FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF WATER RESOURCES AND MINING ENGINEERING

FINAL REPORT

DESIGN AND FABRICATION OF A SEMI-AUTOMATED PLASTERING MACHINE

BY

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REG NO: BU/UP/2020/0286

A final year project submitted to the Department of Water Resources Engineering in partial fulfillment of the requirements for the award of a Bachelor of Science degree in Water Resources Engineering.

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ABSTRACT

This project encompasses the design and fabrication of a semi-automated plastering machine, undertaken as part of the requirements for the Bachelor of Science degree in Water Resources Engineering. The primary objective of this project was to develop a machine that streamlines the plastering process, reducing reliance on manual labor while enhancing efficiency within the construction industry. The report highlights the background and challenges prevalent in the construction sector due to labor-intensive manual plastering techniques, emphasizing the need for automated solutions to improve productivity, reduce labor costs, and expedite project timelines. The report outlines the methodology encompassing the design, fabrication, and testing phases, incorporating key considerations such as material selection, component design, and performance testing. Through a comprehensive review of automated plastering technologies, this deigns project addresses the significance, scope, and objectives of the design. The fabricated system, comparisons with manual methods, and financial analysis carried out elucidate the transformative impact this project aimed to deliver, aligning with Sustainable Development Goals and offering substantial benefits to the construction industry in terms of efficiency, productivity, and sustainable growth.

Keywords: Plastering, manual, labor cost, fabrication, automation, plastering time, etc.

DECLARATION

I **NKOLE AARON** a Busitema University student Reg. No. BU/UP/2020/0286 here by declare that this design project report is s as a result of my own research and efforts and has not been previously submitted in any other higher institution of learning for any academic award.

Name: NKOLE AARON

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DATE: 06 / 09 / 2024

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I take this opportunity to thank God who has protected and provided till this far in my academic journey.

I thank my Parents and siblings for their financial, moral and spiritual support offered to me in this academic journey

I as well thank my class mates for their guidance, cooperation and interactions during our class activities as we aim at succeeding in all we would do.

I also thank, Mr. Baagala Brian Sempijja for the time, guidance and effort invested through my project preparation process.

APPROVAL

I hereby certify that this design project report was written and completed by NKOLE AARON and is prepared for submission to the department of Water Resources Engineering, Faculty of Engineering and Technology, Busitema University

Supervisor

Name: Mr. Baagala Brian Sempijja

Signature: .....

Date: 06/09/2024

DEDICATION

I dedicate this report to my family especially dad, Mr. Ndyabahika Patrick that financially supported throughout this fabrication project, friends that cooperated with me during the smooth running of the project. May God bless you.

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List of Abbreviations

SDG Sustainable Development Goal

GNP Great National Product

UBOS Uganda Bureau of statics

USA United States of America

UN United Nations

Rpm Revolutions per minute

ASTM American Society for Testing and Materials

CHAPTER ONE

Introduction

The current landscape of construction involves conventional methods, particularly in wall plastering, where manual processes dominate. The reliance on skilled labor for plastering work not only contributes to elevated labor costs but also introduces variability in the quality of the final product. This existing paradigm prompts the exploration of innovative solutions to address inefficiencies and enhance overall construction practices. In response, this design project focuses on the development of a semi-automated wall plastering machine. By acknowledging the limitations of traditional techniques and leveraging technological advancements, the project seeks to revolutionize the plastering process, introducing a more efficient and standardized approach to construction

1.1 Back ground

The construction sector serves as the backbone of a nation's progress, complicatedly linked to civilization, industrialization, and transportation, with its genesis in the initial stages of construction(Kumar M et al., 2020),(Askar & Raut, 2017). Globally, the foundation of this design project lies in the realization that the construction industry, comprising 10-20% of the GNP, is still largely reliant on labor-intensive, time-consuming, and repetitive methods for example, contractors in Malaysia are still using the traditional way in the process of plastering walls.(Zulhazreen et al., 2021)(Kumar M et al., 2020).

The evolution in construction practices has encouraged contractors to optimize equipment for maximum efficiency at minimized costs, focusing on reducing labor expenses and plastering time.(Kumar M et al., 2020). Consequently, extended project timelines, increased labor expenses, compromised quality standards, and project delays persist, undermining competitiveness and impeding overall economic growth.

In Uganda, according to Uganda Bureau of statics (UBOS) 2010, nearly 60% of all the houses are constructed with brick walls with the greater percentage employing the present measures within the construction sector that predominantly focus on using traditional plastering techniques. These included the use of trowels to apply the plaster to the wall in different layers until the final desired thickness is achieved after leveling with the float and this highlights the industry's slow pace in

REFERENCES

Askar, A. N., & Raut, L. P. (2017). International journal of engineering sciences & research technology design of automatic wall plastering machine. *International Journal of Engineering Sciences & Research Technology Design*, *6*(3), 543–555.

Askar, A. N., Raut, L. P., Cam, M. T. C. A. D., & Nagpur, G. (2017). *International journal of engineering sciences & research technology design of automatic wall plastering machine*. *6*(3), 543–555.

Ban, C. C., & Ramli, M. (2010). Optimization of Mix Proportion of High Performance Mortar for Structural Applications Cheah Chee Ban and Mahyuddin Ramli Sustainable Housing Research Unit , School of Housing , Building and Planning ,. *Concrete*, *3*(4), 643–649.

Beygi, M. H. A., Kazemi, M. T., Nikbin, I. M., & Amiri, J. V. (2013). The effect of water to cement ratio on fracture parameters and brittleness of self-compacting concrete. *Materials & Design*, *50*, 267–276.

Biradar, A., Shejwal, V., Barate, A., & Barate, S. (2016a). Automatic Wall Plastering Machine. *Ijetr*, *4*(1), 22–32.

Biradar, A., Shejwal, V., Barate, A., & Barate, S. (2016b). *Automatic Wall Plastering Machine*. *0869*(1), 22–32.

Edwards, E. (2023). *What is a 3-Phase Motor and How Does it Work ?* 1–11.

Goldberg, K. (2012). What is automation? *IEEE Transactions on Automation Science and Engineering*, *9*(1), 1–2. https://doi.org/10.1109/TASE.2011.2178910

Gumerova, E., Gamayunova, O., & Gorshkov, R. (2017). Choosing the appropriate way of plastering works for transportation and construction facilities. *IOP Conference Series: Earth and Environmental Science*, *90*(1). https://doi.org/10.1088/1755-1315/90/1/012185

Kumar M, R., V, A., Sharma, C. S., Mujhahid, S., & Alim, A. (2020). Development and

Fabrication of Semi-Automated Wall Plastering Machine. *SSRN Electronic Journal*, *May*, 728–734. https://doi.org/10.2139/ssrn.3510945

Lafhaj, Z., Goueygou, M., Djerbi, A., & Kaczmarek, M. (2006). Correlation between porosity, permeability and ultrasonic parameters of mortar with variable water/cement ratio and water content. *Cement and Concrete Research*, *36*(4), 625–633. https://doi.org/https://doi.org/10.1016/j.cemconres.2005.11.009

Members, G., Al-hamad, A., Khraishi, R., & Yonis, S. (2016). □□□□ □. 3–12.

Morning, T. (1996). Z Z I. *Optical Engineering*, *289*, 87–88.

Nyemba, W. R., Shangwa, N. L., Chinguwa, S., & Mbohwa, C. (2020). Conceptualization, development and design of a mortar spraying machine. *Procedia CIRP*, *91*, 396–401. https://doi.org/10.1016/j.procir.2020.03.105

Of, D., Systems, T., & Flexible, F. O. R. (n.d.). *ME-6601*.

Pulido-Arcas, J. A., Flores-Alés, V., & Pérez-Fargallo, A. (2022). Coating mortars with improved physical properties, economic cost, and carbon footprint. *Case Studies in Construction Materials*, *16*, e01095.

Solution, T. (n.d.). *wgm*.

Sulankivi, K., Zhang, S., Teizer, J., Charles, M., Kiviniemi, M., Romo, I., & Granholm, L. (2013). Utilization of BIM-based automated safety checking in construction planning. *CIB World Building Conference 2013*, 11.

Thakur, A. K., Jaiswal, B. P., Mandal, N. K., Yadav, S. K., Pandit, S., & Yadav, R. (2020). *International Journal of Advanced Engineering Modelling and Fabrication of Automatic Wall Plastering Machine*. *03*(02).

United Nations. (2016). Final list of proposed SDG. *Report of the Inter-Agency and Expert Group on Sustainable Development Goal Indicators*, Annex IV.

Units, S. I. (2005). *A textbook of. I.*

Zulhazreen, M., Goh, C. H., Tan, W. J., Law, J. C., Radhwan, H., Dawi, M. S. I. M., Farizuan, M., & Asyahid, W. A. R. (2021). Design and Analysis of Auto-Plastering Machine. *Journal of Physics: Conference Series*, *2129*(1). https://doi.org/10.1088/1742-6596/2129/1/012031

Askar, A. N., & Raut, L. P. (2017). International journal of engineering sciences & research technology design of automatic wall plastering machine. *International Journal of Engineering Sciences & Research Technology Design*, *6*(3), 543–555.

Askar, A. N., Raut, L. P., Cam, M. T. C. A. D., & Nagpur, G. (2017). *International journal of engineering sciences & research technology design of automatic wall plastering machine*. *6*(3), 543–555.

Ban, C. C., & Ramli, M. (2010). Optimization of Mix Proportion of High Performance Mortar for Structural Applications Cheah Chee Ban and Mahyuddin Ramli Sustainable Housing Research Unit , School of Housing , Building and Planning ,. *Concrete*, *3*(4), 643–649.

Beygi, M. H. A., Kazemi, M. T., Nikbin, I. M., & Amiri, J. V. (2013). The effect of water to cement ratio on fracture parameters and brittleness of self-compacting concrete. *Materials & Design*, *50*, 267–276.

Biradar, A., Shejwal, V., Barate, A., & Barate, S. (2016a). Automatic Wall Plastering Machine. *Ijetr*, *4*(1), 22–32.

Biradar, A., Shejwal, V., Barate, A., & Barate, S. (2016b). *Automatic Wall Plastering Machine*. *0869*(1), 22–32.

Edwards, E. (2023). *What is a 3-Phase Motor and How Does it Work ?* 1–11.

Goldberg, K. (2012). What is automation? *IEEE Transactions on Automation Science and Engineering*, *9*(1), 1–2. https://doi.org/10.1109/TASE.2011.2178910

Gumerova, E., Gamayunova, O., & Gorshkov, R. (2017). Choosing the appropriate way of plastering works for transportation and construction facilities. *IOP Conference Series: Earth and Environmental Science*, *90*(1). https://doi.org/10.1088/1755-1315/90/1/012185

Kumar M, R., V, A., Sharma, C. S., Mujhahid, S., & Alim, A. (2020). Development and

Fabrication of Semi-Automated Wall Plastering Machine. *SSRN Electronic Journal*, *May*, 728–734. https://doi.org/10.2139/ssrn.3510945

Lafhaj, Z., Goueygou, M., Djerbi, A., & Kaczmarek, M. (2006). Correlation between porosity, permeability and ultrasonic parameters of mortar with variable water/cement ratio and water content. *Cement and Concrete Research*, *36*(4), 625–633. https://doi.org/https://doi.org/10.1016/j.cemconres.2005.11.009

Members, G., Al-hamad, A., Khraishi, R., & Yonis, S. (2016). □□□□ □. 3–12.

Morning, T. (1996). Z Z I. *Optical Engineering*, *289*, 87–88.

Nyemba, W. R., Shangwa, N. L., Chinguwa, S., & Mbohwa, C. (2020). Conceptualization, development and design of a mortar spraying machine. *Procedia CIRP*, *91*, 396–401. https://doi.org/10.1016/j.procir.2020.03.105

Of, D., Systems, T., & Flexible, F. O. R. (n.d.). *ME-6601*.

Pulido-Arcas, J. A., Flores-Alés, V., & Pérez-Fargallo, A. (2022). Coating mortars with improved physical properties, economic cost, and carbon footprint. *Case Studies in Construction Materials*, *16*, e01095.

Solution, T. (n.d.). *wgm*.

Sulankivi, K., Zhang, S., Teizer, J., Charles, M., Kiviniemi, M., Romo, I., & Granholm, L. (2013). Utilization of BIM-based automated safety checking in construction planning. *CIB World Building Conference 2013*, 11.

Thakur, A. K., Jaiswal, B. P., Mandal, N. K., Yadav, S. K., Pandit, S., & Yadav, R. (2020). *International Journal of Advanced Engineering Modelling and Fabrication of Automatic Wall Plastering Machine*. *03*(02).

United Nations. (2016). Final list of proposed SDG. *Report of the Inter-Agency and Expert Group on Sustainable Development Goal Indicators*, Annex IV.

Units, S. I. (2005). *A textbook of. I.*

Zulhazreen, M., Goh, C. H., Tan, W. J., Law, J. C., Radhwan, H., Dawi, M. S. I. M., Farizuan, M., & Asyahid, W. A. R. (2021). Design and Analysis of Auto-Plastering Machine. *Journal of Physics: Conference Series*, *2129*(1). https://doi.org/10.1088/1742-6596/2129/1/012031