
\$280USD for 1 year  
\$500USD for 2 year  
*(color copies including taxes and international shipping with TSA approved)*

Find more details at <https://journalspress.com/journals/subscription>

## ENVIRONMENT

London Journals Press is intended about protecting the environment. This journal is printed using led free environmental friendly ink and acid-free papers that are 100% recyclable.

Copyright © 2022 by London Journals Press

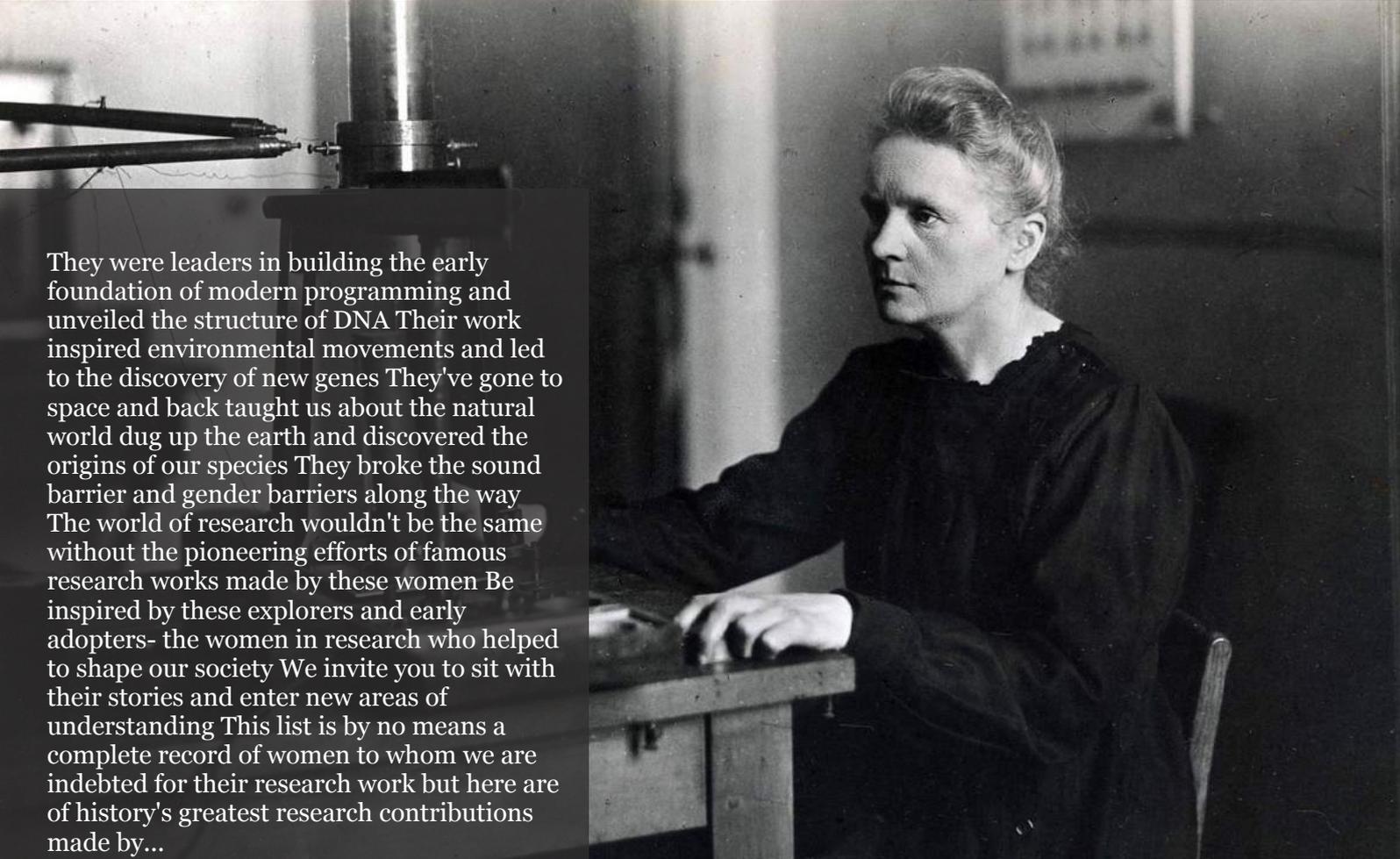
All rights reserved. No part of this publication may be reproduced, distributed, or transmitted in any form or by any means, including photocopying, recording, or other electronic or mechanical methods, without the prior written permission of the publisher, except in the case of brief quotations embodied in critical reviews and certain other noncommercial uses permitted by copyright law. For permission requests, write to the publisher, addressed "Attention: Permissions Coordinator," at the address below. London Journals Press holds all the content copyright of this issue. London Journals Press does not hold any responsibility for any thought or content published in this journal; they belong to author's research solely. Visit <https://journalspress.com/journals/privacy-policy> to know more about our policies.

### London Journals Press Headquarters

1210th, Waterside Dr,  
Opposite Arlington  
Building, Theale, Reading  
Phone:+444 0118 965 4033  
Pin: RG7-4TY  
United Kingdom

Reselling this copy is prohibited.

Available for purchase at [www.journalspress.com](http://www.journalspress.com) for \$50USD / £40GBP (tax and shipping included)



They were leaders in building the early foundation of modern programming and unveiled the structure of DNA Their work inspired environmental movements and led to the discovery of new genes They've gone to space and back taught us about the natural world dug up the earth and discovered the origins of our species They broke the sound barrier and gender barriers along the way The world of research wouldn't be the same without the pioneering efforts of famous research works made by these women Be inspired by these explorers and early adopters- the women in research who helped to shape our society We invite you to sit with their stories and enter new areas of understanding This list is by no means a complete record of women to whom we are indebted for their research work but here are of history's greatest research contributions made by...

Read complete here:  
<https://goo.gl/1vQ3lS>

## Women In Research



## Computing in the cloud!

Cloud Computing is computing as a Service and not just as a Product Under Cloud Computing...

Read complete here:  
<https://goo.gl/VvHC7z>



## Writing great research...

Prepare yourself before you start Before you start writing your paper or you start reading other...

Read complete here:  
<https://goo.gl/np73jP>



- i. Journal introduction and copyrights
  - ii. Featured blogs and online content
  - iii. Journal content
  - iv. Editorial Board Members
- 

1. Some Physiological Responses of the Catfish, *Clarias Gariepinus* (Burchell 1822) Fed Cassava (*Manihot esculenta*) Peel and *Leucaena Leucocephala* Leaf Meal. **1-10**
  2. Experimental Study of Vibrations of Cross-Rod Spatial Structures. **11-18**
  3. Omicronvirus Data Analytics using Deep Learning Technique. **19-28**
  4. Modelling of the resilient modulus ( $M_r$ ) of lateritic soils in tropical Africa (Burkina Faso and Senegal): determination of model parameters  $k_1$ ,  $k_2$  and  $k_3$  (Thom and Brown (1987), Uzan (1985) and the NCHRP 1-28A (2004) (National Cooperative Highway Research Program). **29-40**
  5. Development of a New Profile of the Teeth of a Ginning Saw and its Results. **41-48**
- 

- v. London Journals Press Memberships

# Editorial Board

Curated board members



Dr. Robert Caldelli

---

CNIT - National Interuniversity Consortium for Telecommunications Research Unit at MICC Media Integration and Communication Center Ph.D., Telecommunications and Computer Science Engineering, University of Florence, Italy

Dr. Xiaoxun Sunx

---

Australian Council for Educational Research Ph.D., Computer Science University of Southern Queensland

Dariusz Jacek Jakóbczak

---

Department of Electronics and Computer Science, Koszalin University of Technology, Koszalin, Ph.D., Computer Science, Japanese Institute of Information Technology, Warsaw, Poland.

Dr. Yi Zhao

---

Harbin Institute of Technology Shenzhen Graduate School, China Ph.D., The Hong Kong Polytechnic University Hong Kong

Dr. Rafid Al-Khannak

---

Senior Lecturer Faculty of Design, Media and Management Department of Computing Ph.D Distributed Systems Buckinghamshire New University, United Kingdom

Prof. Piotr Kulczycki

---

Centre of Information Technology for Data Analysis Methods, Systems Research Institute, Polish Academy of Sciences, Faculty of Physics and Applied, Computer Science AGH University of Science and Technology, Poland

Dr. Shi Zhou

---

Senior Lecturer, Dept of Computer Science, Faculty of Engineering Science, Ph.D., Telecommunications Queen Mary, University, London

Prof. Liying Zheng

---

School of Computer Science and Technology, Professor for Computer Science, Ph.D., Control Theory and Control Engineering, Harbin Engineering University, China

Dr. Saad Subair

---

College of Computer and Information Sciences,  
Alazaeim Alazhari University, Khartoum North,  
Sudan, Associate Professor of Computer Science  
and Information Ph.D., Computer Science  
Bioinformatics, University of Technology  
Malasiya

Gerhard X Ritter

---

Emeritus Professor, Department of Mathematics,  
Dept. of Computer & Information,  
Science & Engineering Ph.D.,  
University of Wisconsin-Madison, USA

Dr. Ikvinderpal Singh

---

Assistant Professor, P.G. Deptt. of Computer  
Science & Applications, Trai Shatabdi GGS  
Khalsa College, India

Prof. Sergey A. Lupin

---

National Research,  
University of Electronic Technology Ph.D.,  
National Research University of Electronic  
Technology, Russia

Dr. Sharif H. Zein

---

School of Engineering,  
Faculty of Science and Engineering,  
University of Hull, UK Ph.D.,  
Chemical Engineering Universiti Sains Malaysia,  
Malaysia

Prof. Hamdaoui Oualid

---

University of Annaba, Algeria Ph.D.,  
Environmental Engineering,  
University of Annaba,  
University of Savoie, France

Prof. Wen Qin

---

Department of Mechanical Engineering,  
Research Associate, University of Saskatchewan,  
Canada Ph.D., Materials Science,  
Central South University, China

Luisa Molari

---

Professor of Structural Mechanics Architecture,  
University of Bologna,  
Department of Civil Engineering, Chemical,  
Environmental and Materials, PhD in Structural  
Mechanics, University of Bologna.

Prof. Chi-Min Shu

---

National Yunlin University of Science  
and Technology, Chinese Taipei Ph.D.,  
Department of Chemical Engineering University of  
Missouri-Rolla (UMR) USA

Prof. Te-Hua Fang

---

Department of Mechanical Engineering,  
National Kaohsiung University of Applied Sciences,  
Chinese Taipei Ph.D., Department of Mechanical  
Engineering, National Cheng Kung University,  
Chinese Taipei

Dr. Fawad Inam

---

Faculty of Engineering and Environment,  
Director of Mechanical Engineering,  
Northumbria University, Newcastle upon Tyne,  
UK, Ph.D., Queen Mary, University of London,  
London, UK

Dr. Rocio Maceiras

---

Associate Professor for Integrated Science,  
Defense University Center, Spain Ph.D., Chemical  
Engineering, University of Vigo, SPAIN

Muhammad Hassan Raza

---

Postdoctoral Fellow, Department of Engineering  
Mathematics and Internetworking,  
Ph.D. in Internetworking Engineering,  
Dalhousie University, Halifax Nova Scotia,  
Canada

Rolando Salgado Estrada

---

Assistant Professor,  
Faculty of Engineering, Campus of Veracruz,  
Civil Engineering Department, Ph D.,  
Degree, University of Minho, Portugal

Abbas Moustafa

---

Department of Civil Engineering,  
Associate Professor, Minia University, Egypt, Ph.D  
Earthquake Engineering and Structural Safety,  
Indian Institute of Science

Dr. Babar shah

---

Ph.D., Wireless and Mobile Networks,  
Department of Informatics,  
Gyeongsang National University,  
South Korea

Dr. Wael Salah

---

Faculty of Engineering,  
Multimedia University Jalan Multimedia,  
Cyberjaya, Selangor, Malaysia, Ph.D, Electrical and  
Electronic Engineering, Power Electronics  
and Devices, University Sians Malaysia

Prof. Baoping Cai

---

Associate Professor,  
China University of Petroleum,  
Ph.D Mechanical and Electronic Engineering,  
China

Prof. Zengchang Qin

---

Beijing University of Aeronautics  
and Astronautics Ph.D.,  
University of Bristol,  
United Kingdom

Dr. Manolis Vavalis

---

University of Thessaly,  
Associate Professor, Ph.D.,  
Numerical Analysis,  
University of Thessaloniki, Greece

Dr. Mohammad Reza Shadnam

---

Canadian Scientific Research and Experimental  
Development Manager-Science,  
KPMG LLP, Canada, Ph.D., Nanotechnology,  
University of Alberta, Canada

Dr. Gang Wang

---

HeFei University of Technology,  
HeFei, China, Ph.D.,  
FuDan University, China

Kao-Shing Hwang

---

Electrical Engineering Dept.,  
Nationalsun-Yat-sen University Ph.D.,  
Electrical Engineering and Computer Science,  
Taiwan

Mu-Chun Su

---

Electronics Engineering,  
National Chiao Tung University, Taiwan,  
Ph.D. Degrees in Electrical Engineering,  
University of Maryland, College Park

Zoran Gajic

---

Department of Electrical Engineering,  
Rutgers University, New Jersey, USA  
Ph.D. Degrees Control Systems,  
Rutgers University, United States

Dr. Homero Toral Cruz

---

Telecommunications,  
University of Quintana Roo, Ph.D.,  
Telecommunications Center for Research  
and Advanced Studies National Polytechnic  
Institute, Mexico

Nagy I. Elkalashy

---

Electrical Engineering Department,  
Faculty of Engineering,  
Minoufiya University, Egypt

Vitoantonio Bevilacqua

---

Department of Electrical and Information  
Engineering Ph.D., Electrical Engineering  
Polytechnic of Bari, Italy

Dr. Sudarshan R. Nelatury

---

Pennsylvania State University USA Ph.D., Signal  
Processing Department of Electronics and  
Communications Engineering,  
Osmania University, India

Prof. Qingjun Liu

---

Professor, Zhejiang University, Ph.D.,  
Biomedical Engineering,  
Zhejiang University, China



Scan to know paper details and  
author's profile

# Some Physiological Responses of the Catfish, *Clarias Gariepinus* (Burchell 1822) Fed Cassava (*Manihot esculenta*) Peel and *Leucaena* *Leucocephala* Leaf Meal

*Adewumi, A. A., Idowu, E.O. , Obe, B.W., Abesin, O. & Odeyemi, O.M.*

*Ekiti State University*

## ABSTRACT

This study examined the physiological responses (hematology and enzyme characteristics) of *Clarias gariepinus* juveniles (mean weight  $29.69 \pm 0.91\text{g}$ ) fed diets with varying levels of fermented cassava (*Manihot esculenta*) peel and *Leucaena leucocephala* leaf meal (CPLM), for a period of 10 weeks in the laboratory. Seven iso-caloric and iso-nitrogenous diets were formulated containing 0%, 20%, 30%, 40%, 50%, 60% and 70% CPLM maize replacements tagged diets D<sub>0</sub>; D<sub>20</sub>; D<sub>30</sub>; D<sub>40</sub>; D<sub>50</sub>; D<sub>60</sub> and D<sub>70</sub> respectively.

**Keywords:** proximate, disorders, glucanase, amylase, anti-nutrients, haematology.

**Classification:** DDC Code: 639.37490967 LCC Code: SH125.S8

**Language:** English



LJP Copyright ID: 392911

Print ISSN: 2631-8474

Online ISSN: 2631-8482

London Journal of Engineering Research

Volume 22 | Issue 5 | Compilation 1.0





# Some Physiological Responses of the Catfish, *Clarias Gariepinus* (Burchell 1822) Fed Cassava (*Manihot esculenta*) Peel and *Leucaena Leucocephala* Leaf Meal

Adewumi, A. A.<sup>α</sup>, Idowu, E.O.<sup>σ</sup>, Obe, B.W.<sup>ρ</sup>, Abesin, O.<sup>ω</sup> & Odeyemi, O.M.<sup>¥</sup>

## ABSTRACT

This study examined the physiological responses (hematology and enzyme characteristics) of *Clarias gariepinus* juveniles (mean weight 29.69 ± 0.91g) fed diets with varying levels of fermented cassava (*Manihot esculenta*) peel and *Leucaena leucocephala* leaf meal (CPLM), for a period of 10 weeks in the laboratory. Seven iso-caloric and iso-nitrogenous diets were formulated containing 0%, 20%, 30%, 40%, 50%, 60% and 70% CPLM maize replacements tagged diets D<sub>0</sub>; D<sub>20</sub>; D<sub>30</sub>; D<sub>40</sub>; D<sub>50</sub>; D<sub>60</sub> and D<sub>70</sub> respectively.

The results showed that the final weight gain, DWG, PWG, FCR and PER of the fish fed diets diet D<sub>0</sub>, D<sub>20</sub>, D<sub>30</sub>, D<sub>40</sub>, D<sub>50</sub> were not significantly different ( $P > 0.05$ ) from one another, but were significantly higher ( $P < 0.05$ ) than those of the fish fed diets D<sub>60</sub>. The SGR and survival were not significantly different ( $P > 0.05$ ) from one another. The white blood cell (WBC) and lymphocytes ranged between 7.35-8.14 × 10<sup>3</sup> mm<sup>-3</sup> and 63.00-72.00% respectively. There was increase in the WBC and lymphocytes as the CPLM increased in the diet. The results obtained for MCH and MCV showed that the fishes fed diet containing 50% fermented cassava peel meal had the highest values of 47.00 pg and 160.00 fl for MCH and MCV respectively and the least values of 25.56 pg- 88.89 fl were recorded for MCH and MCV in fish fed diets D<sub>60</sub> to D<sub>70</sub>. Considering these effects, it is recommended that cassava peel-Leucaena leaf meal replacement beyond 50% should be discouraged, as replacement beyond this optimum value have indicated poor growth and physiological performances. Fish

farmers especially in resource poor regions of the world can take advantage of this ingredient as a replacement for more expensive maize when formulating feed for fish in aquaculture.

**Keywords:** proximate, disorders, glucanase, amylase, anti-nutrients, haematology.

**Author α σ ω:** Dept. of Zoology and Envir. Biology, Ekiti State University, Ado-Ekiti.

**ρ:** Dept. of Aquaculture and Fisheries, Ekiti State University, Ado-Ekiti.

**¥:** Dept. of Aquaculture and Fish. Management, University of Ibadan, Ibadan.

## I. INTRODUCTION

Feed is one of the major inputs in aquaculture production and fish feed technology is one of aquaculture least developed sectors of aquaculture, particularly in Africa and other developing countries of the world. FAO (1993) have emphasized the utmost importance of using local feed resources as the key driving force to increase the productivity of fish. High cost of fish feed was observed as one of the problems hampering aquaculture development in Nigeria (Adewumi, 2015). Expensive feeds will marginalize or even nullify the profitability of fish farming thereby incapacitating the expansion of farms to increase production resulting in the scarcity of the commodity (fish) and eventually high cost of the few available ones to the disadvantage of the consumers (Adikwu, 1992).

Cassava peel as a cheap carbohydrate source is capable of supplying adequate calories to *Clarias gariepinus* fingerlings/juvenile with improved

protein value, through fermentation with biomass from organic sources (Ijaiya, 2001). The starch in cassava is highly digestible when compared to that of maize due to the high content of amylopectin (Talthawan et al., 2002). However, cassava peel, as an energy component of the test diets contains some hydrogen cyanide (HCN) derivatives that have been shown to be toxic to livestock (McDonald et al., 1995) and therefore limits the use of cassava peels in the raw state, as feedstuff.

Phytate, found in cassava products binds with phosphorus in diets and render it non bio-available to any animal that is non-ruminant. Besides, phytate has also been reported to form complexes with proteins at both low and high pH values. These complex formations alter the protein structure, which may result in decreased protein solubility, enzymatic activity, and proteolytic digestibility. In order to prevent goitrogenetic and other neuropathological effect on animals, it will be necessary to process the peels before consumption.

Studies on the use of cassava meal in fish feed indicate that cassava can replace the conventional energy feed ingredients such as maize, broken rice and sorghum, which are commonly used in animal diet in most parts of Africa (Akinfala and Tewe, 2001). Cassava has been successfully used to replace maize in *Clarias gariepinus* fingerlings (Abu et al., 2010; Olukunle, 2006). Inclusion of whole cassava root meal in the diet of fish enhanced growth and survival. Though cassava is high in carbohydrate content, it is however low in protein content (Tewe and Egbunike, 2007) and has a very high crude fibre. Therefore, the need to fortify the peel with protein is necessary. *Glyricidia sepium* leaves have been chosen in this study to boost its protein value.

Hematological parameters are good indicators of physiological status of animals and have been found useful for disease prognosis and for therapeutic and feed stress monitoring (Togun et al., 2009; Aro and Akinmoegun (2012).

Hematological constituents reflect the physiological responsiveness of the animal to its internal and external environments which include

feeding. Hematological values could serve as baseline information for comparisons of nutrient deficiency. Haematological components of blood are also valuable in monitoring feed toxicity especially with feed constituents that affect the formation of blood in culture fisheries (Oyawoye and Ogunkunle, 1998). Animals with good blood composition are likely to show good performance (Isaac et al., 2013).

In view of the above, the present research was set up with the objective of determining the optimum replacement level of maize meal by fermented cassava peel meal (CPLM) and the effects on growth, haematology and digestive enzymes of *Clarias gariepinus*.

## II. MATERIALS AND METHODS

### 2.1 Procurement of Materials

The study was carried out at the Animal House of the Department of Zoology and Environmental Biology, Ekiti State University (EKSU), Ado Ekiti, Ekiti State, Nigeria. Fresh cassava peels (2kg) were obtained from Aba Ebira, Iworoko Ekiti, Ekiti State, and fresh *Leucaena leucocephala* leaves (1kg) were harvested from the Department of Plant Science, EKSU, Ado-Ekiti. Fresh poultry dropping (1kg) was collected from a poultry farm in Iworoko Ekiti. A total of healthy, one hundred and eighty (180) samples of juvenile *C. gariepinus* (av. weight  $29.69 \pm 0.91g$ ) were obtained from Mr. Olatunji's farm, Ibadan, Oyo State and transported, in an aerated container, to the Animal House of the Dept. of Zoology and Environmental Biology, EKSU, Ado-Ekiti.

### 2.2 Ingredients and Diet Preparation

Two kg of fresh cassava peel wastes collected were cut into small pieces of about 2cm<sup>2</sup> sizes. These were exposed to the sun for about 5hours, to wilt. The leucaena leaves were added to poultry droppings and mixed together with the cassava peels. These were packed into black polyvinyl bag, tied and left to ferment for 21 days. After 21 days, the mixture was spread out and sundried for four days after which it was milled, with a hammer mill, into powdery form, tagged fermented cassava peel meal (CPLM). The other feed

ingredients; maize, soya beans, 78% Danish fishmeal, ground nut oil, salt, fish premix, lysine and rice bran, were obtained from Metrovet Venture, Ado Ekiti. They were all in milled form, ready for use in feed formulation.

A 2g sample of the CPLM was taken to the lab for proximate analysis (moisture content, crude protein, ash, fibre, fat and carbohydrate) at the Central Science Laboratory of Federal University of Technology, Akure, Ondo state. Based on the crude protein content of the CPLM, seven diets containing different levels of the CPLM replacement for maize (0%, 20%, 30%, 40%, 50%, 60% and 70%) tagged D0, D20, D30, D40, D50, D60 and D70 respectively, were prepared, using Pearson's method (Table 1).

### 2.3 Experimental Set Up

The fish were acclimatized for 2 weeks in plastic aquarium tanks, supplied with clean water and fed with conventional commercial fish feed twice daily (8.00am - 9.00am) and (6.00-7.00pm), in order to adapt to the environmental condition before the commencement of the study. After 2 weeks of acclimatization, the fish were fed with the test diets for eight (8) weeks in each plastic bowls. Eighteen bowls were randomly allocated in triplicates, to six treatment diets, and the fish were randomly distributed into the bowls, at a stocking density of 15 juveniles per bowl. Feeding was carried out twice daily. The left-over feeds and faeces were siphoned off promptly and dead fish were promptly removed to prevent contamination.

**Table 1:** Composition of Experimental Diets (100-1dry Matter Basis) With Varying Inclusion Levels of Fermented Cassava Peel Meals (CPLM).

Ingredient	Diet						
	D0	D20	D30	D40	D50	D60	D70
Fish Meal	28	28	28	28	28	28	28
CPLM	0	3	6	9	12	15	18
Maize	30	27	24	21	18	15	12
Soybeans	19	19	19	19	19	19	19
Rice bran	20	20	20	20	20	20	20
Oil	1	1	1	1	1	1	1
Salt	1	1	1	1	1	1	1
Vit. premix	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Lysine	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Methionine	0.2	0.2	0.2	0.2	0.2	0.2	0.2

### 2.3 Collection of Blood Samples

Blood samples of a set of three fish were collected at the beginning of the feeding trial (week 0) and at the end of trial (week 8) from each set in each bowl. This blood sample was withdrawn from the caudal peduncle, following the procedure described by Stockopf (1993), Joshi et al. (2000a) and Dienne and Olumuji (2014). Two ml of the blood sample from each fish was collected with 2ml syringe and needle and put in ethylenediamine tetra-acetic acid (EDTA) bottle. The samples were taken to the laboratory for hematological analysis which involves

measurement of erythrocyte values: Haemoglobin (Hb), estimated by cyanomethemoglobin method, red blood cells (RBC) and white blood cell (WBC) counted by Neubauer's improved haemocytometer, using Hyem's and Turks solution as a diluting fluid respectively. The absolute erythrocyte indices [mean corpuscular haemoglobin concentration (MCHC); mean corpuscular haemoglobin (MCH) and mean cell volume (MCV)] were calculated respectively using standard formula described by Dacie and Lewis (2001) as follows;

- $MCHC (\%) = \frac{Hb \times 10}{PCV}$
- $MCH (pg) = \frac{Hb \times 10}{RBC}$
- $MCV (fl) = \frac{PCV \times 10}{RBC}$

#### 2.4 Crude Enzyme Preparation

Ten experimental fish from each sample collection were slaughtered and the gut regions of the fish were pooled, homogenized in an ice cold 20mM phosphate buffer pH 7.0 and the homogenates were centrifuged at 1200 rpm for 30 minutes at 40C. The supernatants were used as crude enzyme extracts without further purification. Benedict's qualitative reagents were used for the qualitative assay of glycosidases (carbohydrases) following the methods used by Fagbenro et al., (2005) and Olatunde et al. (1988). Glycosidases (maltase, cellulase, gluconase) were assayed in a reaction mixture containing 2.0 ml of phosphate buffer (pH 7.0), 0.4 ml of 1 % of substrate and 0.2 ml of the enzyme extract. The test and control samples were incubated for one hour in a water bath at 370C. Hydrolysis of polysaccharides and non-reducing disaccharides were determined in terms of the appearance of reducing properties using Benedict's reagents. An aliquot of 5.0 ml of the alkaline copper reagent of Benedict was added to 1.0 ml of the reaction mixture and heated for 30 minutes in a water bath at 1000C. The appearance of brick red to cream yellow precipitate was taken as an index of positive

reaction. Quantitative assays were conducted using the dinitrosalicylate (DNS) methods described by Plummer (1978). Each reaction mixture comprised 0.4 ml of 1% substrate, 0.2 ml phosphate buffer (pH 7.0), 1.6 ml of alkaline 3, 5-dinitrosalicylic acid reagent (DNSA) and 0.2 ml of the enzyme extract. The reaction mixtures for test and control samples were heated for 30 minutes in a water bath at 100C. Each of the mixtures was made to 4.0 ml by diluting with 1.6 ml distilled water. The amount of reducing sugars produced on enzymatic reaction was estimated colorimetrically and the absorbance read at 550 nm on a spectrophotometer.

#### 2.5 Statistical Analysis

All data collected were subjected to analysis of variance (ANOVA). Comparisons among diets means were carried out by Duncan Multiple Range Test (Duncan 1955) at a significant level of 0.05. All computation was performed using statistical package SPSS 15.0 (SPSS Inc., Chicago, IL, U.S.A).

### III. RESULTS

Table 1 shows the percentage composition of the fermented and unfermented cassava peel meals respectively, while Table 2 shows the proximate compositions of the seven diets formulated for the feeding trial. The crude protein content of the diet ranged between 39.32 and 43.06%, crude lipid, 4.40-5.44% and crude fibre, 4.96-8.44%.

**Table 1:** The Proximate Composition (G/100g DM\*) of Cassava Peels Used in Formulating the Experimental Diets

PARAMETER	COMPOSITION	
	Unfermented	Fermented
Crude protein	5.3	11.4
Lipid	1.2	3.5
Ash	5.9	6.3
Crude Fibre	20.9	7.1
Moisture	5.2	5.7
Carbohydrate	61.5	66.0

DM = dry matter

**Table 2:** The Proximate Composition of the Experimental Diets Fed to *C. Gariepinus*, During the Period of Study

INGREDIENTS	DIETS						
	Do	D20	D30	D40	D50	D60	D70
Crude protein	40.24	43.06	41.56	40.79	39.77	39.78	39.32
Moisture	9.96	7.31	8.13	7.76	7.08	7.13	8.25
Ether extract	5.17	5.08	5.41	5.44	4.55	4.57	4.40
Crude fiber	4.96	5.85	6.82	6.91	7.02	7.65	8.44
Ash	5.78	5.67	5.32	5.34	5.72	5.89	6.91
Nitrogen Free extract	33.89	33.03	32.76	33.76	35.86	34.98	32.68

*NFE, Nitrogen free extract*

Table 3 shows the hematological composition of fish fed with varying fermented cassava peel meal-based diet during the experiment. The Packed cell volume (PCV) results showed that the fish fed the control and D20 had increase in PCV values (32.00% and 30.00% respectively) when compared with the initial value. These values were not statistically significant ( $p > 0.05$ ) from one another. The fish fed diets D30 to D60 showed a decrease in the PCV. White blood cells (WBC) result showed that fishes fed D30 to D60 had higher values than fishes fed control and D20 diets. The highest value of  $8.02 \times 10^3 \text{ mm}^3$  was recorded in fish fed diet D70.

The red blood cell (RBC) showed a decrease as fermented cassava peel meal increased in the diet. The fish fed control diet and D20 recorded values of  $3.60 \times 10^3 \text{ mm}^{-3}$  and  $3.20 \times 10^3 \text{ mm}^{-3}$  respectively and were not significantly different ( $P > 0.05$ ) from one another, but were significantly different from fish fed diet D30 to D60.

Hemoglobin (Hb) decreased in fishes fed diet containing D20 to D60. The fish fed the control diet and D20 recorded values of 9.20 g/100 ml and 9.00 g/100 ml respectively. These values showed a significant ( $P < 0.05$ ) difference from fishes fed diet containing D30 to D60.

Lymphocyte (LYMPH) count showed an increase as the level of CPLM increased in the diet. The highest value of 70.00% was recorded in fish fed diet D60 and D70 and the least value of 63.00% was recorded in fish fed the control diet. The highest value (30.77%) for MCHC was recorded in fish fed diet D30 and the lowest value (28.75%) was obtained in fish fed the control diet. The results obtained for MCH and MCV showed that the fishes fed diet D50 had the highest values of 47.00 pg and 160.00 fl for MCH and MCV respectively and the least values of 25.56 pg and 88.89 fl were recorded for MCH and MCV in fish fed D20 diet.

**Table 4:** Hematological Composition of *Clarias Gariepinus* Juveniles Fed With Varying Levels of Fermented Cassava Peel Meal-Based Diet

Parameter	Do	D20	D30	D40	D50	D60	D70
PCV %	27.80 <sup>b</sup>	32.00 <sup>a</sup>	30.00 <sup>a</sup>	27.00 <sup>b</sup>	27.50 <sup>ab</sup>	24.00 <sup>c</sup>	24.00 <sup>c</sup>
WBC ( $10^3 \text{ mm}^{-3}$ )	7.20 <sup>c</sup>	7.45 <sup>bc</sup>	7.50 <sup>bc</sup>	7.60 <sup>b</sup>	7.60 <sup>b</sup>	8.00 <sup>a</sup>	8.02 <sup>a</sup>
RBC ( $10^6 \text{ mm}^{-3}$ )	2.80 <sup>b</sup>	3.60 <sup>a</sup>	3.20 <sup>a</sup>	2.00 <sup>b</sup>	1.90 <sup>b</sup>	1.70 <sup>b</sup>	1.50 <sup>bc</sup>
Hb (g/100ml)	8.00 <sup>b</sup>	9.20 <sup>a</sup>	9.00 <sup>a</sup>	8.10 <sup>b</sup>	8.00 <sup>b</sup>	7.00 <sup>c</sup>	7.05 <sup>b</sup>
LYMPH (%)	60.00 <sup>c</sup>	63.00 <sup>b</sup>	63.02 <sup>a</sup>	64.00 <sup>a</sup>	64.05 <sup>b</sup>	70.00 <sup>a</sup>	70.00 <sup>a</sup>
MCHC (%)	28.78 <sup>ab</sup>	28.75 <sup>ab</sup>	29.00 <sup>a</sup>	29.02 <sup>a</sup>	29.00 <sup>a</sup>	30.17 <sup>a</sup>	30.38 <sup>a</sup>
MCH (pg)	28.57 <sup>cd</sup>	25.56 <sup>d</sup>	28.13 <sup>cd</sup>	40.50 <sup>b</sup>	42.11 <sup>b</sup>	36.84 <sup>c</sup>	47.00 <sup>a</sup>
MCV (fl)	100.00 <sup>c</sup>	88.89 <sup>d</sup>	93.75 <sup>d</sup>	93.00 <sup>b</sup>	92.84 <sup>b</sup>	133.33 <sup>b</sup>	160.00 <sup>a</sup>

Figures on the same row having the same superscript are not significantly different ( $p > 0.05$ ).

PVC = Packed cell volume; WBC = white blood cell; RBC = red blood cell; Hb = hemoglobin; LYMP = lymphocyte; MCHC = mean corpuscular hemoglobin concentration; MCH = mean

corpuseular hemoglobin; MCV=mean corpuseular volume.

Digestive enzyme assays in the gut of *Clarias gariepinus* (Table 3) indicated significant difference ( $P < 0.05$ ) between the gut amylase activity of the fish fed the control diet and the other dietary treatments, with D60 showing the least activity. Sucrase activity increased with increase in CPLM level, while maltase activity was

not significantly different ( $P = 0.05$ ) from one another. The glucanase activity of the fish fed the various diets was not significantly different ( $P > 0.05$ ) from one another, but lower than the initial value. Cellulase activity decreased at lower CPLM level while there was no significant difference ( $P > 0.05$ ) at higher level of CPLM inclusion.

**Table 5:** Sugar Degrading Enzyme Activity From the Gut (G) of Catfish (*Clarias Gariepinus*)

Diet	Amylase	Sucrase	Maltase	Glucanase	Cellulase
Initial	36.64 <sup>b</sup>	4.51 <sup>b</sup>	4.23 <sup>b</sup>	4.23 <sup>b</sup>	1.83 <sup>b</sup>
Do	70.47 <sup>a</sup>	7.26 <sup>a</sup>	4.82 <sup>b</sup>	4.64 <sup>a</sup>	2.92 <sup>a</sup>
D20	66.95 <sup>a</sup>	5.17 <sup>c</sup>	5.07 <sup>a</sup>	4.65 <sup>a</sup>	2.58 <sup>a</sup>
D30	42.58 <sup>a</sup>	12.47 <sup>a</sup>	4.59 <sup>a</sup>	4.19 <sup>a</sup>	1.76 <sup>ab</sup>
D40	41.58 <sup>a</sup>	10.86 <sup>a</sup>	4.52 <sup>a</sup>	4.19 <sup>a</sup>	2.04 <sup>ab</sup>
D50	37.53 <sup>a</sup>	14.29 <sup>a</sup>	4.86 <sup>ab</sup>	3.34 <sup>a</sup>	1.56 <sup>ab</sup>
D60	36.57 <sup>b</sup>	14.22 <sup>a</sup>	4.77 <sup>ac</sup>	1.01 <sup>a</sup>	1.00 <sup>bc</sup>
D70	33.54 <sup>b</sup>	15.12 <sup>a</sup>	5.01 <sup>ac</sup>	1.32 <sup>a</sup>	1.57 <sup>bc</sup>

Note: Samples with the same letter in a column are not significantly different at 5% level

#### IV. DISCUSSION

The potential of a feedstuff such as cassava peel and leaf meal in fish diets can be evaluated on the basis of its proximate chemical composition, which comprises the moisture content, crude protein, crude fibre, crude fat, total ash, carbohydrate and nitrogen free extract. The proximate composition of fermented cassava peel meal in the present investigation revealed that the crude protein content was 28.03%, crude fibre 18.87%, crude fat 2.25%, carbohydrate 48.00 and total ash 6.81%. These values as observed in this study fell within the range obtained by Sotolu, (2010). This confirmed the potential of fermented cassava peel meal as adequate animal feedstuff from nutritional point of view. A trial conducted by Oboh and Akindaunsi (2003) on the fermentation of cassava peels with a consortium of microorganism indicated a significant increase in protein content and digestibility of the microbially treated peels, as against the untreated control. The authors concluded that such fermented cassava by-product could be a good supplement in compounding animal feed.

Antai and Mbongo (1994) observed that fermentation of cassava peels by pure culture of

*Saccharomyces cerevisiae* could increase its protein content from 2.4% in non-fermented cassava to 14.1% in fermented products. They reported that fermented cassava flour, with *S. cerevisiae*, enhanced the protein level (from 4.4% to 10.9%) and decreased the amount of cyanide content (Oboh and Akindahunsi, 2005).

Noomhorm et al. (1992) reported that the conversion of a part of the starch in cassava root meal to protein by microbes, during the process of solid-state fermentation, has great potential as a means of improving the feed value of cassava root meal. As observed in this work, Adeyemi and Sipe (2004) also reported an improvement in crude protein concentration of cassava root when fermented with rumen filtrate with or without ammonium sulphate as the source of nitrogen.

Adeyemi et al. (2004) obtained a value of 237.8 % increase in the crude protein value of whole cassava root meal fermented with rumen filtrate using caged layer waste as source of nitrogen. Ubalua and Ezeronye (2008) have identified fermentation as one of the less expensive means of increasing the protein quality of cassava and cassava wastes. Dried products from roots, which have been fermented or ensiled to detoxify the

HCN or to increase their protein content, are other ways of root processing (Khajareran and Khajareran, 2007).

All the haematological parameters measured in this study were within the recommended physiological ranges reported for *C. gariepinus*. The change in the blood characteristics of *C. gariepinus* caused by stress due to exposure to environmental pollutants, diseases or by pathogens have been studied by a number of workers especially in capture fisheries (Onusiriku and Ufodiye, 2000; Ezeri, 2001; Gabriel et al., 2001).

Blaxhall and Daisley (1973) reported the essence of using haematocrit to detect anaemic condition in fishes. The packed cell volume (PCV) range 24.00 to 32.00% observed in this study is within the range of 20 to 50% reported by Pietse et al. (1981), though, a decrease was observed in the level of PCV as the level of CPLM increased in the diet. Reduction in the concentration of the PCV in the blood usually suggests the presence of toxic factor. The decreasing trend observed in the PCV of this study may be attributed to the presence of remnants of some anti-nutrients, such as some levels of hydrogen cyanide, tannin and mimosine in the fermented cassava peel meal as reported by Oboh and Akindahunsi (2003).

White blood cells (WBC) and lymphocytes results recorded in this study showed an increase as the level of CPLM increased in the diet. White blood cells (WBC) and lymphocytes are the defence cells of the body. Douglas and Jane (2010) demonstrated that the amount has implication in immune responses and the ability of the animal to fight infection. High WBC count is usually associated with microbial infection in the circulatory system (Oyawoye and Ogunkunle, 1998). The value range of  $7.20 \times 10^3$  to  $8.02 \times 10^3$  mm<sup>-3</sup> recorded in this study for WBC was lower compared to  $16.13 \times 10^3$  to  $16.39 \times 10^3$  mm<sup>-3</sup> reported by Sotolu and Faturoti (2009).

Reduction in the red blood cells was observed as the level of fermented cassava peel meal increased in the diet. The range of RBC ( $1.50 \times 10^6$  to  $3.60 \times 10^6$  mm<sup>-3</sup>) recorded in this study is fairly

comparable with ( $1.70 \times 10^6$  to  $4.00 \times 10^6$  mm<sup>-3</sup>) reported by Bhasker and Rao (1990) and lesser than ( $2.24 \times 10^6$  to  $2.49 \times 10^6$  mm<sup>-3</sup>) reported by Sotolu and Faturoti (2009). The decrease in RBC could probably be due to the high concentration of anti-metabolites in the diet containing more fermented cassava peel meal.

The haemoglobin result showed a decrease as the CPLM increased in the diet. The haemoglobin range (7.00 – 9.20g/100ml) recorded were high and fell within the range (5.6 to 15.8 g/100 ml) reported for *Esox lucius* (Mulcahy, 1970). It also compared well with (8.70 g/100 ml) recorded for *C. gariepinus* (Sowunmi, 2003). These values were also higher than 4.46 g/100 ml reported for *Heterotis niloticus* (Fagbenro et al., 2000). The range of haemoglobin concentration recorded in this study is quite high and can be related to large anaerobic metabolism capacity of *C. gariepinus*. The decrease in the level of haemoglobin as CPLM increased in the diet could imply that diets having higher fermented cassava peel meal had negative effect on the blood.

The mean corpuscular volume (MCV) range (88.89 to 160.00 fl) recorded in this experiment was higher than (79.20 to 105.32fl) reported for *Heteroclaris* by Anyanwu et al. (2011), meanwhile the mean corpuscular haemoglobin concentration (MCHC) range (28.75 to 30.77%) recorded in this study compared fairly well with 30.70% reported for *C. gariepinus* from Asejire dam (Adedeji and Adegbile, 2011).

The MCH results showed that the fish fed diet D50 recorded the highest values. The MCH range (25.56 to 47.00 pg) obtained in this study was higher than the range (20.82 to 26.60 pg) reported for *Heteroclaris* fed *Carica papaya* leaf meal incorporated feed (Anyanwu et al., 2011). In recent years, good management practices have been advocated as effective ways of reducing stress in fish culture (Gabriel et al., 2007).

The enzymes present in the gut of the fish fed experimental diets were lower compared to the initial. The decreasing amylase activities in the fish, as the level of CPLM increases in the diets,

can be explained by lower dietary lipid levels. As reported here, Fountoulaki et al. (2005) also reported that in gilthead sea bream, amylase is affected by dietary fat level. Apata and Ojo (2000) suggested that the decrease in the effect of enzymes in the gut may be due to the change arising from the breaking down of high dietary fibre. *Clarias gariepinus* is physiologically equipped to cope with frequently and irregular meals as its digestive enzymes respond faster to feeding than those of eel (*Anguilla anguilla*) or carp (*Cyprinus carpio*) (Yalcin et al., 2001; Adeyemi et al., 2004).

From the above observations, it is evident that maize substitution with fermented cassava peel meal at a rate of up to 50% in catfish (*C. gariepinus*) fish feed have no adverse toxicological effect on the fish as revealed through the haematological indices and digestive enzyme assay. Essers et al., (1995) documented that 50% replacement of maize with cassava meal in broiler diet showed no depression in growth or unfavourable feed conversion ratio. This was also supported by Olurin et al. (2006) who reported a replacement level of 50% cassava meal for maize without a depressing growth in *Clarias gariepinus*.

## V. CONCLUSION

These investigations have revealed that up to 50% substitution rate of fermented cassava peel meal for fishmeal in catfish (*C. gariepinus*) fish feed produces no adverse toxicological effect on the fish as revealed through the haematological and digestive enzyme indices. By fermentation method, fish feed can therefore be produced at relatively cheaper cost by the use of commonly available cassava peels thus increasing the profits to fish farmers.

## REFERENCES

1. Abu, O. M.G.; Gabriel, U. U. and Akinrotimi, O. A. (2010): Performance and survival of hybrid catfish (heteroclaris) fed with whole cassava root meal as a replacement for maize, *J. of Tropical Agri., Food, Envi. and Extension.* 9 (3): 176 -183
2. Adedeji, O.B. and Adegbile, A.F. (2011). Comparative hematological parameters of the Bagrid catfish (*Chrysichthys nigrodigitatus*) and African catfish (*Clarias gariepinus*) from Asejire Dam South western Nigeria. *J. Appl. Sci. Res.* 7(7): 1042–1046.
3. Adeyemi, O. A. and Sipe. B. O. (2004). In vitro improvement in the nutritional composition of whole cassava root-meal by rumen filtrate fermentation. *Indian J. of Anim. Sci.* 74: 321-323.
4. Adeyemi, O. A., Eruvbetine, D., Oguntona, T. O., Dipeolu, M. A. and Agunbiade. J. A. (2004). Improvement in the crude protein value of whole cassava root meal by rumen filtrate fermentation. In: Proceedings of the 29th Annual Conference, Nigerian Society of Animal Production (NSAP) 17-21st March 2004. Akure, Nigeria. On Sustaining Livestock Production under Changing Economic Fortunes. Tukur H. M, Hassan W.A, Maigandi S.A, Ipinjolu J.K, Danejo A.I, Baba K.M, Olorede B.R (Eds). P1-5.
5. Adeyemi, S. O.; Bankole, N. O.; Adikwu, I. A. and Akombu, P. M. (2009). Food and feeding habits of some commercially important fish species in Gbedikere Lake, Bassa, Kogi State, Nigeria. *Internat. J. of Lakes and Rivers.* 2(1): 31 – 36.
6. Adewumi, A.A. (2015). Aquaculture in Nigeria: sustainability issues and challenges. *Dir. Res. J. of Agric. and Food Sci.* 3(12): 22 - 231.
7. Adikwu, I.A. (1992). Dietary carbohydrate utilization in Tilapia (*Oreochromis niloticus*). *J. Agric. Sci. Tech.* 2(1): 33-37.
8. Anyanwu, D.C.; Udedibie, A.B.I.; Osuigwe, D.I., Ogwo, V.O. (2011). Hematological responses of hybrid of *Heterobranchius bidorsalis* and *Clarias gariepinus* fed dietary levels of *Carica papaya* leaf meal. *World Rural Observ.* 3(1):9-12.
9. Aro, S. O. and Akinmoegun, M. B. (2012). Hematology and red blood cell osmotic stability of pigs fed graded levels of fermented cassava peel based diets. *Proc. of the 17th Annual Conf. of Anim. Sci. Assocs. of Nig. (ASAN), Ibadan, Hassan, W.A. (Ed.), Maigandi, S.A. p152-153.*

10. Blaxhall, P.C.; and Daisley, K.W. (1973). Routine hematological methods for use with fish blood. *J. Fish Biol.*, 5:771-781.
11. Dacie, S. I. V. and Lewis, S. M. (2001). *Practical Haematology*. (9th edition). J. and A. Churchill Livingstone, London, Melbourne and New York. 633p.
12. Duncan D.B (1955) Multiple range and multiple F tests. *Biometrics*. 11: 1-42.
13. Essers, A. J.; Ebong, C.; Vander-Grift, R. M.; Nout, M. J. R.; Otim-Nape, W. and Rosling, H. (1995). Reducing cassava toxicity by heap fermentation in Uganda. *Inter J. Food Sci. Nut.* 46:125-136.
14. Fagbenro O, Adedire C.O, Ayotunde E.O, and Faminu E.O, (2000). Hematological profile, food consumption and enzyme assay in the gut of the African bony-tongue fish *Heterotis (clupisudis) niloticus* (Cuvier 1829) (Osteoglossidae). *Trop. Zool.* 13:1-9.
15. FAO (1993). Strategies for sustainable animal agriculture in developing countries. Proc. of the FAO Expert Consultation held in Rome, Italy. Mack S. (Ed) p271.
16. Fountoulaki, E.; Alexis, M.N.; Nengas, I. and Venou, B. (2005). Effect of diet composition on nutrient digestibility and digestive enzyme levels of gilthead sea bream (*Sparus aurata* L.). *Aquac. Research*. 36:1243-1251.
17. Gabriel, U.U.; Alagon, J.K. and Allison, M.E. (2001). Effects of dispersed crude oil water on the haemoglobin and haematocrit of *Clarias gariepinus*. *J Aqua Sci. Environ. Management*. 5(2):9-11.
18. Gabriel, U.U.; Akinrotimi, O.A.; Ayanwu, P.E.; Bekibele, D.O. and Onunkwo, D.N. (2007).
19. Locally produced fish feed: Potential for aquaculture development in sub-sahara Africa. *Afr. J. Agric. Res.* 2:287-295.
20. Ijaiya A.T., (2001). Dry matter and nutrient digestibility in weaner rabbits fed varying levels of maize and fermented cassava peel meal based diet. In. *Proceedings of Agric Society of Nigeria*, Abeokuta, Nyroid S., Machin D. (Eds) p98-102.
21. Khajareran, S. and Khajareran, J. (2007). Use of Cassava products in poultry feeding, Roots, Tubers, Plantains and Bananas in animal feeding. <http://www.fao.org/DOCREP/003/TO554E/T0554E10.htm>. Accessed 18/09/2010.
22. McDonald, P.; Edwards, R. A. and Greenhalgh, J.F.D. (1995). *Animal Nutrition*. 5th edn. Longman Group Ltd. UK. pp481-488.
23. Noomhorm, A. S., Ilangitileke S. and Bautista. M. B. (1992). Factors in the protein enrichment of cassava by solid state fermentation. *J. of Sci. and Food Agric.* 58: 117 – 123.
24. Oboh, G. and Akindahunsi, A. A. (2005). Nutritional and toxicological evaluation of *Saccharomyces cerevisiae* fermented cassava flour. *J. of Food Composition and Analysis*. 18: 731 – 738.
25. Olurin, K.B.E.; Oluju, A.A. and Olukoya, O.A. (2006): Growth of African catfish (*Clarias gariepinus*) fingerlings fed different levels of cassava. *World J. of Zool.*, 1:54-56.
26. Sowunmi, A.A. (2003). Haematology of the African catfish, *Clarias gariepinus* (Burchell 1822) from Eleiyele reservoir, Ibadan, Southwest Nigeria. *The Zoologist*, 2(1): 40-44.
27. Talthawan, B. E.; Lic, O. and Froyland, L. (2002). Lipid metabolism and tissue composition in Atlantic Salmon (*Salmo salar*) effects of capelin oil, palm oil and oleic enriched sunflower oil as dietary lipid sources. *Lipids* 35:653-664.
28. Togun, V.A.; Oseni, B.S.A.; Ogundipe, J.A.; Arewa, T.R.; Hamed, A. A.; Ajonijebu, D.C.; Oyeniran, A.; Nwosisi, I. and Mustapha, F. (2009). Effects of chronic lead administration on the hematological parameters of rabbit: A Preliminary Study. *Proceedings of the 41st Conference of the Agric. Soc. Lagos, Nig., Eyo A.A., (eds)*. p341.
29. Ubalua, A. O. and Ezeronye, O. U. (2008). Growth responses and nutritional evaluation of cassava peel-based diet on Tilapia (*Oreochromis niloticus*) fish fingerlings, *J. of Food Technol.* 6 (5): 207 – 212.
30. Yalcin, S., Akyart, I. and Solak, K. (2001). Stomach content of the catfish *Clarias gariepinus* in the River Asi (Turkey). *Turkish J. of Zool.*, 25: 461 – 46

*This page is intentionally left blank*



Scan to know paper details and  
author's profile

# Experimental Study of Vibrations of Cross-Rod Spatial Structures

*Khalmuradov R.I., Khudoynazarov K. & Isabekov K.*

*Samarkand State University*

## ABSTRACT

This article explores a technique for studying the dynamic characteristics of cross-rod spatial structures (CRSS) using small-scale models, including the developed nodal connection of spatial frame rods, protected by copyright. The use of a nodal connection makes it possible to regulate the construction lifting of large-span structures, increases their strength and reliability. The developed nodal connection of the structure can be used for any spatial frames of buildings and structures and is especially effective for the frames of buildings erected in areas of high seismicity.

The issue of choosing methods for excitation of free and forced vibrations is being investigated, equipment for recording and recording vibrations is selected, and a layout of vibration sensors and sources of excitation of free and forced vibrations is being developed. Natural vertical oscillations of the structure model were caused by removing it from the state of equilibrium by concentrated loads applied in the middle and in a quarter of the span with their subsequent removal.

*Keywords:* NA

*Classification:* DDC Code: 572.86 LCC Code: QH450.2

*Language:* English



LJP Copyright ID: 392912

Print ISSN: 2631-8474

Online ISSN: 2631-8482

London Journal of Engineering Research

Volume 22 | Issue 5 | Compilation 1.0





# Experimental Study of Vibrations of Cross-Rod Spatial Structures

Khalmuradov R.I.<sup>α</sup>, Khudoynazarov K.<sup>σ</sup> & Isabekov K.<sup>ρ</sup>

## ABSTRACT

*This article explores a technique for studying the dynamic characteristics of cross-rod spatial structures (CRSS) using small-scale models, including the developed nodal connection of spatial frame rods, protected by copyright. The use of a nodal connection makes it possible to regulate the construction lifting of large-span structures, increases their strength and reliability. The developed nodal connection of the structure can be used for any spatial frames of buildings and structures and is especially effective for the frames of buildings erected in areas of high seismicity.*

*The issue of choosing methods for excitation of free and forced vibrations is being investigated, equipment for recording and recording vibrations is selected, and a layout of vibration sensors and sources of excitation of free and forced vibrations is being developed. Natural vertical oscillations of the structure model were caused by removing it from the state of equilibrium by concentrated loads applied in the middle and in a quarter of the span with their subsequent removal.*

*The test results and their analysis are analyzed. The elements of experimental models at all stages of loading worked in the elastic stage. The tests carried out showed that the structure has sufficient strength, stability, rigidity and seismic resistance. On the basis of the results obtained, recommendations were made for their use in the calculation and design of CRSS for seismic regions.*

*Author α σ ρ:* Doctor of Technical Sciences, Professor of department of Theoretical and Applied Mechanics, of Samarkand State University.

## I. INTRODUCTION

Due to the variety of seismic actions and the specific features of the CRSS, the range of problems associated with their oscillations and dynamic calculation is very wide. From a seismic point of view, PSPKs are systems with distributed parameters and an infinite number of degrees of freedom. Vibrations of spatial structures are of a complex nature and are determined by the joint spatial displacements of nodes and rod elements of the CRSS [1].

The analysis of literary sources also showed that there is a significant discrepancy between the experimental and theoretical results obtained in the process of experimental studies on full-scale structures [2, 3, 4].

Therefore, despite the successes, in general, the problem of seismic resistance of the CRSS has not been resolved. To solve it, further theoretical and experimental studies are required. Carrying out full-scale studies of the seismic resistance of FPCS, especially with various design schemes, seems to be very laborious and expensive. Based on this, in this article an attempt is made to solve these problems in a more accessible way with the help of experimental studies on small-scale models. In this article, we study a technique for studying the dynamic characteristics of CRSS using small-scale models, including a newly developed nodal connection of rods of a spatial frame, protected by an author's certificate [5].

## II. METHOD

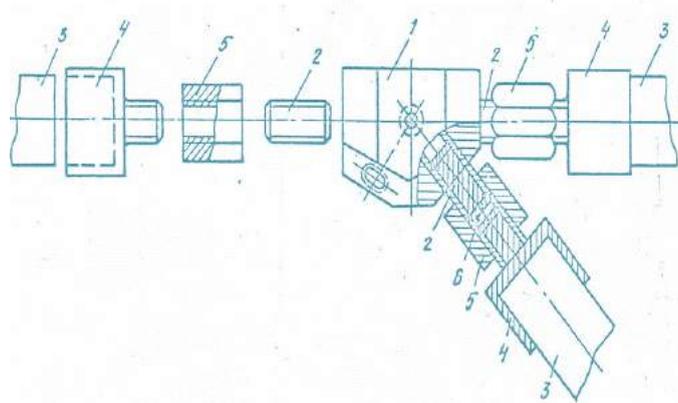


Fig. 1: Nodal Connection of the Rods of the Spatial Frame

### 2.1 Description of the Nodal Connection of the CRSS

The experimentally investigated nodal connection contains a nodal element 1 of a spatial frame with studs 2 freely fixed in it, to which rods 3 with rigidly fixed tips 4 are attached by means of a moving coupling 5 with a gap. The connection of the rod 3 with the nodal element 1 is carried out by moving the coupling 5 from the pin 2 to the threaded part of the tip 4, while the length of the rod in the axes of the nodal elements is regulated by the gap 6 between the pin and the tip, and the preliminary tension is achieved by the depth of screwing the pin 2 into the threaded hole of the nodal element. The use of a nodal connection makes it possible to regulate the construction lifting of large-span structures, increases their strength and reliability. The developed nodal connection of the structure can be used for any spatial frames of buildings and structures and is especially effective for the frames of buildings erected in areas of high seismicity.

### 2.2 Creation of a Model Structure

New structures intended for construction in seismic areas are investigated not only for the effects of seismic loads, but also for the effects of conventional static loads.

In addition, the method for calculating structures for seismic regions adopted by the current standards assumes that after determining the seismic loads, the latter are applied statically to

the structures. In experimental studies of CRSS, sometimes the dynamic load is replaced by a static one in order to identify, as a first approximation, the general nature and features of the stress-strain state of CRSS. Thus, static studies of structures for seismic regions are, on the one hand, of independent importance, and on the other hand, they serve as a kind of model for the work of the CRSS on seismic effects.

Taking into account the specifics of the impact on the structure of harmonic vibrations, which depend on external factors and, in particular, on the material of the model, for model imitation of metal rod structures, it was decided to make a model from metal rod and node elements.

The prerequisites underlying the constructive solution of the experimental model were the following:

- geometric similarity between the model and the real structure, achieved by the ratio of the lengths of the rods equal to 1/10;
- the similarity of the rigidity of the rods of the model and the real design achieved by using tubular rods of various diameters of 6.8 and 12 mm;
- the similarity of the nodal connection in the model and the real structure, achieved by using a single bolted connection, working on longitudinal tensile-compression forces.

Tests of the structure model for a static load were carried out in order to establish a qualitative and

quantitative coincidence of the results of the actual stress-strain state with the results of an accurate calculation performed on a computer [6, 7].

During the experiment, the ambient air temperature was constant, which made it possible to measure vibrations of any direction with the same sensor (horizontal or vertical). The tests were carried out to make a decision on the possibility of using the experimental model for dynamic testing.

Oscillations of the structure model, both in the vertical and horizontal directions, were excited:

- instant removal of suspended loads;
- guying of the column heads with the calculated static load when it is instantly released;
- falling load;
- vibration motor, on the shaft, which was mounted with eccentrics.

Natural vertical oscillations of the structure model were caused by removing it from the state of equilibrium by concentrated loads applied in the middle and in a quarter of the span with their subsequent removal. The natural horizontal oscillations of the structure model were caused by a static load pulling the top of the columns with its instantaneous release. The load was released and the columns were pulled using a system of cables, and the mass of the load was 10–15% of the mass of the structure model under study.

The maximum number of revolutions developed by the vibrating machine used was 1800 revolutions per minute, which corresponded to the highest frequency of forced vibrations of the PSPK 30 Hz. At the maximum number of revolutions, the amplitude of the load created was 90 N. The eccentric load had a mass of 100 g. and fastened at a distance of 2.5 from the axis of rotation. The number of revolutions of the vibrator (the frequency of the studied oscillations) was regulated using an autotransformer introduced into the installation circuit of the vibrator. In this case, the inertial force was determined by the well-known formula:

$$P = 4\pi^2 m_{\text{э}} l_{\text{э}} \omega^2$$

Where  $m_{\text{э}}$  is the mass of the eccentrics;  $l_{\text{э}}$  is the eccentricity equal to 2.5 sm;  $\omega$  - is the number of revolutions in 1 second. Note that the magnitude of the inertial force of the vibrating machine was chosen in such a way as to cause oscillations with amplitudes that could be recorded by an oscilloscope with sufficiently large magnifications and at the same time not cause nonlinear oscillations [8].

### 2.3 The Choice of Equipment

The choice of equipment for recording vibrations was made taking into account the possibility of recording waveforms in the frequency range from two to 30 Hz, and amplitudes from 1 to 100 microns and obtaining multipoint recording in movements to identify possible forms of vibrations. The following equipment was used during the tests:

1. A set of devices for measuring vibration of type K001, consisting of horizontal vibration sensors of type I001G, vertical vibration sensors of type I001B, a magnification regulator R001, integrating galvanometers of type M002 and a 14-channel light-beam oscilloscope of type POB-14. The frequency measurement range for the kit K 001 was 1.5-200 Hz. The permissible oscillation amplitude is up to 1000 microns.
2. Miniature seismic receivers SMV-30 of the "Firefly" type, used to control some experiments that exclude the influence of the mass of vibration sensors K001. They are converters of mechanical movements into electrical signals and are designed to register the vertical components of seismic waves. The range of measured frequencies is from 1 to 300 Hz, and the natural frequency of the device is  $29 = 1$  Hz, the diameter of the device is 29 mm, the length with a tip is 100 mm, the weight of the device without a tip is 100g.
3. In some rods of the design model, deformations were recorded by strain gauges with recording on the POB-14 oscilloscope via the V-ANCH-7M amplifier.

The square shape of the experimental models determined the installation location of the vibration sensors along the axes of the quarter, and the vibration machines in the center of the structure and the quarters of the spans.

Micro-vibrations of the base were excluded by the massiveness of the experimental stand and were controlled by a vibration sensor. By pre-installing the vibration sensors on the model, they were calibrated to determine the frequency and amplitude characteristics and to adjust the same phase of the vibration sensors necessary to determine the waveforms.

Vertical vibration sensors were installed on special round plates using 4 M6 bolts, and horizontal vibration sensors were installed on special angles using 4 M-6 bolts.

#### 2.4 Calibration of a Set of Devices

Calibration of the set of instruments was carried out as follows:

1. Vibration sensors were installed on special calibrated stands that create vibration with the required frequency and amplitude. The vibration stand platform produced harmonic vibrations. The control of the frequency and amplitude of the oscillations was carried out with greater accuracy than the control of the tested devices.
2. Galvanometers used in conjunction with a set of instruments were installed in certain channels of the oscilloscope, and when measuring vibrations, galvanometers were installed, and the same channels of the oscilloscope.
3. The frequency and amplitude characteristics in the operating range of frequencies and amplitudes were removed, the values of the magnification coefficients were determined. Dynamic tests began with the installation of minimal eccentric loads on the vibrating machine and the creation of vibrations with a slow increase and decrease in the speed of the electric motor, regulated by an autotransformer in the frequency range from 1 to 30 Hz.

By visual observation on the oscilloscope screen, the resonant oscillation zones were determined and the recording scale and the speed of the photo paper were determined. In the zone of resonant revolutions of the fundamental tone, the attenuation of free vibrations was studied when the vibrating machine was switched off. Only mechanical devices were installed to measure vertical movements along the lower belt of the model. By changing the place of application of force or load (the source of excitation of free and forced oscillations), the nature of changes in dynamic parameters was established [9].

The frequency of free oscillations was determined both by the oscillograms of damped free and forced oscillations, and by the diagrams of resonant curves[10]. The values of the logarithmic decrement were determined by damped free oscillations, as well as by resonant curves [11].According to the amplitudes recorded simultaneously at 6 points, plots representing waveforms were constructed.

#### 2.5 Determination of Dynamic Characteristics

The tests were carried out to identify the stress-strain state and dynamic parameters (periods, shapes, and decrement fluctuations) of the CRSS with various support options and structural schemes and to establish the influence of enclosing structures on the stress-strain state and dynamic characteristics. All waveforms recorded during dynamic tests were processed according to a single methodology. At each level of free oscillations, the most characteristic and stable section was selected, on which the dynamic parameters of the design model were determined. According to these values, taking into account the calibration data of the equipment, the movements of individual points of the model were determined, which made it possible to identify the forms of its oscillations.

The oscillograms represented a picture of oscillatory motion expanded in time. They were used to determine the frequencies and periods of oscillations, as well as the amplitudes of oscillations. To determine the oscillation amplitudes on an oscillogram, the distance

between adjacent half-wave vertices was measured. Half of this distance is the amplitude. For the accuracy of determining the amplitude, the scale of recording the waveforms was of great importance, therefore, the maximum magnification of the regulator was used. When determining the oscillation period, the first two half-waves of the oscillogram were not taken into account, since they were influenced by various transients.

The rest of the waveform obeyed a general pattern and the oscillation periods were determined by it. On the oscillogram, the natural oscillation period of the structures is 0.2 and 0.16 s, respectively, hence the oscillation frequencies  $f = 1 / T$  turned out to be equal to 5 Hz and 6 Hz, respectively.

Recordings of free damped oscillations made by:

- at different stages and with different types of loads of the structure with a constant load and with different support options;
- various design schemes;
- various levels of dynamic stresses characterized by the magnitude of the broken load allowed us to obtain numerical values of the logarithmic decrement.

According to the recording of the oscillogram, the ratio of adjacent amplitudes and periods was found, the vibration attenuation coefficient  $K_3$  was determined.

$$K_3 = \delta / T$$

Where,  $\delta$  is the natural logarithm of the ratio of adjacent amplitudes, called the logarithmic decrement of oscillations.  $T$  is the period of free oscillations.

The value of the coefficient for metal structures is usually recommended to be taken depending on the level of dynamic stresses at low loads of 0.01, and at high loads - 0.025. The amplitudes of movements in the center of the PSPC served as a generalized characteristic of the level of dynamic stresses of the structure, since the fluctuations of the PSPC during the breakage of the load occurred in the first form.

### III. RESULTS AND DISCUSSIONS

According to the results of processing vibrograms of their own damped oscillations, the dependences of  $\gamma(a)$  of the loss coefficient on the amplitude of the oscillations (in the first form) in the center of the plate were found. According to the obtained oscillograms, the first 3 forms of natural vibrations of the structure were constructed. The amplitude - frequency characteristics of oscillations for individual points were also constructed. The frequencies, shapes and amplitudes of the natural oscillations of the unloaded model were also determined, as well as at a loading stage of 20% of the calculated one. Then a vibration motor was installed and forced vibrations were created at various stages of loading.

At the same time, the experimental results (the frequency and amplitude of the natural oscillations of the model) corresponding to different stages of loading with a constant load, in the presence of loads differ from each other by more than 20%, and the frequencies in the presence of loads are greater than in the absence of it.

This is due to the fact that loading practically does not affect the rigidity of the model. Loading caused an increase in mass, which, in turn, caused an increase in the values of the period of natural oscillations. Experimental studies show that with low-mass eccentrics, changes in frequencies and decrements of vibrations both at the beginning of the vibration machine and after some time of operation of the vibration machine occur slightly, only amplitudes increase.

With eccentrics of a larger mass, the oscillation frequencies noticeably decrease and the amplitudes and decrements of oscillations significantly increase. According to the results of processing the oscillograms of their own damped oscillations, the dependences of the loss coefficient  $\gamma(a)$  were found from the amplitude of the oscillations in the center of the CRSS model. The arrangement of the curves in Fig.2 indicates that with increasing static stresses in the structure, the value of the inelastic resistance coefficient decreases.

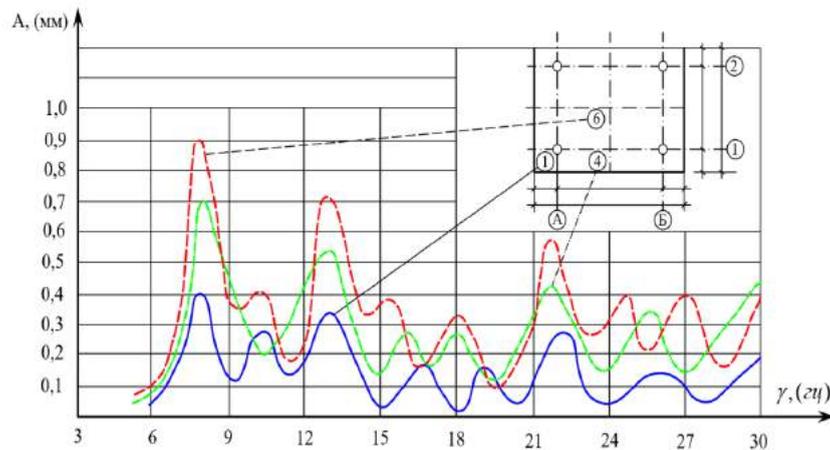


Fig. 2: Resonant Curves of Forced Oscillations of Various Nodal Points

It has been experimentally established that the coefficient  $\gamma$  at a low level of dynamic stresses can take a value less than that accepted in regulatory documents. It is characteristic that at a low level of dynamic stresses, the value of the loss coefficient ( $\gamma = 0.0065$ ) for PSPC is 35% less than that accepted in regulatory documents. At the maximum level of dynamic stresses, the value of  $\gamma$  is equal to 0.018 for the same type of structures, which is 20% less than accepted in regulatory documents. This fact has a noun meaning, since we are talking about calculations of oscillations of repeatedly statically indeterminate systems in the resonant mode [12,13]. The results of tests for vertical seismic loads showed that 3 resonant zones were recorded on the oscillogram for the PSPC models with a smooth decrease in often forced vertical oscillations. With the growth of external uniformly distributed static and dynamic loads, there was a decrease in the frequencies of natural vertical vibrations and the dynamic stiffness of the PSPC, and their shapes did not change [14].

This is typical for systems in which the dissipation of oscillation energy is caused by an internal inelastic resistance [15,16]. Under the action of a horizontal load, a coating with columns in the first approximation can be considered as a system with one degree of freedom or with an infinite number of degrees of freedom. For example, for a system with one degree of freedom, comparing the values of frequencies can cancel the proximity of their values.

At all stages of loading, the structure worked elastically, without residual deformations after unloading. The forces in the rods increased in proportion to the increase in the inertial impact and the design load in the range up to 2700 Pa. From the evenly distributed load over the entire coating, the struts of the structure along the main diagonal were the most loaded. Under seismic impacts, the forces in these struts increased from 5 to 18%. The greatest tensile force from the 9-point seismic load was recorded in the rod of the upper belt above the support, the greatest compressive force from the 9-point seismic load was in the struts of the support zone.

As can be seen from Fig.3. When the constant load  $q = 1080$  Pa and 2700 Pa, the graphs  $\gamma(a)$  have a horizontal increase in amplitudes and a sharp decrease in the values of  $\gamma$  in the regions of small amplitudes. In the center of the structure, the greatest force in the rods reached 825N. The greatest effort was in the rod directed towards the center of the structure along the main diagonal of the support pyramid. In the rods forming the base of the support pyramid and located above the braces, the forces are small-163 N.

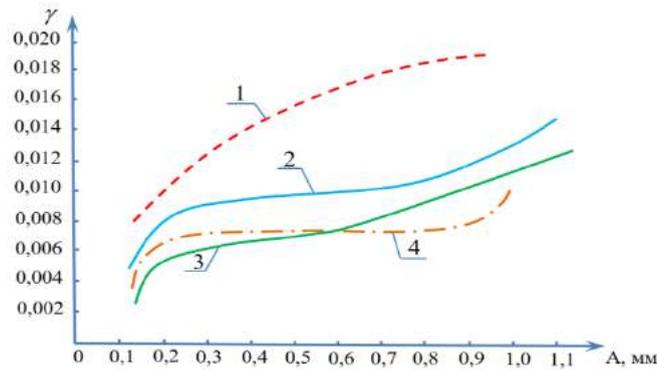


Fig. 3: Dependence  $\gamma(A)$  for Different Levels of Loading of the Model With a Constant Load: 1,2,3,4 - at a Load of 0.54; 1.08; 1.68; 2.7 kN/m<sup>2</sup>.

With the growth of the external uniformly distributed load and dynamic loads, there is a decrease in the frequencies of natural vertical vibrations and the dynamic stiffness of the PSPC while maintaining their constant shape.

The results of tests for vertical loads of the seismic type showed that the CRSS model, with a smooth decrease in the frequencies of forced vertical oscillations, three resonant zones are fixed on the oscillogram.

Experiments have also shown that the periods of proper vertical oscillations of experimental models are in the range of 0.06 - 0.207 sv depending on the type of models and the conditions of support. The nature of the variation in the oscillation amplitudes of individual points of the CRSS was revealed, gradually fading in time, and logarithmic decrements were determined for vertical oscillations, the value of which is not less than 0.09.

#### IV. CONCLUSION

The results of testing experimental models have shown that under the action of a horizontal load, the PSPC together with the columns can be considered as a system with one degree of freedom in the first approximation or as a system with an infinite number of degrees of freedom.

Comparison of the frequency values obtained theoretically in accordance with the recommendations of building codes and regulations for systems with one degree of freedom with the results of experimental studies

showed that these values practically coincide (respectively equal to 12.5 and 11.8 Hz.

The periods of horizontal natural oscillations of the PSPC were in the range of 0.03 - 0.147 s, and the logarithmic decrements of the oscillations did not exceed 0.04. From the evenly distributed load over the entire coating, the struts in the support zone of the structure were the most loaded. The increase in the forces in the core elements of the structure, taking into account the vertical seismic load, amounted to a maximum of 18% for the model with a plan size of 3.0 x 3.0 m, and 14% for the 3.6 x 3.6 m model. The elements of the experimental models at all stages of loading worked in the elastic stage.

The nature of the deflections of the model corresponded to its tense state. The greatest deflection under normal symmetrical load was fixed in the middle of the model and is equal to 5.23 mm, which was 1/425 of the span and indicated sufficient rigidity of the model structure.

A comparison of the experimental data obtained with the results of calculations using the displacement method using finite elements showed their fairly good correspondence. The experimental data exceeded the calculated ones by only 12-19%. The tests have shown that the structure has sufficient strength, stability, rigidity and earthquake resistance. Based on the results obtained, recommendations are made for their use in the calculation and design of PSPCS for seismic areas [17].

## REFERENCES

1. Isabekov K. Experimental studies of cross-rod spatial structures on small-scale models., Samarkand: 2021. Navruz Polygraph. 121 p.
2. Abdurashidov K.S. In the collection "Effective spatial structures in the practice of design and construction of the Republics of Central Asia and Kazakhstan". G. Frunze, 1989. Pp.102-106.
3. Ivanov M.N., Mironov E.M., Mixylov G.G., Platov G. S. In the collection. "The use of aluminum alloy structures in high-speed construction of industrial and civil buildings." Moscow: Metallurgy. 1988.pp. 77-102.
4. Bolotin V.V., Radin V.P., Cyirkov V.P. Modeling of dynamic processes in elements of building structures during earthquakes. News of universities. Construction. Moscow: 1999. pp122- 129.
5. Isabekov K. SSSR. Patent No. 885478. (22 July 1981).
6. Ibragimov N. X., Isabekov K. To the choice of a mathematical model of rod systems of the truss type. "Promlems of architecture and construction" (scientific and technical journal). Samark and .2021.No.2.pp.121-125.
7. Sventikov A.A. Computational Civil and Structural Engineering, Volume 4, Issue 2, 2008.pp83-88.
8. Khalmuradov R.I., Khudoynazarov Kh., Khudoyberdiyeva S. Uzbekistan Problems of Mechanics, No.2-3, 2017, pp. 46-52.
9. Khalmuradov R.I. Scientific Bulletin of Samarkand State University, No.3, 2017, pp.86-90.
10. Isabekov K. Middle European Scientific Volume - 18 (2021) .221-224.November ISSN (E): 2694-9970
11. Khalmuradov R.I., Khudoynazarov K., Nishonov U.A. Int. Journal of Advanced Research in Science, Engineering and Technology. Vol. 5, Issure 3, March 2018. – pp. 5289-5296.
12. Khudoynazarov Kh. Kh., Khalmuradov R.I., Yalgashev B.F. 2021 Tomsk State University. Journal of Mathematics and Mechanics. 69, 139-154. DOI: 10.17223/19988621/69/11
13. Khudoynazarov Kh., Khudoyberdiyev Z. Khudoyberdiyeva S. Int. J. of Advanced Research in Science, Engineering and Technology, 2018. Vol.5, Issue 10.-pp.7117-7121.
14. Raximov A.K. European Scholar Journal (ESJ) Available Online Vol. 2 No.12, 277-281. December 2021 ISSN: 2660-5562.
15. Khudoynazarov Kh., Yalgashev B.F. and T.Mavlonov 2021. IOP Conf. Series: Mater. Sci. Eng.1030012098 DOI:10.1088/1757-899X/1030/1/012098.
16. Filippov, I. G. Kudainazarov, K. (1998). International Applied Mechanics, 34(12), 1204–1210.
17. Guidelines for the design of structural structures. Moscow: Stroyizdat. 1984. pp.258-274.



Scan to know paper details and  
author's profile

# Omicronvirus Data Analytics using Deep Learning Technique

*Mr. Anand Kumar Gupta, Dr. Asadi Srinivasulu, Dr. Kamal Kant Hiran, Dr. Tarkeswar Barua,  
Mr. Goddindla Sreenivasulu, Dr. Sivaram Rajeyyagari & Dr. Madhusudhana Subramanyam*

*BlueCrest University*

## ABSTRACT

The Man-made brainpower (AI) methods overall and convolutional brain organizations (CNNs) specifically have achieved victories in clinical picture examination and grouping. A profound CNN design partakes projected into this research article for the analysis of OMICRON grounded onto clinical radiography analysis (X-ray). As matter of fact the non-availability in adequate scope and excellent X-ray picture database, a compelling & exact Convolutional NN (CNN) characterization remained an examination. Managing those intricacies, for example, accessibility with a very-little measured and contrast database of picture resolution challenges, the database has pre-processed been into various stages utilizing various strategies to accomplish a powerful preparation database of the applied Convolutional NN (CNN) prototypical to achieve its finest presentation.

**Keywords:** omicron disease, cross-validation methods, classification algorithms, disease prediction, CNN, data minelaying, feature selection, data pre-processing.

**Classification:** DDC Code: 171.2 LCC Code: PA6308.D5

**Language:** English



LJP Copyright ID: 392913

Print ISSN: 2631-8474

Online ISSN: 2631-8482

London Journal of Engineering Research

Volume 22 | Issue 5 | Compilation 1.0



© 2022. Mr. Anand Kumar Gupta, Dr. Asadi Srinivasulu, Dr. Kamal Kant Hiran, Dr. Tarkeswar Barua, Mr. Goddindla Sreenivasulu, Dr. Sivaram Rajeyyagari & Dr. Madhusudhana Subramanyam. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncom-mercial 4.0 Unported License (<http://creativecommons.org/licenses/by-nc/4.0/>), permitting all noncommercial use, distribution, and reproduction in any medium, provided the original work is properly cited.



# Omicronvirus Data Analytics using Deep Learning Technique

Mr. Anand Kumar Gupta<sup>α</sup>, Dr. Asadi Srinivasulu<sup>σ</sup>, Dr. Kamal Kant Hiran<sup>ρ</sup>,  
Dr. Tarkeswar Barua<sup>ω</sup>, Mr. Goddindla Sreenivasulu<sup>¥</sup>, Dr. Sivaram Rajeyyagari<sup>§</sup>  
& Dr. Madhusudhana Subramanyam<sup>X</sup>

## ABSTRACT

The Man-made brainpower (AI) methods overall and convolutional brain organizations (CNNs) specifically have achieved victories in clinical picture examination and grouping. A profound CNN design partakes projected into this research article for the analysis of OMICRON grounded onto clinical radiography analysis (X-ray). As matter of fact the non-availability in adequate scope and excellent X-ray picture database, a compelling & exact Convolutional NN (CNN) characterization remained an examination. Managing those intricacies, for example, accessibility with a very-little measured and contrast database of picture resolution challenges, the database has pre-processed been into various stages utilizing various strategies to accomplish a powerful preparation database of the applied Convolutional NN (CNN) prototypical to achieve its finest presentation. Pre-processing phases in the database acted into research incorporate database adjusting, clinical specialists' picture investigation, and information expansion. The exploratory outcomes reveal general precision up to 98.08% that exhibits its great capacity of the prototypical Convolutional NN (CNN) system of the ongoing application space. Convolutional NN (CNN) prototype has tried been into 2 (two) situations. The primary situation explains that it has tried been utilizing the 7762 X-ray pictures as database, it accomplished a precision of 98.08 percent. To the subsequent situation, the prototypical has tried been utilizing the autonomous database of Omicron X-ray pictures from Kaggle. The execution into current assessment the situation remained just about 98.08%. It additionally demonstrates that the prototypical system beats different systems, as a

similar examination has finished been thru a portion of AI calculations. The proposed model has superseded every one of the models by and large and explicitly when the model testing was finished utilizing a free testing set.

**Keywords:** omicron disease, cross-validation methods, classification algorithms, disease prediction, cnn, data minelaying, feature selection, data pre-processing.

**Author** <sup>α</sup> <sup>σ</sup> <sup>ρ</sup> <sup>ω</sup> <sup>¥</sup> <sup>§</sup>: Azteca University, Data Science Research Laboratory, BlueCrest University College, Monrovia, Liberia.

## I. BRIEF INTRODUCTION

The infection known as the extreme intense breathing disorder COVID-19 had found been in the year late 2020. The infection started in World turned into reason for an illness called as COVID-19 (Corona Virus Disease 2019). The pioneer organisation in health sector, WHO (World Health Organization), proclaimed of sickness as an epidemic declared in the month of March of the year 2020. As per intelligence records gave & refreshed by worldwide medical care specialists and state legislatures, the pandemic impacted large number of individuals globally most major disease brought about by COVID19 is connected with the lungs like pneumonia. The side effects via infection may fluctuate & incorporate respiratory disorders, high feverishness, fluid muzzle, and stroke. These clinical conditions may utmost generally been analyzed utilizing lung x-ray investigation of the irregularities. Radiography is an electromagnetic (x-radiation or x-beam or x-ray) type of infiltrating contamination that uses radio-emissions are gone over the ideal hominoid body

elements to make pictures of interior subtleties. The x-beam (x-ray) pictures are the portrayal of human's body interior organs/parts in highly contrasting shadows. The x-beams (x-rays) are the utmost established & ordinarily utilized clinical determination experiments. Lungs' x-beam is utilized into analyzing the chest and related illnesses such as lung sicknesses, breathing issues, pneumonia [4], etc. which gives a picture of thoracic hole, comprising of spine bones and chest alongside of delicate internal sensitive body parts together with the veins, airways, and lungs x-beam (x-ray) pictures strategy gives various advantages as a selective analysis technique of COVID19 compared with substitute examining procedures. Its advantages incorporate minimal expense, tremendous accessibility of x-beam (x-ray) facilities, harmless, less time utilization, and gadget moderateness. Thus, X-beaming can be well-thought-out a superior contender of mass, simple, & speedy analysis methodology to a global epidemic (also pandemic) such as COVID19 thinking about of ongoing worldwide medical services emergency. Profound learning and ANNs have supported a dramatic exploration center during the period of ten years and more. Profound Artificial NNs (ANNs) has superseded supplementary regular prototypes on numerous fundamental standards. Thus, Artificial NNs (ANNs) has commonly ended up being the cutting-edge innovation across a wide scope of use regions, including NLP, discourse acknowledgment, natural sciences, picture handling, other businesses, and scholarly extents headway for the Artificial NNs (ANNs) have gigantic possible into medical care applications, explicitly into clinical information examination, determination through clinical picture handling, and investigation. As found as of late, different regions of the planet face the medical care emergency both with regards to the required number of medical services experts and testing gear. Considering what is going on, there is a connection among recognizing COVID19 victims, lung x-beam picture investigation & characterization. In existing projected research, a programmed indicative framework has been created utilizing Convolutional NN (CNN) it utilizes lung x-beam examination outcomes to analyze if an individual

is COVID19 impacted or ordinary. Fundamental investigation of the existing review have exposed satisfactory outcomes as far as its precision and other execution boundaries to analyze the sickness in a savvy and time-productive manner is review utilized Convolutional NN (CNN) thru additional flakes to further develops COVID19 x-beam picture characterization exactness. In brain organizations, the CNN structure is extraordinarily intended to handle the two-layered picture assignments in spite of the fact that it could likewise been utilized in 1-3 layered information. Preparing the CNN prototype, primarily, database has gotten been from GitHub.com.

## II. LITERATURE SURVEY

Profound knowledge has exposed a sensational expansion into clinical utilizations overall & explicitly into clinical x-ray image-based conclusion. Profound training prototypes achieved unmistakably. Because of its exceptionally encouraging outcomes given by CNNs in clinical picture examination and grouping, they are considered as accepted norm in this area [9, 10]. CNN has been utilized for an assortment of order assignments connected with clinical analysis, for example, lung infection [10], discovery of disease (malarial) organism into pictures of tinny plasma cell [11], mammary gland cancer recognition [12], remote scanned pictures [13], mediate chest illness [14], determination of membrane malignant growth through characterization, & programmed finding the different lung sicknesses utilizing lung x-beam picture arrangement. Developments with COVID-19 in the Dec, 2019, various analysts were locked in the trial & error and exploration exercises connected with analysis, treatment, and the executives of COVID19. Scientists has detailed its meaning of relevance of Artificial Intelligence (AI) techniques into picture examination of the discovery and the board of COVID19 cases.

## III. SYSTEM METHODOLOGY

### 3.1 Existing System

There are approachable in superficial learning strategies, for example, convolution neural

organization and intermittent neural organization. CNN computation Drawbacks: The disservices are:

1. Little precision
2. In flood Time Complexity
3. In flood Executing Time
4. In flood Error prone
5. Small Data Size

*Computation downside*

1. Little precision
2. In flood Time Complexity
3. In flood Execution Time
4. In flood Error prone
5. Little Data Size

### 3.2 Proposed System

There are available in deep learning method like Extended Convolutional Neural Networks i.e., in Deep Learning Technique.

ECNN algorithm Advantages:

1. In flood accuracy
2. Less time consuming
3. Little Performance Time
4. Little Mistake Degree
5. Big Data Scope

## IV. INVESTIGATIONAL RESULTS

Basic idea is to execution, is to assure that the Omicron disease severer affected role collected statistics functioned in the way that can compel preparation, subdivision from their first outlook.

### 4.1 ECNN Algorithm

Two trials of one or the other CC or MLO seen should be adjusted utilizing the picture enlistment method. At that point, a distinction picture is got by deducting the earlier test from the current test and afterward scaled to the full-range force. The territorial pictures from the refined district proposition are trimmed from the three pictures and scaled to  $224 \times 224 \times 3$  for each picture, which are utilized for ECNN is floodlight extraction. The three channels are rehashed from one-channel grayscale pictures (e.g., current sweep of  $224 \times 224 \times 1$ ) since the pertained ECNN and ECNN models expect 3-channel pictures.

Multi-measurements of three-state in floodlights (from earlier sweep, current output, and contrast pictures) are made to prepare a CNN model. For instance, The ECNN is floodlights utilizing ResNet-60V3 of  $2048 \times 3$  measurements for each view (CC or MLO) of a subject's side (left or right bosom). Remember that earlier sweep consistently relates to the ordinary (sound) status in any event, for a destructive subject. Assume we code sound and carcinogenic as 0 and 1 individually, at that point the ground realities (yields) compared to the three states (earlier, current, distinction) of a destructive view are [0 1 1]. This coding instrument can be handily stretched out to at least two earlier sweeps.

### 4.2 Algorithm

The following is the ECNN algorithm steps: The Omicron disease infection data index, i.e., the absolute 522 pictures, our experiment involved the related following steps:

1. Introduces mandatory collection
2. Introduces training dataset
3. Executes in floodlight ordering of change data
4. Composition with 70-time phases and 2 yield
5. Introduce Keras deep learning library with all supporting bundles of the package
6. Resets ECNN
7. Enhances ERNN part & about regulation of loss calculation function.
8. Enhancement of yield part.
9. Adds the ECNN
10. Fits ECNN in the training dataset
11. Loads the Omicron disease infection test image data of the year 2020
12. Become a predicted Omicron disease infection in Dec 2019
13. Imagine aftereffects with anticipated or genuine Omicron disease infection

*INPUT DATSET:* Here the input dataset is having 14 columns with target class, i.e., severity level of the Omicron disease.



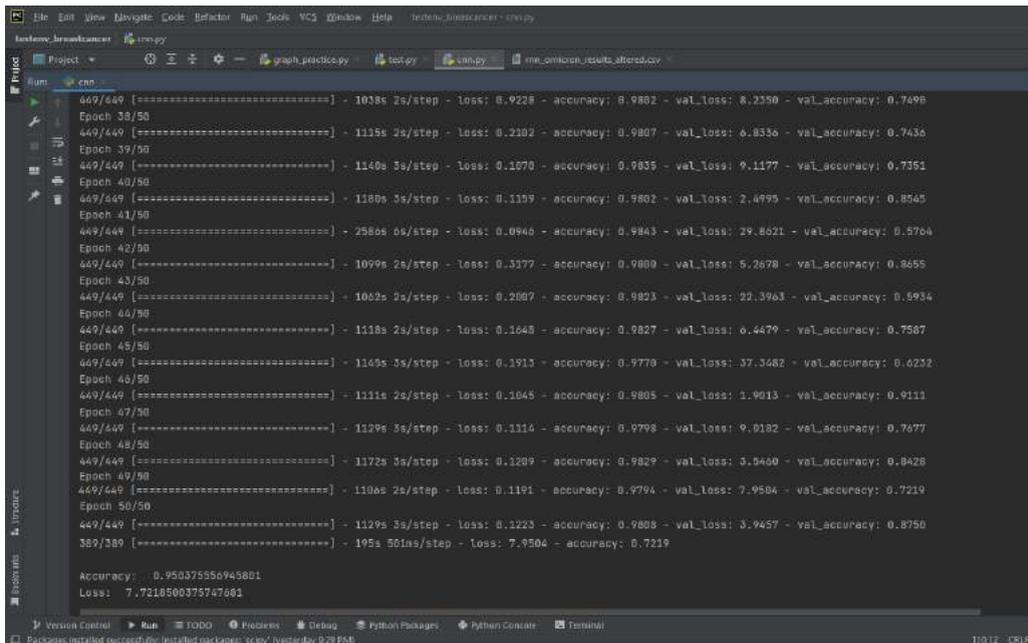


Fig. 4.2: Executing flow of Omicron disease sensing ECNN

Fig 4.2 Explains the final output on dataset from UCI, Google, Kaggle, Microsoft, Executing flow of through the epochs.

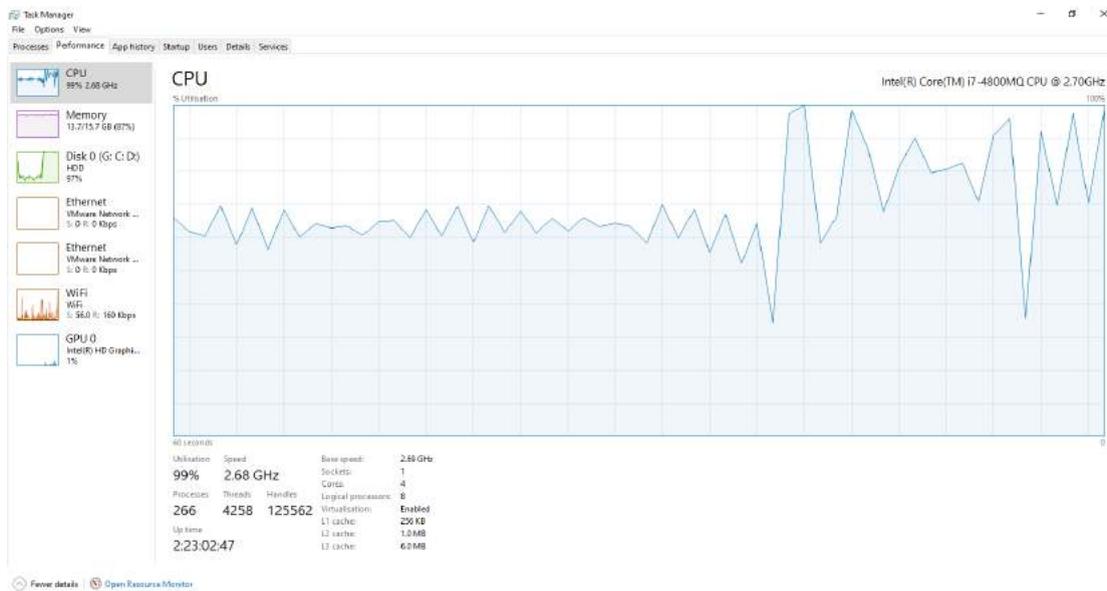


Fig. 4.3: CPU occupancy in the executing of ECNN with Windows OS

In the above figure it demonstrates the Processor occupancy rendering to the iterations with Epochs onto Omicron virus dataset with Windows OS.



Fig. 4.4: CPU occupancy for Omicron disease Dataset using ECNN with Linux OS

In the above figure it exemplifies processing power occupancy rendering to the amount of Epoches on Omicron illness with Linux OS.

### 5.1 Evaluation Methods

The following are measurements of evaluation methods or metrics.

$$Quality = \frac{BP+VM}{BP+VP+BM+VM}$$

$$Preciseness = \frac{BP}{BP+VP}$$

$$Callback = \frac{BP}{BP+VM}$$

$$F - measure = \frac{2xPrecisenessxCallback}{Preciseness+Callback}$$

Data Input: As previously said, our experiment will consider 6098 images.

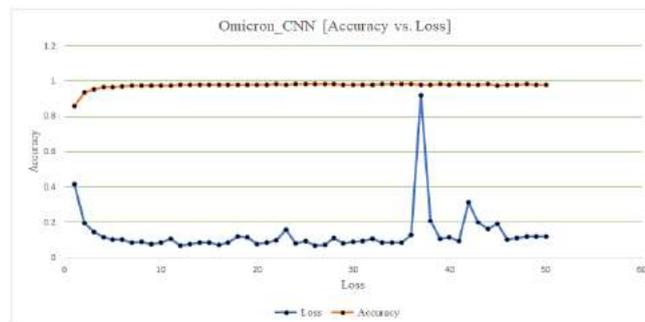
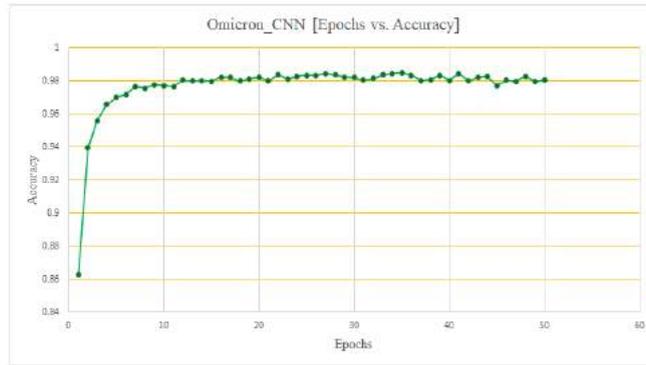


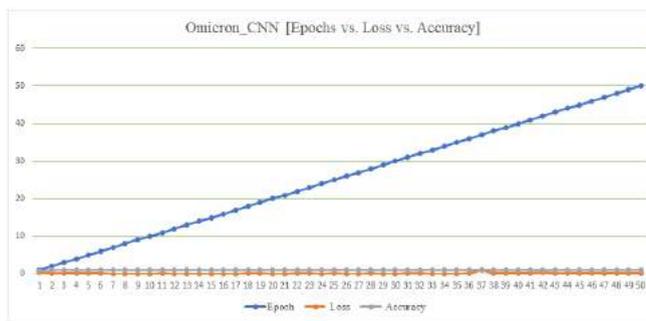
Figure 4.6: Omicron disease data Accuracy vs. Loss

Fig 4.6 Exemplify the executing epoches between Accuracy and Loss.



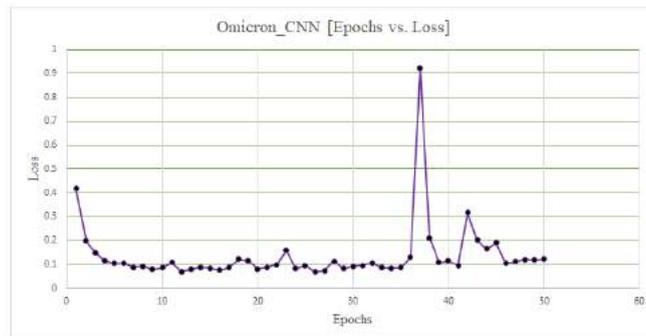
*Fig. 4.7:* Accuracy vs. Number of Epochs

Fig 4.7 lucubrate the executing epochs between Accuracy and number of iterations.



*Fig. 4.8:* Omicron Disease Dataset with Accuracy vs. Loss vs. Epoch

Fig 4.8 demonstrates the executing time between loss, Epochs and accuracy of the ECNN model.



*Fig. 4.9:* Omicron disease dataset with Epochs vs. Loss vs. Epoch

Fig 4.9 Demonstrates the executing time between Epochs, loss and accuracy of the ECNN model.

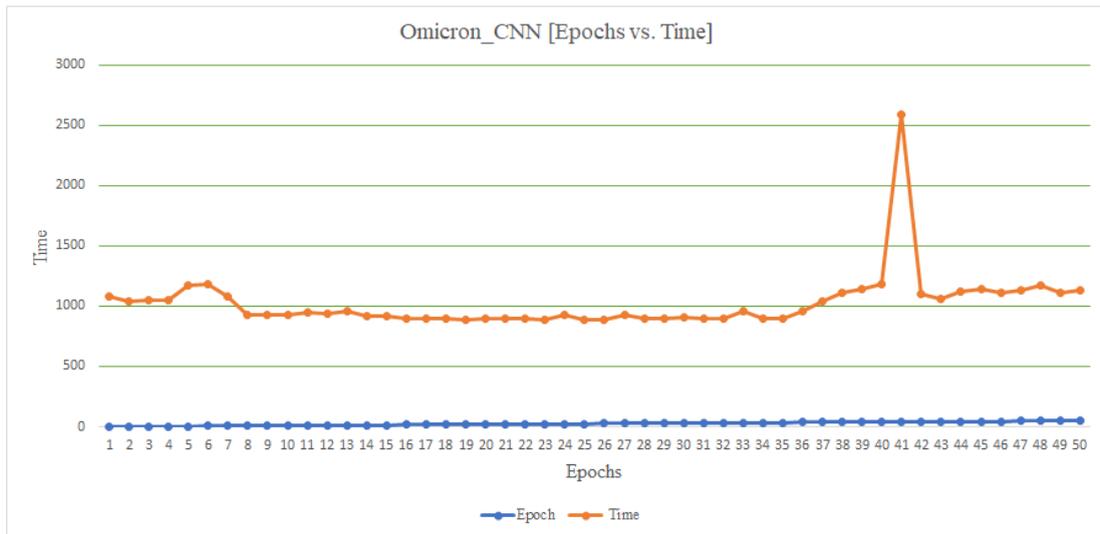


Fig. 4.10: Omicron Disease Dataset with Time vs. Loss

Fig 4.10 Demonstrates the executing time between Time and Loss of the ECNN model.

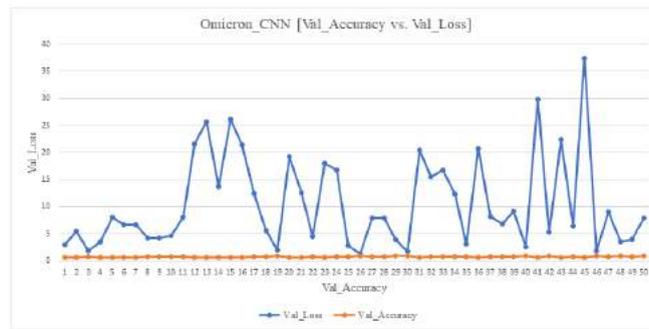


Fig 4.11: Omicron Disease Dataset with Time vs. Loss

Fig 4.11 Demonstrates the executing time between loss and Loss of the ECNN model.

### V. CONCLUSIONS

This study has been directed to exhibit the powerful and precise analysis of Omicron utilizing ECNN which was prepared on chest X-beam picture dataset model preparation was performed gradually with various datasets to accomplish the greatest exactness and execution. Essential dataset was extremely restricted in size and furthermore imbalanced as far as class dispersion set problems thru the essential database impacted exhibition with model overview gravely. Towards conquering those problems, database had pre-processed utilizing various strategies, with database adjusting method, physical investigation thru x-beam pictures via appropriate clinical specialists & information expansion procedures. To adjust the database of prototype preparation

then furthermore assessment of its presentation boundaries, a more than adequate amount of x-rays (chest) was gathered through various accessible causes. In the wake of preparing & testing the ECNN prototype upon the completely handled database, exhibition output has accounted been for. Likewise, for testing additional prototype execution, especially its exactness, the projected ECNN prototype have tried been utilizing autonomous database as a free approval & genuine examination acquired from organizations (such as IEEE) Data Portal. It is detailed into the outcomes of together the examination situations, the projected ECNN prototype have exposed profoundly encouraging outcomes. Hence this review involves a steady methodology in preparing the model utilizing various scopes & kinds of database, methodology

affirmed its way that ECNN prototypes entail adequate measure thru picture information for the productive and more-precise order. Information expansion procedures are extremely powerful to altogether further develop the ECNN model execution by creating additional information from a current restricted amount of database & furthermore via providing the capacity of differences with ECNN. Projected ECNN prototype's iterations of CNN layers were likewise settled into a gradual methodology; i.e., into the main addition, solitary CNN layer remained utilized, after that, at that point, based on model execution measurements, one layer in every augmentation was expanded till it arrives at a steady and productive stage regarding its presentation. A last adaptation of the ECNN comprised with 6 combined layers. Similar investigation have likewise been conducted additional examination to the extent with the projected ECNN prototype via execution examinations of a portion thru conspicuous AI systems like GBM, RF, SVC, KNN, and LR. The outcomes demonstrate projected ECNN have bypass everything the prototypes especially at times all prototypes were tried onto autonomous approved database. Bearing in mind that the huge impact by information expansion methods with prototype (model) exhibitions, creators is presently chipping away at the use of other best in class information increase calculations and procedures. Later on, the outcomes got from the review worried about the appropriateness of these cutting-edge information expansion strategies in various application spaces will be distributed.

## REFERENCES

1. Aijaz Ahmad Reshi et al., "An Efficient CNN Model for COVID-19 Disease Detection Based on X-Ray Image Classification", *Hindawi Complexity* Volume 2021, Article ID 6621607, 12 pages <https://doi.org/10.1155/2021/6621607>.
2. D. Cucinotta and M. Vanelli, "WHO declares COVID-19 a pandemic," *Acta Biomedica: Atenei Parmensis*, vol. 91, pp. 157–160, 2020.
3. F. Rustam, A.A. Reshi, A. Mehmood et al., "COVID-19 future forecasting using supervised machine learning models," *IEEE Access*, 2020.
4. D. J. Cennimo, "Coronavirus disease 2019 (COVID-19) clinical presentation," vol. 8, pp. 101489–101499, 2020, <https://emedicine.medscape.com/article/2500114-clinical#b2>, online. 2020.
5. X-ray (Radiography)-Chest, 2020, <https://www.radiologyinfo.org/en/info.cfm?Pgchestra#overview>.
6. J. P. Cohen, "Github Covid19 X-ray dataset," 2020, <https://github.com/ieee8023/covid-chestxray-dataset>, 2020. Online.
7. Z. H. Chen, "Mask-RCNN detection of COVID-19 pneumonia symptoms by employing stacked autoencoders in deep unsupervised learning on low-dose high resolution CT," *IEEE Dataport*, 2020.
8. A. S. Lundervold and A. Lundervold, "An overview of deep learning in medical imaging focusing on MRI," *Zeitschrift für Medizinische Physik*, vol. 29, no. 2, pp. 102–127, 2019.
9. M. Ahmad, "Ground truth labeling and samples selection for hyperspectral image classification," *Optik*, vol. 230, Article ID 166267, 2021.
10. B. Kayalibay, G. Jensen, and P. van der Smagt, "CNN-based segmentation of medical imaging data," 2017, <http://arxiv.org/abs/1701.03056>.
11. Q. Li, W. Cai, X. Wang, Y. Zhou, D. D. Feng, and M. Chen, "Medical image classification with convolutional neural network," in *Proceedings of the 2014 13th International Conference on Control Automation Robotics & Vision (ICARCV)*, pp. 844–848, Singapore, December 2014. Dr. Asadi Srinivasulu, and Tarkeswar Barua "COVID-19 Virus Prediction Using CNN and Logistic Regression Classification Strategies", *Journal of Data Analysis and Information Processing*, 2022, 10, 78-89, ISSN Online: 2327-7203, ISSN Print: 2327-7211, DOI: 10.4236/jdaip.2022.101005 Feb. 28, 2022, <https://www.scirp.org/journal/jdaip/> (Scopus Journal).
12. Dr. Asadi Srinivasulu, and T. Sree Lakshmi, "Malware Similarity Unveiling Using Twin Neural Networks", *Design Engineering journal*, ISSN:0011-9342, issue:01, Vol:01, pages: 1904-1916, February, 2022. <https://>

- Infectious diseases-and-treatment.imedpub.com (Scopus Journal).
13. Dr. Asadi Srinivasulu, and Dr. Tarkeswar Barua, "Early Prediction of Covid-19 Using Modified Recurrent Neural Networks", *Journal of Infectious Diseases and Treatment (IPJIDT-21-P-7633)*, ISSN 2472-1093, Vol.7 No.8:7633, 2021. <https://infectious-diseases-and-treatment.imedpub.com> (SCI Journal).
  14. Dr. Asadi Srinivasulu., Soora, N.R., Mohammed, S.W. et al., "Prediction and detection of breast cancer text data using integrated EANN and ECNN techniques", *Appl Nanoscience* (2021, Received 22 July 2021, Accepted 18 August 2021, Published 01 September 2021). <https://doi.org/10.1007/s13204-021-02033-w> <https://link.springer.com/article/10.1007/s13204-021-02033-w#citeas> – Springer Nature Journal. (SCI)
  15. Dr. Asadi Srinivasulu, and Mr. Tarkeshwar Barua, "Early Prediction of Covid-19 using Modified Convolutional Neural Networks", *International Journal of Advanced Computational Engineering and Networking*, ISSN (p): 2320-2106, ISSN (e): 2321-2063 Volume-9, Issue-4, Apr.-2021, <http://iraj.in>, [http://iraj.in/journal/IJACEN//paper\\_detail.php?paper\\_id=17921&nameEarly\\_Prediction\\_of\\_Covid-19\\_using\\_Modified\\_Convolutional\\_Neural\\_Networks](http://iraj.in/journal/IJACEN//paper_detail.php?paper_id=17921&nameEarly_Prediction_of_Covid-19_using_Modified_Convolutional_Neural_Networks).
  16. Dr. Asadi Srinivasulu Asadi and P. Satya Narayana et al., "A new algorithm for detection of nodes failures and enhancement of network coverage and energy usage in wireless sensor networks", *wireless sensor networks, Materials Today: Proceedings*, <https://doi.org/10.1016/j.matpr.2021.05.355>. 2214-7853/2021 Elsevier Ltd., 5th, June 2021. (Elsevier) <https://www.sciencedirect.com/science/article/pii/S2214785321039547>.
  17. Dr. Asadi Srinivasulu, and Ch, G., S., T., R., R., Sri Sai Satyanarayana, D., (2022), "Association of vaccine medication for the efficacious COVID-19 treatment", *World Journal of Engineering*, Vol. 19 No. 1, pp. 98-108. <https://www.emerald.com/insight/content/doi/10.1108/WJE-01-2021-0062/full/html>, 10th May 2021 (Scopus).
  18. Dr. Asadi Srinivasulu, A., Ramanjaneyulu, K., Neelaveni, R. et al., "Advanced Lung Cancer Prediction Based on Blockchain Material Using Extended CNN", *Applied Nanoscience*, APNA-D-21-00538, Received: 26 March 2021 / Accepted: 24 May 2021 *Applied Nanoscience*, (), 1-13, 10.1007/s13204-021-01897-2, 09-06 <http://link.springer.com/article/10.1007/s13204-021-01897-2> (SCI - Journal) – Springer Nature Journal.
  19. Dr. Asadi Srinivasulu<sup>1</sup>, Surya Prasada Rao Borraaa, Vishal Moyalb et al., "An Efficient Shape Adaptive Techniques for the Digital Image Denoising", *Turkish Journal of Computer and Mathematics Education (Scopus-Journal)*, Vol.12 No.9 (2021), 2709-2719. <https://doi.org/10.17762/turcomat.v12i9.4328>. <https://www.turcomat.org/index.php/turkbilmater/article/view/4328/3693>.
  20. Dr. Asadi Srinivasulu, Dr. Umesh Neelakantan, Tarkeshwar Barua, "Early Prediction of Lung Cancer Detection Using Extended Convolutional Neural Networks", ISSN: 00333077, *Psychology and Education* (2021) 58(1): 5614-5624, Article Received: 18 October 2021, revised: 6 February 2021, Accepted: 20 January 2021. <https://doi.org/10.17762/pae.v58i1.1966>, <http://psychologyandeducation.net/pae/index.php/pae/article/view/1966>. (Scopus – Journal).
  21. Dr. Asadi Srinivasulu<sup>1</sup> and Gangadhar Ch et al., "Association of vaccine Medication for the Efficacious COVID-19 Treatment", *World Journal of Engineering*, Vol. ahead-of-print No. ahead-of-print. <https://doi.org/10.1108/WJE-01-2021-0062> (Scopus – Journal).



Scan to know paper details and  
author's profile

# Modelling of the Resilient Modulus ( $M_r$ ) of Lateritic Soils in Tropical Africa (Burkina Faso and Senegal): Determination of Model Parameters $K_1$ , $K_2$ and $K_3$ (Thom and Brown (1987), Uzan (1985) and the NCHRP 1-28A (2004) (National Cooperative Highway Research Program)

*KI Bibalo Ida Josiane, BA Makhaly & COULIBALY Mory*

*University Ibar Der Thiam*

## ABSTRACT

The study of the cyclic behavior of materials has been very successful with the development of increasingly powerful computer tools that allow to limit costly experimental studies in favor of numerical models. This development has led to an increasing demand from the scientific community in terms of accuracy of numerical simulations and in terms of calculation time. The numerical tool allows to simulate the material behavior based on plastic, viscoplastic or elastoplastic behavior models [1]. Our study will focus on the determination of the parameters of three models used for the determination of the reversible moduli ( $M_r$ ).

**Keywords:** lateritic soil; cyclic triaxial repeated loading (TCR); measured ( $M_{rm}$ ) and predicted ( $M_{rp}$ ) resilient modulus;  $k_1$ ,  $k_2$ ,  $k_3$  model parameters.

**Classification:** DDC Code: 631.4 LCC Code: S592.2

**Language:** English



LJP Copyright ID: 392914

Print ISSN: 2631-8474

Online ISSN: 2631-8482

London Journal of Engineering Research

Volume 22 | Issue 5 | Compilation 1.0





# Modelling of the Resilient Modulus ( $M_r$ ) of Lateritic Soils in Tropical Africa (Burkina Faso and Senegal): Determination of Model Parameters $k_1$ , $k_2$ and $k_3$ (Thom and Brown (1987), Uzan (1985) and the NCHRP 1-28A (2004) (National Cooperative Highway Research Program))

KI Bibalo Ida Josiane<sup>a</sup>, BA Makhaly<sup>o</sup> & COULIBALY Mory<sup>p</sup>

## ABSTRACT

The study of the cyclic behavior of materials has been very successful with the development of increasingly powerful computer tools that allow to limit costly experimental studies in favor of numerical models. This development has led to an increasing demand from the scientific community in terms of accuracy of numerical simulations and in terms of calculation time. The numerical tool allows to simulate the material behavior based on plastic, viscoplastic or elastoplastic behavior models [1]. Our study will focus on the determination of the parameters of three models used for the determination of the reversible moduli ( $M_r$ ). These models are those of Thom and Brown [2], Uzan [3] and the NCHRP [4] (National Cooperative Highway Research Program) of the MEPDG (Mechanistic-Empirical Pavement Design Guide) which are a function of the loading level (the confining stress ( $\sigma_3$ ), the deviatoric stress ( $\sigma_d$ ), the octahedral stress and the total stress ( $\theta$ )). The research will be carried out on 4 samples of lateritic gravelly soils, 2 of which are from Burkina Faso (the Badnogo and Dédougou sites) and 2 from Senegal (the Sindia and Lam-lam sites). We carried out cyclic triaxial tests with repeated loading (TCR) according to the European standard Nf EN-13286-7 [5]. The tests were performed at variable confining stress to calculate the measured Reversible Modulus ( $M_{rm} = \sigma_d / \epsilon_{1,r}$ ).

The materials studied have a maximum diameter of 20 mm and a percentage of fines lower than

20%. The samples are compacted to three water contents ( $w_{opm} - 2\%$ ,  $w_{opm}$  and  $w_{opm} + 2\%$ ) and to an optimum dry density ( $\gamma_{dopm}$ ) equal to 95% and 100%. The methodology used was least squares ( $\Sigma(\Delta M_r)^2$ ) and iteration by the "non-linear GRG" solving method used by the Solver calculation engine in Excel software. This allowed us to determine the values of the parameters  $k_1$  (in kPa and  $> 0$ ),  $k_2$  (unitless and  $< 0$ ),  $k_3$  (unitless and  $> 0$ ) of the above numerical models. It is found that the  $k_1$ ,  $k_2$ ,  $k_3$  parameters and correlation coefficients are on average equal to 3511.540 kPa, -0.420, 0, and 0.91 for Thom and Brown's model [2]; 4988.974 kPa, -0.289, 0.536, and 0.97 for Uzan's model [3]; and 2436.959 kPa, -0.398, 1.864, and 0.91  $> 0.90$  for NCHRP [4] respectively. The predicted summary reversible modulus (MRSP) by the NCHRP model [4] is on average equal to 377.543 MPa. On the other hand, for the materials Ded/9.93/95.42 and Ded/8.16/95.39 the parameter  $k_1$  increases by 37.83% and the modulus MRSP also increases by 39.26%.

Moreover, for Ded/8,16/95,39 and Ded/6,23/95,52 the  $k_1$  parameter increases by 65,77% and the MRSP module also increases by 39,11%. This justifies that the parameter  $k_1$  tells us about the hardening effect of the material.

**Keywords:** lateritic soil; cyclic triaxial repeated loading (TCR); measured ( $M_{rm}$ ) and predicted ( $M_{rp}$ ) resilient modulus;  $k_1$ ,  $k_2$ ,  $k_3$  model parameters.

*Author*  $\alpha$   $\sigma$ : University Ibar Der Thiam “Laboratoire de Mécanique et Modélisation” (L2M) of Department of engineering Sciences, Cité Malick SY Route du CNEPS Villa N°100, Thiès BP 967, Senegal.

## I. INTRODUCTION

The resilient behavior of granular materials is affected by several factors, the most important of which is the level of stress applied. It is so essential that the stress-deformation relationship be modeled exactly with mathematical laws to predict the long and short term behavior as well as the performance of granular materials. The simplicity of the material response analysis procedure makes it difficult to establish models that respect the theoretical principles of soil mechanics [6]. The resilient modulus (MR) of road materials is one of the most important parameters in the analysis and design of pavements. This parameter is used in empirical and mechanistic-empirical methods as the main parameter to express the stiffness and behavior of road construction materials. To determine this parameter in the laboratory, it is necessary to perform a dynamic triaxial loading test under different confinement and deflection constraints, which is a costly and time-consuming approach [7]. To overcome these very exorbitant costs, several researchers have developed digital models such as Thom and Brown [2], Uzan [3] and the NCHRP (National Cooperative Highway Research Program) [4] that we studied in our research.

However, the objective of this work is to determine their parameters. For this we based ourselves on the experimental results to calculate the measured resilient modulus ( $M_{rm}$ ), in order to predict the resilient modulus ( $M_{rp}$ ) by the aforementioned digital models and determined their parameters. One of the most important aspects for the design and sizing of pavements is the elastic or resilient modulus (MR) which allows to characterize the mechanical behavior of materials necessary for the sizing of a pavement (AASHTO American Association of State Highway and Transportation Officials 1986 [8]). Studies on gravelly lateritic rocks have rarely been reported in the literature. The only works to be found are those of ((Sikali et al. (1980) and Sweere et al.

(1990) in [9]). To this can be added the work carried out in Senegal during the last two years. decades to discover the advanced parameters of granular materials (Fall, Ba, Samb, Dione, and Aïdara [10]) have contributed to deepening knowledge on the advanced mechanical behavior of road materials used in Senegal. In order to contribute to the improvement of the technical documents used for the design and dimensioning of pavements in tropical Africa, we carried out cyclic triaxial repeated loading tests (TCR) of the SCHENCK brand at the Gustave Eiffel University in Nantes in s " based on European standard EN 13286-7 [5] while maintaining the variable confinement pressure (method A). The measured stress-strain results are interpreted for the resilient part by applying the Boyce model, extended to the axial anisotropy [10]. The materials used come from Burkina Faso and Senegal and are of a gravelly lateritic nature, class B4-B6 according to the GTR classification.

## II. MATERIALS AND METHOD

About two hundred years ago the term "laterite" first appeared in the scientific literature. Despite various vicissitudes, this term is still widely used. We could think that it covers perfectly recognized and defined facts. However, a study, even a brief one, of synthetic works dealing with this problem shows that, under the brevity of the term, sometimes very different objects are hidden. It is therefore useful to first look at the definitions that have been given to this term. We will then discuss the soil formation processes called "laterites" and their location in the world [11]. In local dialects these formations are called "brick earth". The name "laterite" is therefore only the Latin translation of a vernacular terminology.

### 2.1 Classification of materials used

- *General information on lateritic soils*

Laterite has the root "later" which means brick in Latin, this only by reference to the use of these blocks (Maignien, 1966; Autret 1983; Bourgeon & Gunnell, 2005 in [12]).

Theories dealing with the origin and formation of laterites are varied. Nowadays, the definition which seems to be unanimous among authors is

that of Schellman in 1986 in [13] because it is based on the conditions of alteration of the bedrock and the mineralogical composition. For this author: "Laterites are products of intense meteoric weathering and are made up of a mineral assemblage that can be made of goethite, hematite, aluminum hydroxide, kaolinite and quartz" figure 1 ". The  $SiO_2 / (Al_2O_3 + Fe_2O_3)$  ratio compared to that of the parent rock must be such that the laterite formation does not contain more silica than that which is retained in the remaining quartz and that which is necessary for the formation of kaolinite "[13].

Laterites are widely distributed throughout the world, but more particularly in intertropical regions of Africa, Australia, India, Southeast Asia and South America. Laterites extend beyond subhumid tropical climates and can be observed even in desert regions (African and Australian deserts) where they point to wetter past influences. Considering that the intertropical zone covers 40% of the terrestrial surface of the globe, the lateritic cover is estimated at 33% of the surfaces of the continents, in addition to the desert zones and the steppe zones where laterite does not form (Tardy, 1997 in [14] "figure 2".

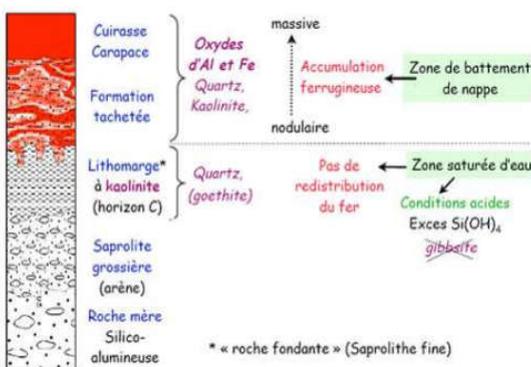


Fig. 1: Lateritic profile (Retallack, 1997 in [14])

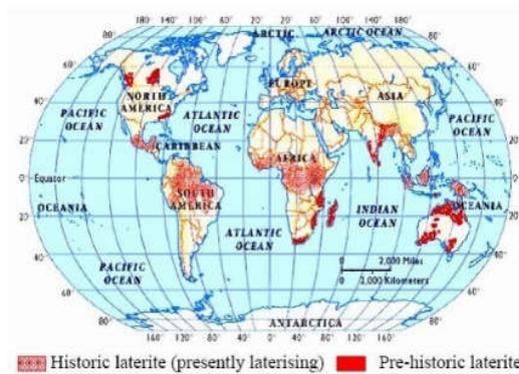


Fig. 2: current and prehistoric laterites (Persons, 1970 in [12])

- *Characterization of laterites from Senegal and Burkina Faso used*

The study as a whole focused on the laterites of two borrowings sites in Burkina Faso (Badnogo and Dédougou) "figure 3" and of two (2) quarries in Senegal (Sindia and Lam-Lam) "figure 4". The laterites and many other soils of the intertropical regions are located in areas where it is very hot and where the rains are abundant, either all year round or during a wet season (Legros, 2013 in [15]).

The summary of the material characterization tests is presented in "Table 1". It appears that:

After analysis of the materials, it can be seen that the samples, despite the diversity of their origin, are gravelly materials with little clay (lateritic gravels with little clay) and of class B4, B5 and B6 "table 1" according to the book of the "Guide of Road Earthworks "[10].



Fig. 3: location of borrowing sites in Burkina Faso (Dédougou et Badnogo)

Modelling of the Resilient Modulus ( $M_r$ ) of Lateritic Soils in Tropical Africa (Burkina Faso and Senegal): Determination of Model Parameters  $K_1$ ,  $K_2$  and  $K_3$  (Thom and Brown (1987), Uzan (1985) and the NCHRP 1-28A (2004) (National Cooperative Highway Research Program)

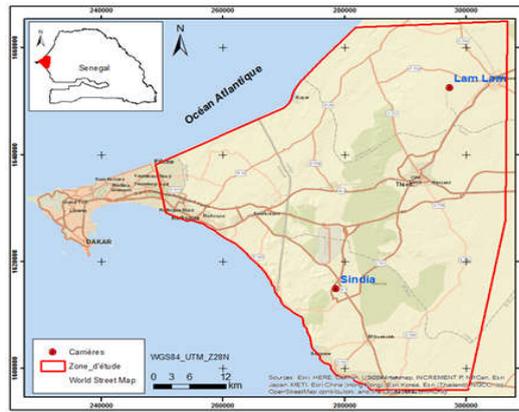


Fig. 4: location of borrowing sites in Senegal (Sindia et Lam-Lam)

Table 1: Physical and mechanical characterization of lateritic soils samples [10]

Designation of borrow sites	Particle size Analysis				Materials classification				Parameters of the Atterberg limit			CBR compactness and lift parameters				
	Sand (%)	Fines (%)	Ratio									Water content	Dry density	Parameters of the Modified Proctor		CBR after 4 days of immersion
	2 mm	80 µm	Cu	Cc	GTR	LCPC	AASHTO	USCS	LL (%)	PI (%)	Ic	wn (%)	Gs	γd max (kN/m <sup>3</sup> )	wop m (%)	95% OPM
Sindia	41.6	17.86	207	0.34	B5	GA	A2-4a (o)	GC - CL	29.85	9.2	2.7	4.7	2.76	19.7	9.66	54.8
Lam-Lam	39.3	18.19	130	0.28	B5	GA	A2-4a (o)	GC - CL	30.3	10.1	2.4	5.6	2.69	17.52	11.8	30.5
Dedougou	25.2	10.21	763	29.5	B4	GA	A2-4a (o)	GM - GC	27.5	7.2	3.2	4.3	2.82	22.5	8.05	65
Badnogo	34.6	16.63	129	11.6	B6	GA	A2-6 (o)	GC - CL	28	13	1.8	4.6	2.76	21.45	9.7	58

### 2.2 Methodology of the cyclic triaxial test with repeated loading

Like Untreated Graves, laterites are natural granular materials without binder, which exhibit a highly non-linear behavior, depending on the stresses applied and the number of loading cycles. The triaxial repeated loading test is widely used to study the mechanical behavior of these types of materials [16]. The TCR consists in subjecting a cylindrical specimen of untreated granular material to cyclic loadings, simulating the stresses existing in a road bedding layer, and in measuring the axial and radial deformations of the specimen produced by these phase loads. The standard used is EN 13286-7 [5] and defines three different test procedures (method B with constant confining pressure  $\sigma_3$ , method A with variable confining pressure  $\sigma_3$  and stepwise method the one we have used). From the identification and characterization tests (particle size, Atterberg limit, Proctor,

etc.) we notice that the laterites are close to the GNT. This justifies the choice of this aforementioned standard [10].

For entering the input data for the confinement stress, we deduce 2kPa. This corresponds to the weight of half the height of the water contained in the cell. The test pieces after preparation to the desired water content and density of compactness are assigned the sensors for measuring axial and radial deformations “figure 5” and “figure 6”.

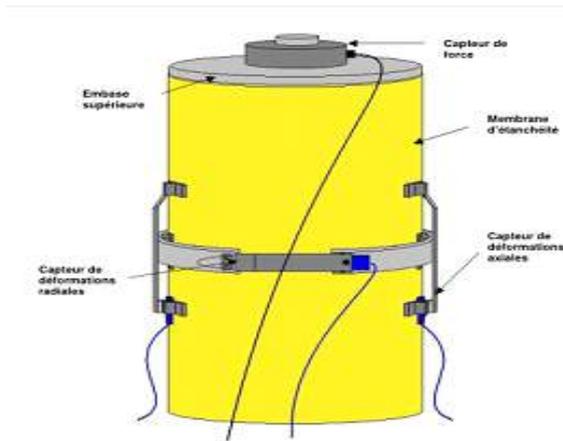


Fig. 5: Complete device for measuring axial and radial deformations [16]

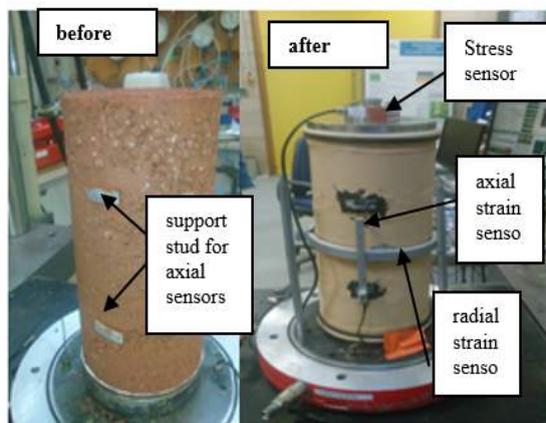


Fig. 6: Test specimen with sensor fixing studs (before) and with sensor installation (after)

### III. MODELING BY SEVERAL NO LINEAR MODELS OF THE RESILIENT MODULUS

The resilient behavior of granular materials is affected by several factors, the most important of which is the level of stress applied; where they exhibit no linear behavior. It is essential that the stress-strain relationship be modeled exactly with mathematical laws to predict the long and short term behavior as well as the performance of granular materials. The simplicity of the material response analysis procedure makes it difficult to establish models respecting the theoretical principles of soil mechanics (Lekarp et al., 2000 in [17]).

To take into account the non-linearity of bass behavior, the modulus of elasticity is replaced by the Resilient Modulus (Seed et al., 1965 in [17]). The term "resilient" refers to the portion of the recoverable energy of a material that is stressed,

when it is discharged. This is how the resilient modulus concept was developed to allow better simulation of the loading of pavements by rolling loads [14].

Lekarp, Isacson, & Dawson [6] reported on numerous studies carried out since 1960 in order to characterize the resilient behavior of granular materials. The studies found in the literature, show that this behavior can be affected, with different degrees of importance, by several factors such as the level of stress, the history and number of loading cycles, the loading frequency, the effect of density, grain fraction and grain shape, water content. However, the most important parameter affecting the resilient response is the level of stress applied to the sample (Table 2.1) [14].

#### 3.1 No linears models of resilient modulus used

An elastic constitutive law is chosen, can be elastic linear isotropic (from the normative point of

view), hypo elastic (model K- $\theta$ ) or hyper elastic (model of Boyce) [18]. There are several digital models used in the bibliography for the digital modeling of the resilient module. These models are either according to the level of loading or according to the physical parameters. The methodology used is that of least squares ( $\sum (\Delta Mr)^2$ ) and iteration by the "no linear GRG" resolution method used by the Solver calculation

engine in the Excel software. This allowed us to determine the values of the parameters  $k_1$  (in kPa and  $> 0$ ),  $k_2$  (without unit and  $< 0$ ),  $k_3$  (without unit and  $> 0$ ) of the aforementioned numerical models.

We determine the residual ( $R_i$ ) by equation 1 which will be the objective to be defined in the Solver and the variable cells which correspond to the cells of the parameters  $k_i$  to be determined.

$$R_i = \frac{\left( \sum_{i=1}^n (\Delta Mr)_i^2 \right)}{Nb} = \frac{\left( \sum_{i=1}^n (Mr_m - Mr_p)^2 \right)}{Nb} \quad (1)$$

$R_i$  is the residual,  $M_{rm}$  the measured modulus,  $M_{rp}$  the modulus predicted by the chosen model and  $Nb$  corresponding to the matrix of cells (number of sequences).

Several models have been developed for the prediction of the resilient modulus of untreated bass (GNT). Among which we have:

Uzan [3] proposes a modification of the  $k - \theta$  model to take into account the effect of the deviatoric stress. This relationship is expressed by equation (2) as follows:

$$M_r = k_1 p_a \left( \frac{\theta}{p_a} \right)^{k_2} \left( \frac{\sigma_d}{p_a} \right)^{k_3} \quad (2)$$

$k_1, k_2$  et  $k_3$  are parameters of model  $p_a$  is atmospheric pressure in kPa;

$\theta =$  sum of principal stresses in k Pa  $\sigma_d$  is the deviatoric stress in kPa

Uzan's model seems to agree well with the experimental results on GNT even at confinement stresses greater than the deviatoric stress

Thom and Brown [2] experiment the Resilient Modulus as a function of the following stress ratio according to the equation:

$$M_r = k_1 \left( \frac{p}{q} \right)^{k_2} \quad (3)$$

$k_1, k_2,$  are the parameters of the model,  $q = \sigma_d = \sigma_1 - \sigma_3$  deviatoric stress,  $p =$  average pressure ( $p = (\sigma_1 + \sigma_2 + \sigma_3) / 3$ ).

A new "harmonized" test protocol for the resilience module has been developed as part of the NCHRP project 1-28A [4]. This model, called either the NCHRP model or the MEPDG model, is implemented in the new "Mechanistic-Empirical Pavement Design Guide" (MEPDG). This new protocol uses the universal nonlinear model which is applicable to unbound base or subbase

materials given by equation (4) [17]. This equation combines the hardening effect of the sum of the principal stresses and the softening effect of the shear stress; thus, the value of  $k_2$  must be positive and that of  $k_3$  negative. But in our study for severe lateritics the value of  $k_2$  will be negative and that of  $k_3$  positive. To properly identify the model constants, the multiple correlation

coefficients determined for the test must exceed 0.90. It should be noted that the use of this model is proposed for both the granular materials of the

base layers and for the fine soils of the foundation layers.

$$M_r = k_1 pa \left( \frac{\theta}{pa} \right)^{k_2} \cdot \left( \frac{\tau_{oct}}{pa} \right)^{k_3} \quad (4)$$

$k_1, k_2, k_3$  are the parameters of the model. ( $k_1 > 0$ ;  $k_2 < 0$ ;  $k_3 > 0$  for our lateritic materials).

### 3.2 The results obtained and interpretations

It appears that:

- After the analysis of the materials, it can be seen that the samples, despite the diversity of their origin, are gravelly materials with little clay (lateritic gravels with little clay) and of class B4, B5 and B6 according to the book of the "Guide de Terrassement Routier "Table 1»
- Table 2 and figures 7 (a), 7 (b) and 7 (c) show that the parameter  $k_1$  is positive and varies according to the type of material and the type of model. Their maximum, average and minimum values are represented by diagrams in « Box »
- Table 2 and figures 8 (a), 8 (b) and 8 (c) show that the parameter  $k_2$  is negative and varies depending on the type of material and the type of model. Their maximum, average and minimum values are represented by diagrams in « Box »
- Table 2 and figures 9 (a), 9 (b) and 9 (c) show that the correlation coefficient  $R$  varies according to the type of material and the type of model. Their maximum, average and minimum values are represented by diagrams in « Box ». We deduce that:
- Figure 10 shows a regression curve of the measured Resilient Modulus ( $M_{rm}$ ) against

the predicted Resilient Modulus ( $M_{rp}$ ) of the models: (Uzan [3], Thom and Brown [2], NCHRP [4]) of the sample Sin 12.10 / 95.75. We deduce that the Uzan model is closer to the line of equation  $Y = X$ , from which it correlates well especially for the material Sin / 11.7 / 95.71 with a correlation coefficient equal to 0.994.

- The parameters  $k_1, k_2, k_3$  are on average respectively equal to 3511.540 kPa, -0.420, 0, and 0.91 for the model of Thom and Brown [2]; 4988.974 kPa, -0.289, 0.536 and 0.97 for that of Uzan [3] and 2436.959 kPa, -0.398, 1.864 and 0.91 for the NCHRP [4] « Table 2 ».
- The summary resilient modulus predicted by the NCHRP model [4] is on average equal to 377.543 MPa for the four samples « table 2 ».
- In addition, table 2 shows us that for the materials Ded / 9.93 / 95.42 and Ded / 8.16 / 95.39 the parameter  $k_1$  increases by 37.83% and the MRSP modulus also increases by 39.26 %. In addition, for Ded / 8.16 / 95.39 and Ded / 6.23 / 95.52, the parameter  $k_1$  increases by 65.77% and the MRSP modulus also increases by 39.11%. This justifies that the parameter  $k_1$  tells us about the hardening effect of the material.

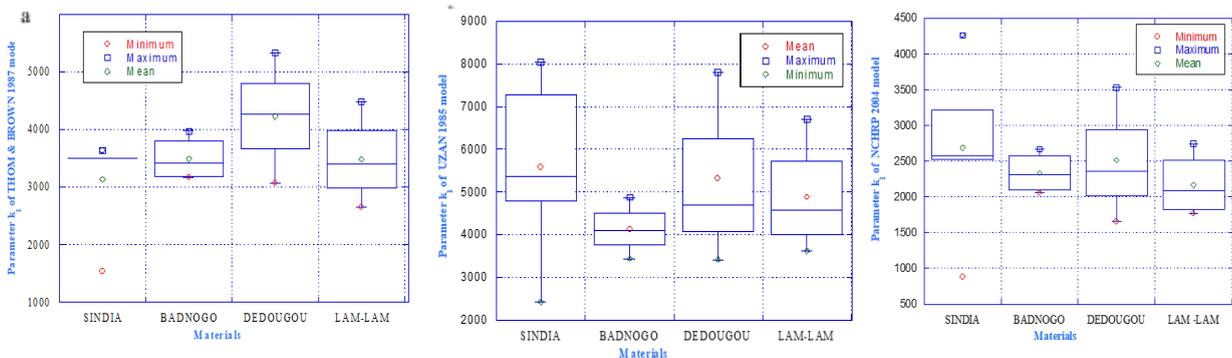
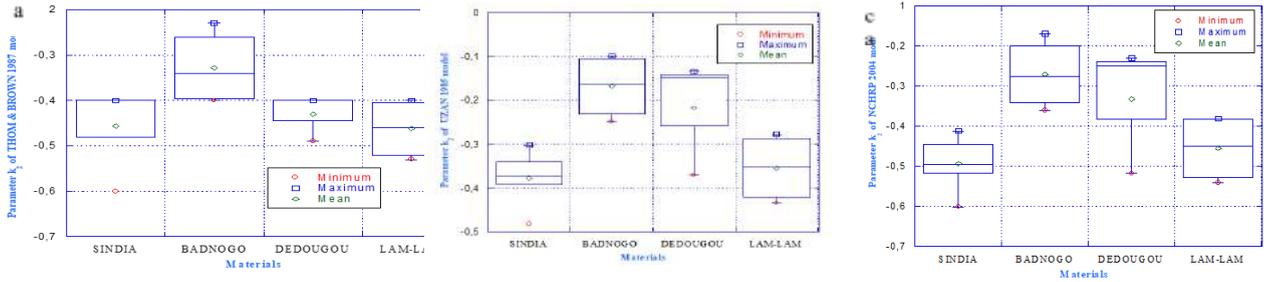
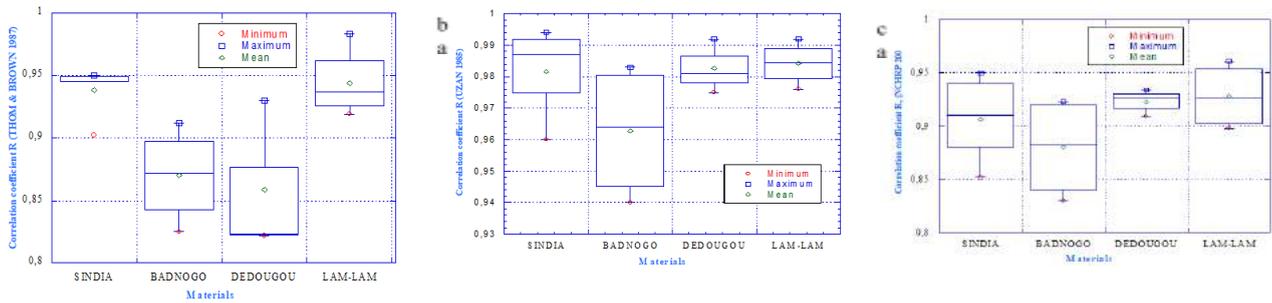


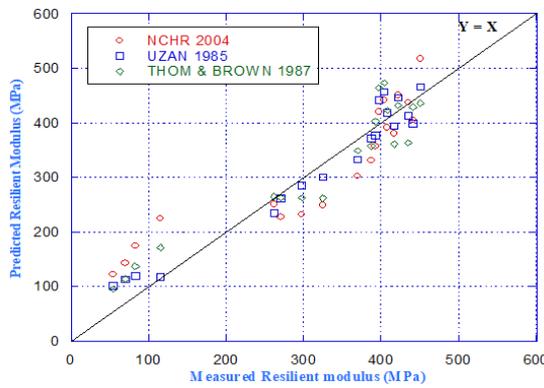
Fig. 7: Parameter  $k_1$  (a) of the Thom and Brown model [2]; (b) of the Uzan model [3]; (c) of the NCHRP model [4]



**Fig. 8:** Parameter  $k_2$  (a) of the Thom and Brown model [2]; (b) of the Uzan model [3]; (c) of the NCHRP model [4]



**Fig. 9:** correlation coefficient (a) of the Thom an Brown model [2]; (b) of the Uzan model [3]; (c) of the NCHRP model [4]



**Fig. 10:** Resilient Modulus measured / Resilient Modulus predicted by the models (UZAN [3], THOM and BROWN [2], NCHRP [4]) of the Sin sample 12.10 / 95.75

**Table 2: Summary of the parameters and correlation coefficient and determination of the digital models of the resilient module**

Name	Model of THOM & BROWN 1987		Coefficients		Model of UZAN (1985)			Coefficients			Model of NCHRP (2004)			Coefficients		Predicted Resilient Modulus Summary (MRSP) (MPa) $\theta = 0_3, 208$ kPa $\tau_{wet} = 48,6$ kPa $\sigma_3 = \sigma_1 = 35$ kPa
	$k_1$	$k_2$	Correlation	Determination	$k_1$	$k_2$	$k_3$	Correlation	Determination	$k_1$	$k_2$	$k_3$	Correlation	Determination		
SINDIA Wop% = 9,66	1532,67	-0,60	0,902	0,814	2421,05	-0,482	0,860	0,994	0,988	874,634	-0,601	2,606	0,95	0,905	158,496	
	3489,45	-0,40	0,945	0,894	4798,57	-0,301	0,454	0,975	0,950	2567,506	-0,412	1,632	0,91	0,822	363,430	
	3635,15	-0,48	0,949	0,900	5356,91	-0,371	0,568	0,987	0,973	2525,042	-0,496	1,957	0,852	0,923	382,110	
	3489,45	-0,396	0,945	0,894	8032,71	-0,340	0,465	0,960	0,922	4253,516	-0,446	1,644	0,880	0,775	590,010	
Sin/7,59/95,94	3489,45	-0,40	0,945	2	7279,08	-0,391	0,642	0,992	0,984	3210,334	-0,516	2,124	0,940	0,884	511,592	
Bad/11,43/95,48	3608,36	-0,23	0,864	6	4083,44	-0,106	0,265	0,938	0,879	2669,361	-0,225	1,175	0,835	0,697	361,414	
Bad/10,04/95,58	3167,07	-0,29	0,825	0	3438,19	-0,099	0,372	0,945	0,893	2058,260	-0,174	1,295	0,855	0,730	303,366	
Bad/7,57/95,32	3973,45	-0,40	0,883	0	4872,05	-0,215	0,516	0,983	0,967	2476,969	-0,322	1,749	0,923	0,853	392,118	
Bad/9,36/100,06	3203,82	-0,39	0,912	3	4119,91	-0,249	0,484	0,978	0,956	2143,762	-0,360	1,698	0,917	0,840	323,581	
Ded/9,93/95,42	3068,14	-0,40	0,822	6	3413,88	-0,148	0,568	0,992	0,984	1655,390	-0,249	1,847	0,934	0,873	287,385	
UGOU Wop% = 8,05	4269,22	-0,40	0,823	7	4704,63	-0,134	0,538	0,981	0,963	2358,181	-0,231	1,757	0,909	0,827	400,204	
Ded/6,23/95,52	5329,26	-0,49	0,930	5	7799,18	-0,370	0,601	0,975	0,950	3530,922	-0,518	2,101	0,926	0,858	556,713	
LAM-L AM Wop% = 11,8	3489,45	-0,51	0,983	5	4762,95	-0,434	0,579	0,992	0,983	1765,563	-0,515	2,562	0,961	0,923	334,751	
Lam/12,43/98,92	3308,74	-0,40	0,932	9	4403,64	-0,277	0,485	0,983	0,966	2276,177	-0,385	1,699	0,907	0,823	337,386	
Lam/13,92/96,51	2647,89	-0,41	0,941	5	3629,59	-0,297	0,472	0,976	0,953	1882,254	-0,382	1,655	0,898	0,807	274,747	
Lam/10,15/96,04	4483,07	-0,53	0,919	4	6707,81	-0,408	0,709	0,986	0,972	2743,480	-0,542	2,320	0,946	0,895	463,386	

## IV. CONCLUSION

At the end of our research we can conclude that the gravelly lateritic materials, despite their geographic diversity, have almost the same physical and compact characteristics; they are class B4, B5 and B6 according to the GTR classification. In addition, after testing the cyclic triaxial (TCR) by standard EN 13286-7 [5] with method A, the resilient molds obtained differ from the type of materials (percentage of fine, water content, and stress level. Three mathematical models were used in our work for analysis. The Resilient modulus measured ( $M_{rm}$ ) with respect to the Resilient modulus predicted ( $M_{rp}$ ) by these models (Uzan [3], Thom and Brown [2], NCHRP [4]) tells us that the Uzan model [3] presents a very good correlation whatever the material, especially for the Sin / 11.7 / 95.71 material with a correlation coefficient equal to 0.994. In addition, the parameters  $k_1$ ,  $k_2$ ,  $k_3$  are at least respectively equal to 1532.670 kPa, -0.600, 0, and 0.82 for the model of Thom and Brown [2]; 2421.050 kPa, -0.482, 0.265 and 0.94 for that of Uzan [3] and 874.634 kPa, -0.601, 1.175 and 0.84 for the NCHRP [4]. The summary resilient modulus predicted by the NCHRP model [4] is on average equal to 377.543 MPa for the four samples. We also notice that for the materials Ded / 9.93 / 95.42 and Ded / 8.16 / 95.39 the parameter  $k_1$  increases by 37.83% and the MRSP modulus also increases by 39.26%. In addition for Ded / 8,16 / 95,39 and Ded / 6,23 / 95,52 the parameter  $k_1$  increases by 65.77% and the MRSP modulus also increases by 39.11%. This justifies that the parameter  $k_1$  tells us about the hardening effect of the material.

In perspective, propose to strengthen studies by determining the  $SiO_2 / (Al_2O_3 + Fe_2O_3)$  ratio and other chemical and mineralogical mechanical tests in order to better classify our material.

## ACKNOWLEDGEMENTS

Firstly I say thank you to my creator God of the visible and invisible universe. Secondly, my gratitude goes to the staff of the Laboratory, Auscultation, Modeling, Experimentation, Transport Infrastructures (LAMES) of the campus

of the Gustave Eiffel University of Nantes, formerly the IFSTTAR institute of Nantes, who accompanied me in the realization of triaxial tests (TCR). Furthermore, I would like to thank the staff of the Laboratoire National du Bâtiment et des Travaux Publics (LNBTP) of Burkina Faso as well as the staff of the Laboratoire de Mécanique et de Modélisation (L2M); of the doctoral school (ED2DS) of the University Iba Der Thiam of Thiès in Senegal (Unité de Formation en Sciences de l'Ingénieur). Thirdly, I reiterate my gratitude to the National Fund for Education and Research (FONER) of Burkina Faso for their financial support. Finally, I would like to reiterate my thanks to all the people who contributed to the realization of this work.

## REFERENCES

1. Djimli, L., Analyse du phénomène de rochet : essais et modélisation. INSA de Rouen; Université Mentouri Constantine, Algérie 2020.
2. NH Thom, SF Brown Effect of moisture on the structural performance of a crushed-limestone road base 1987.
3. Uzan, J. "Characterization of granular material", Transp. Res. Rec. 1022, Transportation Research Board, Washington, D.C. 1985, pp. 52-59.
4. NCHRP "Laboratory determination of Resilient Modulus for flexible pavement design," National Cooperative Highway Research Program (NCHRP) Project 1-28A. Transportation Research Board of National Academies 2004.
5. Nf EN-13286-7, Norme Européenne pour l'essai triaxial sous charge cyclique pour mélange sans liants hydraulique 2004.
6. Lekarp, F., Isacsson, U., Dawson, A., State of the art. I: Resilient response of unbound aggregates. Journal of Transportation Engineering / January/February 2000.
7. Heidarabadizadeh, N., Ghanizadeh, A.R., Behnood, A., Prediction of the resilient modulus of non-cohesive subgrade soils and unbound subbase materials using a hybrid support vector machine method and colliding bodies optimization algorithm. Construction and Building Materials 275, 122140 2021.

8. AASHTO "Guide for Design of Pavement Structures," American Association of State Highway and Transportation Officials 1986.
9. Fall, M., Identification et caractérisation mécanique de graveleux latéritiques du Sénégal: application au domaine routier. Institut national polytechnique de lorraine Ecole Nationale Supérieure De Géologie De Nancy 1993.
10. Ki, B.I.J., Ba, M., Gueye, R., Hornych, P., Sana, A., Effect of Water Content and Grains Size Distribution on the Characteristic Resilient Young's Modulus (Ec) Obtained Using Anisotropic Boyce Model on Gravelly Lateritic Soils from Tropical Africa (Burkina Faso and Senegal). *Open Journal of Civil Engineering* 11, 134–152 2021. <https://doi.org/10.4236/ojce.2021.111009>.
11. Bohi, Z.P.B., Caractérisation des sols latéritiques utilisés en construction routière: cas de la région de l'agneby (côté d'ivoire). L'école nationale des ponts et chaussées, France 2008.
12. Lawane Gana, A., Caractérisation des matériaux latéritiques indurés pour une meilleure utilisation dans l'habitat en Afrique L'Université du Havre et de la Fondation 2iE 2014.
13. Millogo, Y., Etude géotechnique, chimique et minéralogique de matières premières argileuse et latéritique du Burkina Faso améliorées aux liants hydrauliques: application au génie civil (bâtiment et route). Université de Ouaga 2008.
14. Samb, F., Modélisation par éléments finis des chaussées en graveleux latéritiques traités ou non et application au dimensionnement Mécanistique-Empirique Université De Thiès, Sénégal 2014.
15. Issiakou, M.S., Caractérisation et valorisation des matériaux latéritiques utilisés en construction routière au Niger Université de Bordeaux 2016.
16. El Abd, A., Développement d'une méthode de prédiction des déformations de surface des chaussées à assises non traitées (Thèse de doctorat). Université de Bordeaux I, 1970-2013, France 2006.
17. Ba, M., Comportement mécanique sous sollicitations cycliques de granulats quartzitiques de Bakel - Comparaison avec des matériaux de référence du Sénégal et d'Amérique (USA). Application au Dimensionnement Mécanistique-Empirique des chaussées souples. Université Cheikh Anta Diop de Dakar, Sénégal 2012.
18. Habiballah, T.E.M., Modélisation des déformations permanentes des graves non traitées. Université de limoges 2005.

*This page is intentionally left blank*



Scan to know paper details and  
author's profile

# Development of a New Profile of the Teeth of a Ginning Saw and its Results

*Shukhratjon Imomkulov Bokijanovich & Muxtorova Iroda Kamoljon Qizi*

## ABSTRACT

Currently, there is no scientific justification for improving the geometric parameters of the genie saw and the standards of accuracy of functional parameters. However, despite the success achieved in separating fiber from seeds during ginning, there are major disadvantages in that most cotton plants produce cotton fiber and seeds with increased ginning vices. The study on change of geometric parameters of various authors is considered. The issue of improving the geometrical parameters of the saw is important and therefore requires urgent resolution. The article discusses issues related to improving the profile of the teeth of the genie saw and increasing its productivity.

**Keywords:** improvement of the working surface, fiber size, fiber removal, brush drum, tooth thickness, fiber defects, fiber content.

**Classification:** DDC Code: 813.54 LCC Code: PS3553.L245

**Language:** English



London  
Journals Press

LJP Copyright ID: 392915

Print ISSN: 2631-8474

Online ISSN: 2631-8482

London Journal of Engineering Research

Volume 22 | Issue 5 | Compilation 1.0



© 2022. Shukhratjon Imomkulov Bokijanovich & Muxtorova Iroda Kamoljon qizi. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncom-mercial 4.0 Unported License <http://creativecommons.org/licenses/by-nc/4.0/>, permitting all noncommercial use, distribution, and reproduction in any medium, provided the original work is properly cited.



# Development of a New Profile of the Teeth of a Ginning Saw and its Results

Shukhratjon Imomkulov Bokijanovich<sup>α</sup> & Muxtorova Iroda Kamoljon Qizi<sup>σ</sup>

## ABSTRACT

*Currently, there is no scientific justification for improving the geometric parameters of the genie saw and the standards of accuracy of functional parameters. However, despite the success achieved in separating fiber from seeds during ginning, there are major disadvantages in that most cotton plants produce cotton fiber and seeds with increased ginning vices. The study on change of geometric parameters of various authors is considered. The issue of improving the geometrical parameters of the saw is important and therefore requires urgent resolution. The article discusses issues related to improving the profile of the teeth of the genie saw and increasing its productivity.*

**Keywords:** improvement of the working surface, fiber size, fiber removal, brush drum, tooth thickness, fiber defects, fiber content.

**Author α:** Associate professor of the department “General technical disciplines”, Namangan engineering and technology institute, Uzbekistan, Namangan.

**σ:** Senior Lecturer of the Department “General Technical Disciplines”, Namangan engineering and technology institute, Uzbekistan, Namangan.

## I. INTRODUCTION

Since the most ancient times, people have used cotton mainly after separating the fiber from its seeds. Initially, the separation of cotton fibers from seeds was carried out manually. At the same time, the productivity of one person did not exceed 1 kg per day [1].

The development of the history of mankind has led to the fact that the separation of cotton fiber from seeds has been carried out by machine.

Especially in such areas, the achievement of science is the improvement of the main working bodies of the profile of the laser saw [2].

Taking into account the prevailing influence of the state of the teeth of the saw blade on the quality of processed raw cotton products, it is necessary to ensure high-quality production of the disk in compliance with both the geometric parameters of the tooth and the roughness of its working surfaces.

The articles of E. A. Normatov [3] and A. A. Ismailov et al. [2] were published on the change in the geometric parameters of the tooth.

In both articles, the questions of the geometry of the saw tooth were considered in more detail and the following conclusions were made:

Akhmedova S. came to the conclusion that " With a shorter tooth with a constant pitch and a cavity having the most rational shape, i.e. the shape of an isosceles triangle with the largest gripping area, the gripping ability does not decrease, and the tooth becomes more stable and more economical in operation. Based on this, you can find the height."

According to Normatov E. A., the tooth height is equal to 2.6 mm [3].

Ismailova A. A. and others on the basis of theoretical research came to the following main conclusions:

The maximum value of the fiber capture area will be at the angle:  $\alpha = 90^\circ - \gamma$ ;

where:  $\gamma$  is the angle between the guides of the relative speed of the fiber and the circumferential speed of the saw. Note that the article does not address issues related to the height of the tooth and does not draw appropriate conclusions, it is not agreed with the statement of the authors, we note that to the angle  $\alpha=45^\circ$ , the corresponding height of the tooth is  $h=2.6$  mm (at  $r=0.4$  mm and the angle of sharpening  $\delta=20^\circ$ ) [4].

Makhkamov R. G., based on the analysis of the literature [3], as well as on the basis of his previous theoretical assumptions, considers the issue of the geometry of the tooth of a chain saw and makes the following proposals: Reduce the height of the saw teeth to 2.6 mm; keep the gap between the grates within 2.8–3.2 mm; the tooth chamfer should be removed.

However, despite the success achieved in separating fiber from seeds during ginning, there are major disadvantages, they are that most cotton mills produce cotton fiber and seeds with increased ginning defects.

In order to determine the optimal variants of the profile of the teeth of the laser saw, a laboratory installation was tested. The optimal profile of the saw tooth was determined, aimed at reducing its height. Then the teeth with such profiles were tested in production jeans and some results were obtained to reduce the amount of fiber defects and seed crushing.

When analyzing the results of ginning and with the same tooth profiles on the laboratory and production gin, we found some changes.

For example, when ginning "VL-10", intense cotton notes occurred with a long tooth, and when testing saw blades with a height of 2 mm on a production gin, the opposite results were obtained, i.e. intense cotton notes occurred with a short tooth [7].

## II. EXPERIMENTAL PROCEDURES

E. A. Normatov, on the basis of logical assumptions, considered the work of the tooth in relation to the work of the grate, the raw chamber and the brush drum. The author did not consider the issues of tooth geometry.

He [4], in the article "Points of ginning saws", also considered the geometry of the tooth of a gin saw; "... the slope of the back of the top of the tooth is not needed today, and the saw tooth can have a trapezoidal shape with a flat top, rather than a triangular one ...". The author proposed to obtain such a flat top at a point due to a slight shortening of the tooth height. In conclusion, the author

suggests that the proposed method allows for the possibility of repeated tooth points, since the analysis of its operation proves that the working face of the tooth, i.e. the face, which is really necessary for work and gives products, does not exceed  $\frac{3}{3}$  of its entire height, therefore, there is no danger of deterioration in productivity, even if the saw tooth is worn off and  $\frac{1}{2}$  of its height."

In the collection No. 4 of the Pilot Plant, an article was published by U.A. Sapaev, "Evaluation of the use of various devices for ginning wet snapper", in which an attempt was made to install a stirrer in the raw gin chamber to ensure normal rotation of the raw roller when ginning cotton from a wet snapper. The author came to the conclusion that the use of agitators does not provide significant assistance. Therefore, they have not found application in industry.

During the same period, a researcher at Central Research Institute of the Cotton Industry (CRICI) Tilabov B. N. studied the influence of the quality of steel used for the production of saws and the properties of raw cotton on the service life of saws in the work "The influence of hardness and strength of steel on the main indicators of ginning". As a result of the research, the author came to the conclusion that the service life of the saw cylinder is determined not by the wear resistance of the saw steel, but solely by the amount of foreign impurities that got into the working chamber of the gin, the size of the tooth and the mechanical qualities of the steel from which the saw is made.

In 1989, No. 5 of the Textile Industry magazine published an article by Gulidov N. G. "On the profile of the tooth of a genie saw", in which the idea is expressed about determining the rational profile of the tooth, according to which an increase in the angle  $\alpha$  (front face) should be accompanied by a decrease in the height of the tooth.

According to Gulidov's proposal, the angle  $\alpha$  and the height  $h$  should mean that an increase in the angle  $\alpha$  (the front face) corresponds to a decrease in the height of the tooth (the other parameters do not change).

In 2008, an article by R. G. Makhkamov "On the theory of fiber separation" was published, which deals with the issues of deducing the shape of the tooth of the parabolic form of its anterior face, the author wrote "Based on the optimal conditions of tooth strength to increase its gripping ability by increasing the angle of inclination of the working face, we build a parabola with a vertex at the base of the working face of the tooth".

Note that a tooth with a parabolic construction of the front face has not found application in industry due to the complexity of its manufacture.

This contradiction is explained by the design features of the laboratory and production gins, that is, the first fiber is removed by a brush drum, and the second by an air-removing device. There are also differences in power, speed, working bodies, and much more [5].

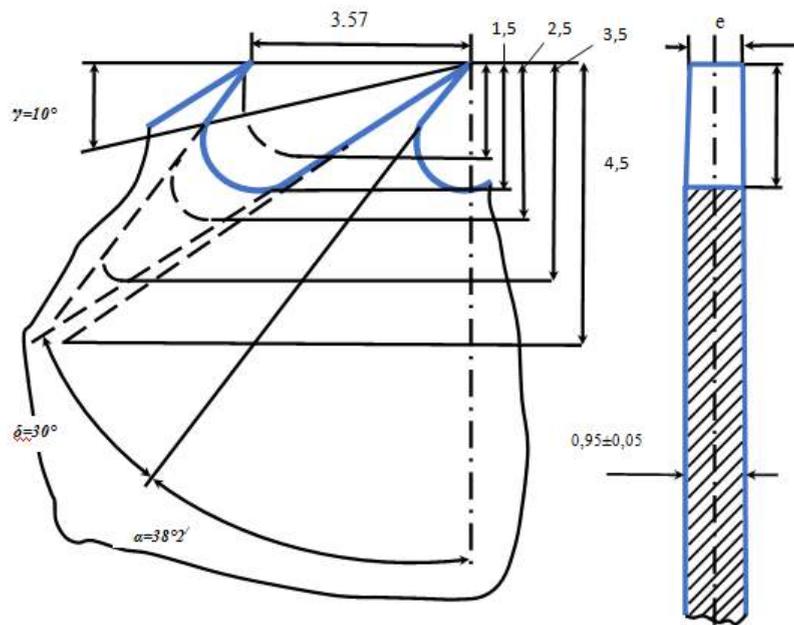


Fig. 1: Schemes of the tooth of a chain saw with different thickness at the top

e-I option-saw blades had teeth of thickness at the top = 0.2-0.3 mm, i.e. on both sides of the tooth, the chamfer was removed on abrasives

This was the objective reason that forced us to conduct further experiments only in production conditions - on existing gins.

Further, on the basis of experiments conducted only on production gins, the issues of the influence of different tooth heights of a genie saw on the technological properties and on the nature of ginning are highlighted.

Experiments of some factories have shown that the work of teeth with an increased thickness of the tooth tip against GOST 1413-48 gave some improvements in product quality. In this regard, the first task was to determine the thickness of the tooth at the top, and then to determine the rational height of the tooth.

When determining the optimal thickness of the top of the saw tooth, the remaining parameters of the tooth remained in accordance with GOST 1413-48.

The peculiarity of our tests was to conduct them in production conditions.

Saw blades with a diameter of 312 mm with different thicknesses at the tops of the teeth were prepared in five versions of 100 saws each (Fig. 1).

Option II - at  $e = 0.4-0.5$  mm, the chamfer is removed from both sides of the tooth.

Option III - at  $e = 0.6-0.7$  mm, the chamfer is slightly removed from both sides of the tooth.

Option IV - at  $e = 0.8-0.9$  mm, only the burrs were removed from the exit side of the punch.

V option - at  $0.95 > e > 0.9$ , i.e. the teeth after the intersection were not processed for chamfering or burr removal, only grinding was carried out in sand baths according to the existing operating instructions of the saw shop equipment.

The saw blades of the I-IV variants were also subjected to grinding under different conditions, in a sand bath according to the existing instructions.

The saw blades of each variant were separately mounted on certain shafts for a separate battery genie. Thus, each gin was completed with saws of a certain variant, after which all gins underwent the same adjustment.

The tests were carried out under the same conditions and different ginning modes. All gins worked mainly on the fourth tooth of the power supply, which corresponded to a productivity of 9-10 kg of fiber per saw per hour. The pressure in the air chamber was maintained equal to 180-140 water column. The duration of the test on the II, III and IV variants was 48 hours, on the I and V variants 4 hours. The reason for the short duration of the I and V variants was a noticeable deterioration in the quality of fiber and seeds due to an increase in the density of the raw roller and poor removal of fiber from the teeth, especially in the V variant. In the II, III and IV variants, the ginning process proceeded normally and the fiber was also eaten normally.

Further research was carried out at sawmills of cotton gins.

The object of the test work was laser saws of various shapes and parameters. The tests were carried out in 3 stages.

At the first stage of research work, saws were installed on the sewing machines according to the PDI 64-2016 standards, and during one shift, the operation of the machine and the quality indicators of the products were monitored. The obtained data are summarized in a table.

At the second stage of the study, the object of the study was 5 types with different thickness of the tooth tip ("e"): 0,2-0,3; 0,4-0,5; 0,6-0,7; Laser saws of 0.8-0.9 and  $0.95 \pm 0.05$  mm were obtained. The remaining parameters of the pil gin were adopted in accordance with the current PDI 64-2016 guidelines.

The different height in the third direction was achieved by changing the angle of penetration of the tooth, the radius of the tooth was 0.4 mm, and the difference in the height of the tooth in the third direction was associated with a change in the angle of penetration of the tooth. the radius of the tooth (in all variants, the cutting angle was about  $20^\circ$ ).

In all variants, the thickness of the tooth tip was  $0.8 \pm 0.1$  mm, the tooth pitch was 3.57 mm, the disc diameter was 312 mm, the tooth thickness was  $0.95 \pm 0.05$  mm. As a result, 1 in the first line; 1,5  $\pm$  0,2; 2,5; 3,5; 4,5, 1,5 on the second line; 2.0  $\pm$  0.1; 2.5; 3.5; Divided into teeth with a height of 4.5. From saws with such teeth, saw cylinders were made in the current order, placed in a denim machine and the cleaning process was carried out.

In the initial test, the quality of cotton fiber obtained with a tooth tip thickness of  $0.8 \pm 0.1$  mm, a tooth height of  $1.5 \pm 0.2$  and  $2.0 \pm 0.1$ , and a tooth rounding radius of 0.6-0.8 mm, showed that they changed for the better. The results confirmed that the direction of the study was chosen correctly.

The third chapter of the dissertation, entitled "Fundamentals of the design of the teeth of the gin saw", is devoted to the parameters of the saw, which is the main working organ of the gin saw, and its teeth. In fact, the main working surface of the saw is the tooth profile. The geometric parameters of the tooth profile determine the efficiency of the saw, that is, increasing the service life of the saw teeth, improving the quality and quantity of cotton products largely depend on the parameters of the saw teeth.

While the main parameters of the saw blade are its diameter, thickness and number of teeth, the main geometric parameters of the tooth profile are its height, pitch, angle of the front blade, the

radius of rounding of the sub-tooth and the thickness of the tooth.

Changes in the geometric parameters of the teeth of the saw blade significantly affect the speed of the roller of the initial material of the saw blade and the composition of the cotton layer on its periphery, the size of the arc in contact with the saw blade, and the distance of penetration of the saw blade inside. untreated roller. Therefore, the height of the tooth has long been the subject of study of scientific and production personnel.

As a result of theoretical and practical studies of pil gin, equations were obtained for determining the optimal geometric parameters of pil gin. The theoretical height of the tooth can be determined from the following equation:

$$h = \frac{t \cdot \sin \gamma \cdot \cos \alpha}{\cos(\alpha + \gamma)}$$

where:  $\gamma$  is the angle of inclination of the leading edge of the saw;

$\alpha$  - angle of inclination of the rear edge of the saw;

t-tooth pitch

A graphical analysis of the obtained equation showed that the most active factor affecting the height of the tooth is the distance between the teeth. As the tooth pitch increases, the tooth height increases linearly. As the slope of the front edge of the tooth increases, the height of the tooth increases, decreasing with decreasing. The angle of inclination of the posterior edge of the tooth, on the contrary, negatively affects the height of the tooth, i.e. its increase leads to a decrease in the height of the tooth.

Experimental studies on the justification of dental parameters were carried out on a 30-caliber denim device in the scientific laboratory of the Namangan Institute of Engineering and Technology. To facilitate the experiments, one factor was selected for each experiment. In the first experiment, the effect of the height of the saw tooth on the mass fraction of impurities and defects in the fiber was studied. An empirical equation of the following form was chosen for the study:

$$y = ax + b_0$$

where: a is the angular coefficient of the straight line;

x is the height of the gin saw tooth;

b is the section of a straight line from the ordinate axis

Based on the results of the experiment, we determine the value of the parameters "a" and "b" in the equation by the least squares method from the following equation:

$$a = \frac{n \sum x_i y_i - \sum x_i \sum y_i}{n \sum x_i^2 - (\sum x_i)^2} = 0,181$$

$$b = \frac{n \sum x_i y_i - \sum x_i \sum y_i}{n \sum x_i^2 - (\sum x_i)^2} = 2,41$$

where: n is the number of variants of the condition being checked, that is, 5.

Thus, the empirical equation that we are looking for is the relationship between the mass fraction of impurities and defective impurities in the fiber "y" and the height of the tooth "x" of the gin saw:

$$y = 0,181x + 2,41$$

In the same way, the effect of the height of the saw teeth on the mechanical damage of cotton seeds was studied. The empirical equation obtained as a result of the study represents the effect of mechanical damage to a tooth with a height of "x" on mechanical damage to "y":

$$y = 0,0696 x + 0,3589 ,$$

### III. RESULT AND DISCUSSION

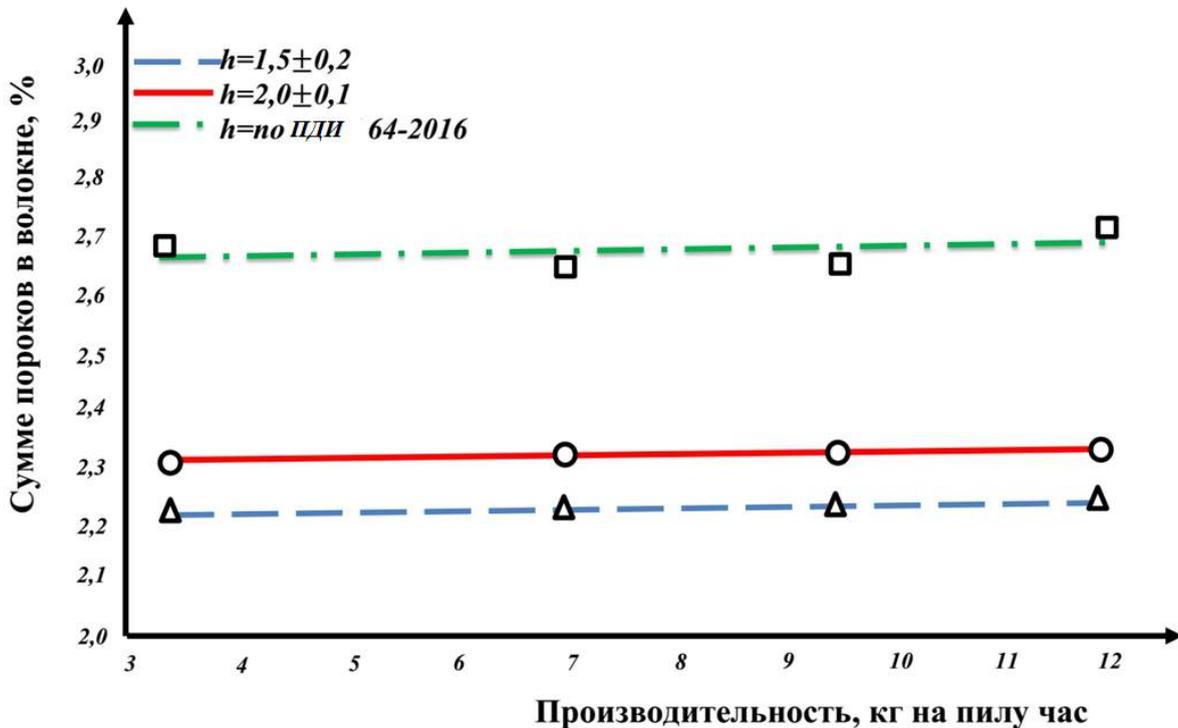
To assess the technological properties of fiber and seeds, the plant's laboratories were sampled under our control and according to the developed methodology [10].

Fiber samples were taken from the neck of each gin for each variant, seed samples from the seed trays of each gin. The sample was taken three times per shift, i.e. for the II, III and IV variants 18 times, and for I and V-3 times.

Technological analyses were carried out in the laboratory of the plant according to the existing rules.

At the time of sampling, the current strength in the phases of the electric motor of the gin saw cylinder was also measured.

For clarity, the results are presented in the form of graphs 1-3.



Graph 1: The dependence of the amount of fiber defects on the effectiveness of gin

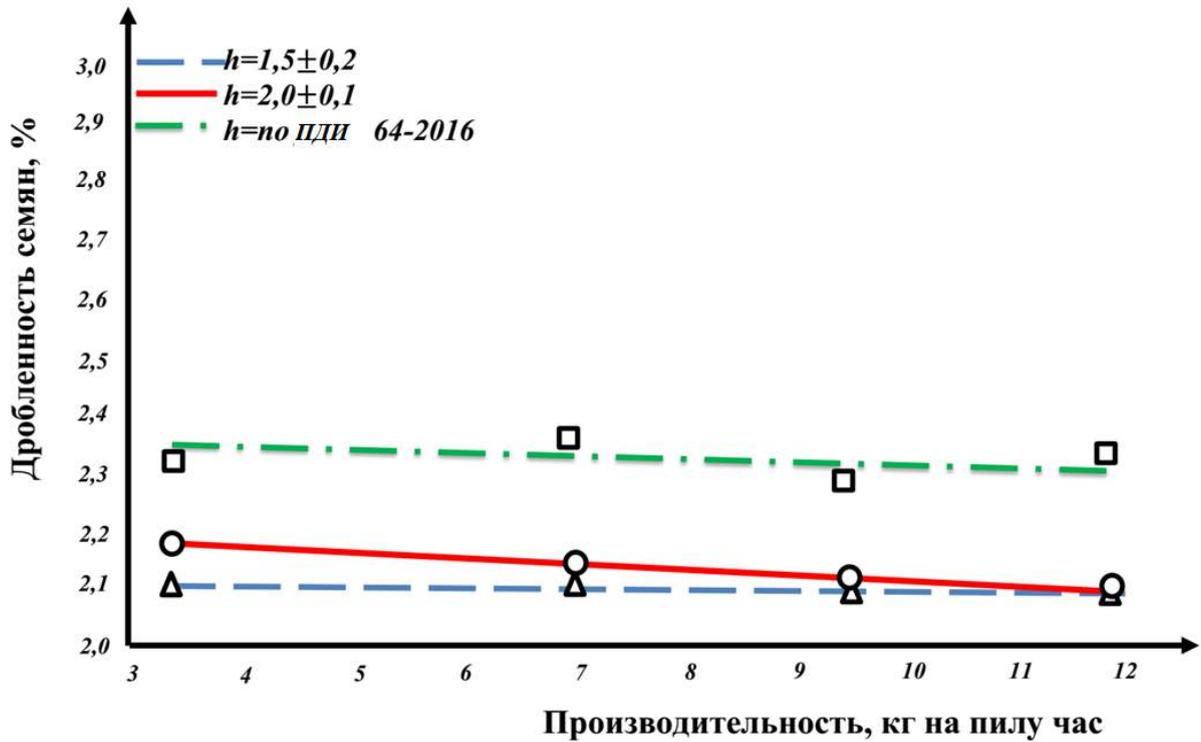
From Graph 1, it can be seen that with an increase in the thickness of the tooth vertices, the amount of defects in the fiber decreases, which occurred mainly due to a decrease in broken seeds in the fiber. At the same time, the content of litter and notes in the fiber almost does not change.

The explanation that an increase in the thickness at the top of the tooth causes a decrease in the amount of defects in the fiber, apparently, is that the specific pressure of the tooth edge on the fiber and seeds decreases and this was accompanied by a decrease in the damage of the latter.

In contrast to the general pattern, the sum of fiber defects on the V variant of saws had an overestimated value.

This can be explained by the fact that the saw blades of the V variant after the tooth crossing did not undergo chamfering, only the teeth were

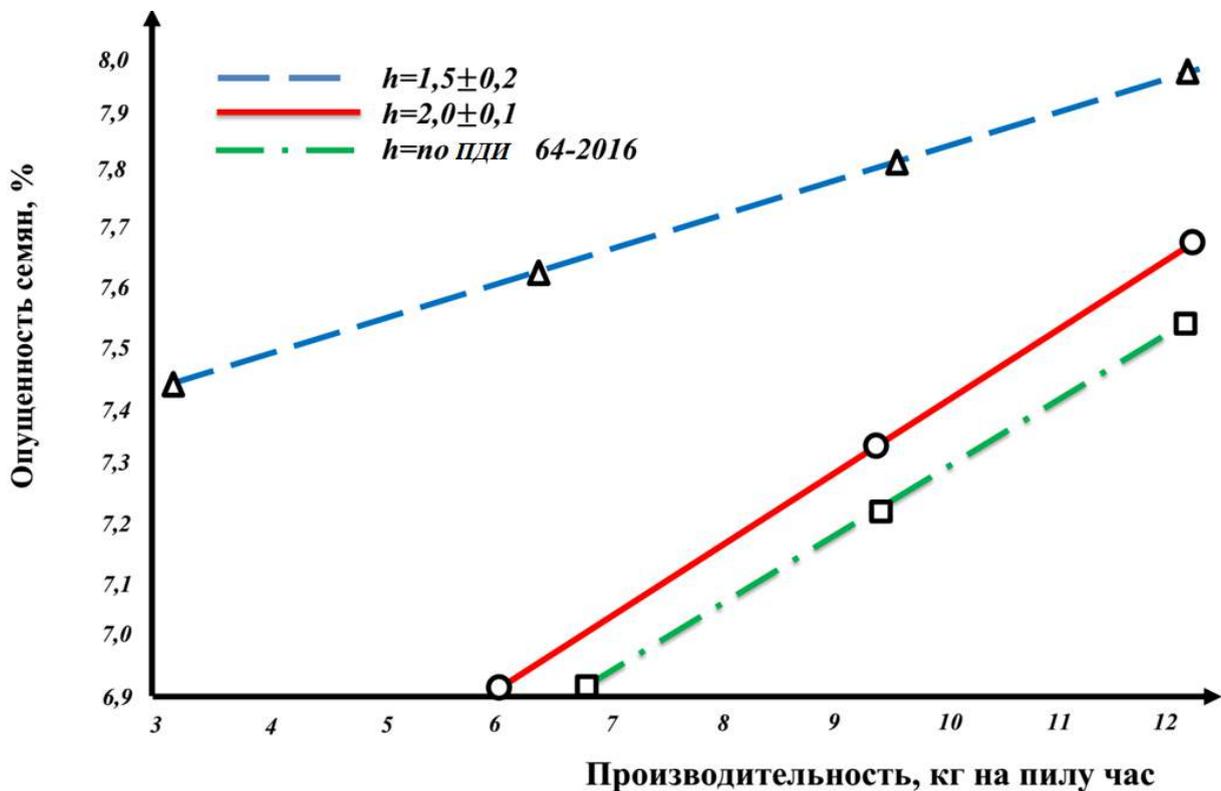
ground in a sand bath under different conditions with other options for preparing saws. Apparently, such an identical condition for processing teeth for all variants is insufficient for the V variant and the teeth of the V variant, obviously, have not been freed from invisible burrs. Thus, the number of burrs on the teeth of the V variant was greater than on the teeth of the I, IV variants. And in the industry, it has long been known that the presence of burrs leads to a deterioration in the quality of products.



Graph 2: The dependence of mechanical damage to seeds on the effectiveness of gin

Graph 2 shows that the change in the crushing of seeds is inversely proportional to the change in thickness at the vertices of the tooth. The reasons

for this can also be found in the change in the specific pressure on the seeds from the edge of the tooth.



Graph 3: Dependence of seed pubescence on the effectiveness of gin

It can be seen from Graph 3 that the change in the total omission of seeds occurs in the opposite proportion to the change in the thickness of the top of the tooth.

#### IV. CONCLUSION

It is possible that partial linterization processes also occur during the ginning process. If we assume this, then in our case, an increase in the

thickness at the top of the tooth also caused an intensification of the linterization process during ginning. Therefore, an increase in the thickness at the top of the tooth caused a decrease in the complete omission of seeds.

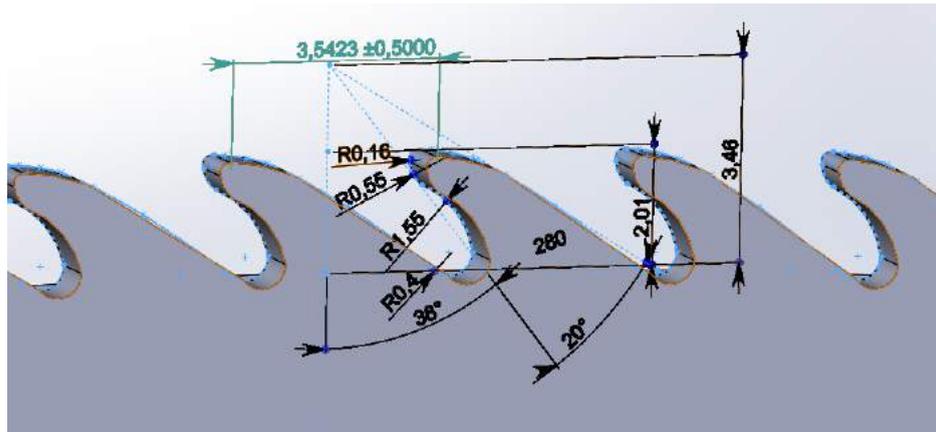


Fig. 2: The developed profile of the tooth of the genie saw

It can be seen from Graph 4 that the residual fiber content of the seeds changes in inverse proportion to the change in the thickness of the tooth tip. The explanation for this is the same as in Graph 3.

And, finally, it can be seen from Graph 5 that the law of changing the load on the electric motor of the gin saw cylinder with respect to the change in tooth thickness proceeds according to the law of direct proportion.

The explanation of the latter is that with an increase in the thickness at the top of the tooth, the degree of its contact with the mass of the raw roller increases and this causes an increase in the load on the gin shaft.

Thus, according to the results of the test, we come to the conclusion that the rational thickness at the top of the saw tooth is equal to  $e = 0.8 \pm 0.1$  mm, at which it is possible to obtain products of the proper quality.

#### REFERENCES

1. Sapaev, U. A. Evaluation of the use of various devices when ginning a wet snapper. "Problems of textiles" Tashkent, 2009, No. 2. pp. 51-56.
2. E. A. Normatov, A. A. Ismailov, U. A. Sapaev, "Theoretical study of the oscillation frequency of the gin grate". Collection of the scientific and practical conference. Namangan 2011, 2-volume, pp. 303-305.
3. E. A. Normatov, A. A. Ismailov, "Methods of increasing the durability of diamond saws and grates". Collection of materials of the republican scientific and practical conference of young scientists. Tashkent, 2011, pp. 71-73.
4. A. A. Ismailov, A.M. Akhmedov, A. A. Safоеv, E. A. Normatov. "Improvement of the grate and the teeth of the genie saw" Collection of materials of the republican scientific and practical conference of young scientists. Tashkent, 2011, pp. 27-30.
5. E. A. Normatov, A. A. Ismailov, A.M. Akhmedov, U. A. Sapaev, " Study of the wear resistance of various materials of laser saws " Collection of materials of the republican scientific and practical conference of young scientists. Tashkent, 2010, pp. 119-121.

# London Journal Press Membership

For Authors, subscribers, Boards and organizations



London Journals Press membership is an elite community of scholars, researchers, scientists, professionals and institutions associated with all the major disciplines. London Journals Press memberships are for individuals, research institutions, and universities. Authors, subscribers, Editorial Board members, Advisory Board members, and organizations are all part of member network.

Read more and apply for membership here:  
<https://journalspress.com/journals/membership>



For Authors



For Institutions



For Subscribers

Author Membership provide access to scientific innovation, next generation tools, access to conferences/seminars /symposiums/webinars, networking opportunities, and privileged benefits.

Authors may submit research manuscript or paper without being an existing member of LJP. Once a non-member author submits a research paper he/she becomes a part of "Provisional Author Membership".

Society flourish when two institutions come together." Organizations, research institutes, and universities can join LJP Subscription membership or privileged "Fellow Membership" membership facilitating researchers to publish their work with us, become peer reviewers and join us on Advisory Board.

Subscribe to distinguished STM (scientific, technical, and medical) publisher. Subscription membership is available for individuals universities and institutions (print & online). Subscribers can access journals from our libraries, published in different formats like Printed Hardcopy, Interactive PDFs, EPUBs, eBooks, indexable documents and the author managed dynamic live web page articles, LaTeX, PDFs etc.



GO GREEN AND HELP  
SAVE THE ENVIRONMENT

## JOURNAL AVAILABLE IN

PRINTED VERSION, INTERACTIVE PDFS, EPUBS, EBOOKS, INDEXABLE DOCUMENTS AND THE AUTHOR MANAGED DYNAMIC LIVE WEB PAGE ARTICLES, LATEX, PDFS, RESTRUCTURED TEXT, TEXTILE, HTML, DOCBOOK, MEDIAWIKI MARKUP, TWIKI MARKUP, OPML, EMACS ORG-MODE & OTHER



SCAN TO KNOW MORE

[support@journalspress.com](mailto:support@journalspress.com)  
[www.journalspress.com](http://www.journalspress.com)

 \*THIS JOURNAL SUPPORT AUGMENTED REALITY APPS AND SOFTWARES