



**BUSITEMA  
UNIVERSITY**  
*Pursuing Excellence*

**FACULTY OF ENGINEERING  
DEPARTMENT OF WATER RESOURCES AND MINING ENGINEERING  
WATER RESOURCES ENGINEERING PROGRAMME**

**FINAL YEAR PROJECT REPORT**

**PROJECT TITLE**

**INVESTIGATING THE EFFECTIVENESS OF USING MACADAMIA NUT SHELLS  
AGGREGATE FOR MAKING LIGHT-WEIGHT AND HIGH TEMPERATURE  
RESISTANT CONCRETE WATER STORAGE TANK.**

**BY**

**NUWAHEREZA ONAM**

**BU/UG/2016/1724**

[nuwaherezaonam@gmail.com](mailto:nuwaherezaonam@gmail.com)

**SUPERVISOR: MR. MASERUKA BENDICTO**

*A final year project report submitted to the Department of Water Resources and Mining Engineering as a partial fulfillment of the requirements for the award of a Bachelor of Science in Water Resources Engineering*

## ABSTRACT

Water tanks are containers that can be used for storing water. These tanks are used to provide storage of water for use in many applications like; drinking water, agriculture use as irrigation, fire suppression, agricultural farming, chemical manufacturing, as well as many other uses. Water tank parameters include the general design of the tank, and choice of construction materials, linings. The various materials that can be used for making a water tank include: plastics (polyethylene, polypropylene), fiberglass, concrete, stone, steel (welded or bolted, carbon, or stainless). Amongst the potential available materials for the construction of water tanks is the use of light weight aggregates consisting of Natural materials (like volcanic pumice, scoria and macadamia nut shells), manufacture from industrial by-products (such as fly ash), thermal treatment of natural raw materials (like clay, slate or shale and processing of industrial by-products (such as pelletised expanded slab, i.e. Pellite). In this research study, the use of agricultural wastes was evaluated for potential use as light weight aggregates. Macadamia was obtained from Mushandika village in Kyenjojo district. The macadamia shells were mainly composed of Silicon (iv) Oxide (63.0%), Aluminium Oxide (19.9%) and Iron (iii) Oxide (6.2%). The macadamia shells mix combinations were evaluated at eight (8) levels for potential use as light weight concrete with a slump of between 50-100mm from which the cubes were cast. The minimum macadamia shells-mix combination to achieve  $1505\text{kg/m}^3$  was macadamia mix 30% and this had a compressive strength of 22.4MPa at 28 days. The Normal Concrete (NC) was designed for C25 and this was observed to yield 32.8MPa at 28 days with a unit weight of  $2798\text{kg/m}^3$ . With respect to the increase of temperature, the compressive strength and unit weight for all the macadamia shells mix combinations and normal weight concrete were observed to decrease with an increase in temperature. The macadamia shell 30% mix combination was observed to have a compressive strength of 22.4MPa, 22.2 MPa, 20.1MPa and 19.6MPa at  $25^{\circ}\text{C}$ ,  $45^{\circ}\text{C}$ ,  $90^{\circ}\text{C}$  and  $150^{\circ}\text{C}$  respectively. The suitable macadamia shells mix combination was obtained at 30% mix which was used in the design and simulation of a RC water tank using TEKLA TEDDs Software.

**DECLARATION**

I **NUWAHEREZA ONAM**, hereby declare to the best of my knowledge, that this project report is an outcome of my efforts and that it has not been presented to any institution of learning for an academic award.

Signature: .....

Date: ...../...../.....

**APPROVAL**

This research report has been submitted to the Faculty of Engineering for examination with approval of my supervisor.

**SUPERVISOR**

MR. MASERUKA BENDICTO

Signature..... Date...../...../.....

## **DEDICATION**

This report is dedicated to my beloved parents in appreciation for their selfless care and unflinching support provided to me since childhood, and for the spirit of hard work, courage and determination instilled into me, which attributes I have cherished with firmness and which have indeed made me what I am today.

## **ACKNOWLEDGEMENT**

I express my deepest gratitude to my supervisor Mr. Benedicto Maseruka, lecturers at the department of water Resources and Mining Engineering Busitema University for their guidance and support throughout this work.

I would like to thank my class mates, friends for their practical help during the synthesis of the work.

Finally, unconditional love, support and encouragement of my family to continue my effort in difficult times was wonderful, they deserve much love and thanks.

## Table of Contents

ABSTRACT .....	i
DECLARATION .....	ii
APPROVAL .....	iii
DEDICATION .....	iv
ACKNOWLEDGEMENT .....	v
1.0 CHAPTER ONE .....	1
Introduction.....	1
1.1 Background .....	1
1.2 Problem statement.....	4
1.3 Objectives .....	5
<i>1.3.1 Main objective.....</i>	<i>5</i>
<i>1.3.2 Specific objectives .....</i>	<i>5</i>
1.4 Scope of the study.....	5
1.5 Justification of the study .....	5
2.0 LITERATURE REVIEW .....	6
2.1 Existing water storage tanks in Uganda.....	6
2.1.1 Concrete tanks .....	6
2.1.2 Steel Tanks .....	6
2.1.3 Plastic tanks. ....	6
2.1.4 Fiberglass Tanks.....	7
2.2.1 Existence of macadamia shells .....	8
2.2.2 Uses of Macadamia Shells .....	8
2.2.3 Properties of Macadamia Shells.....	9
2.3.0 Light weight concrete.....	9

2.3.1	<i>Types of Light Weight Concrete</i> .....	9
2.3.2	<i>Properties of light weight concrete</i> .....	11
2.3.3	<i>Advantages of light weight concrete</i> .....	11
2.3.4	<i>Disadvantages of light weight concrete</i> .....	11
3.0	CHAPTER THREE: METHODOLOGY .....	11
	Introduction.....	11
3.1	CHARACTERISATION OF THE SHELLS .....	12
3.1.1	<i>Sourcing of the material</i> .....	12
3.1.2	<i>Sampling</i> .....	12
3.1.3	Chemical composition .....	13
3.1.4	<i>Preparation of the material</i> .....	13
3.1.5	Tests done on macadamia nut shells.....	14
3.1.5.1	Sieve analysis (gradation test) .....	14
3.1.5.2	Moisture content. ....	14
3.1.5.3	Aggregate Crushing Value (ACV).....	14
3.2.1	<i>Concrete ratio mix design using ACI Method</i> .....	15
3.2.1	Concrete Mix Design using ACI method.....	16
3.2.2	<i>SLUMP TEST</i> .....	17
3.2.3	<i>Compressive strength</i> .....	17
3.2.4	<i>Test on the concrete subjected to high temperature (ACI 211.1-91)</i> .....	18
3.2.5	<i>chloride ion penetration test</i> .....	18
3.2.6	<i>obtaining the optimum mix ratio which will give light weight and high temperatures resistant tank</i> .....	18
3.3	Designing and simulating of the circular concrete tank using the optimum mix ratio. ....	18
3.4	Cost effectiveness of using macadamia nut shells aggregates as compared to normal Concrete aggregates. ....	19



4.0 RESULTS AND DISCUSSION .....	21
.....	21
4.1 Biochemical composition of macadamia shells .....	22
4.2 Mineralogical composition of macadamia shells.....	22
4.3 LABORATORY TESTS RESULTS .....	23
4.3.1 Gradation test .....	23
4.3.2 Moisture content test.....	26
4.3.3 Specific gravity test.....	26
4.3.4 Aggregate Crushing Value (ACV) test .....	27
Normal Aggregate (Granite).....	27
4.3.5 Slump test.....	28
4.3.6 COMPRESSIVE STRENGTH TEST .....	29
The value of $F_{critical}$ is greater than the value of F meaning there is a significance change in the data .....	31
4.3.7 EFFECT OF TEMPERATURE ON COMPRESSIVE STRENGTH.....	31
The value of $F_{critical}$ is less than the value of F meaning there is a slight significance in the data.....	33
4.3.8 EFFECT OF TEMPERATURE ON UNIT WEIGHT AT 28 DAYS.....	33
The value of $F_{critical}$ is less than the value of F meaning there is a slight significance change in the data.....	35
4.3.9 CHLORIDE PENETRATION ION TEST .....	35
The value of $F_{critical}$ is less than the value of F meaning there is a slight significance change in the data.....	37
4.4 Designs and simulations of the 10m <sup>3</sup> circular concrete tank according to ACI3370 part 2 using approximate method.....	37
4.5 SIMULATIONS .....	40

4.5.1 RC RECTANGULAR COLUMN DESIGN (ACI318-11).....	40
4.5.2 RC member analysis & design for the top beam (EN1992-1-1:2004).....	41
4.5.3 Foundation analysis & design (ACI318) .....	42
1.1.1 Footing analysis .....	42
4.5.5 RC Wall design (ACI318-05) .....	44
4.5.6 Slab on ground (ACI 360R).....	45
4.5.7 RC beam design (ACI318-2011) .....	46
4.6 Cost effectiveness of using macadamia nut shells aggregates as compared to normal Concrete aggregates. ....	47
5.1 CONCLUSION.....	50
5.2 RECOMMENDATION .....	51
REFERENCES .....	52

## LIST OF FIGURES

Figure 1; macadamia nut shells.....	8
Figure 2; A map of kyenjojo town council showing pick points .....	21
Figure 3; A graph showing Particle size distribution (PSD) for fine aggregate .....	23
Figure 4: A graph showing Particle size distribution (PSD) for coarse aggregate .....	24
Figure 5: A graph showing Particle size distribution(PSD) for macadamia shells.....	25
Figure 6: A graph showing compressive strength at 7 and 28 days.....	30
Figure 7: A graph showing effect of temperature on compressive strength .....	32
Figure 8: A graph showing effect of temperature on compressive strength .....	32
Figure 9: A graph showing effect of temperature on unit weight at 28 days.....	34
Figure 10: A graph showing effect of temperature on unit weight at 28 days.....	34
Figure 11: A graph showing chloride penetration ion test.....	36
Figure 12: Showing rectangular column design .....	41
Figure 13: Showing RC member analysis & design for the top beam.....	42
Figure 14: Showing a footing .....	43

Figure 15: Showing RC wall design .....	44
Figure 16: Showing slab on ground .....	45
Figure 17: Showing RC beam design .....	46

## LIST OF TABLES

Table 1. showing the strength classes and characteristic strength of light weight aggregate concrete .....	<b>Error! Bookmark not defined.</b>
Table 2.sample mix percentages .....	15
Table 3; Location points of kyenjojo town council .....	21
Table 4:Biochemical composition of macadamia shells.....	22
Table 5: Mineralogical composition of macadamia shells .....	22
Table 6; Particle size distribution(PSD) for fine aggregate .....	23
Table 7; Particle size distribution(PSD) for coarse aggregate .....	24
Table 8; Particle size distribution(PSD) for macadamia shells .....	25
Table 9:Moisture content test.....	26
Table 10: Showing Specific gravity test results.....	26
Table 11: Showing slum test results .....	28
Table 12: Showing compressive strength test results .....	29
Table 13: Showing effect of temperature on compressive strength.....	31
Table 14: showing effect of temperature on unit weight at 28 days.....	33
Table 15: Showing chloride penetration ion test results.....	35

## List of acronyms

ASTM.....	American Society of Testing and Materials
ACI .....	American Concrete Institute
BS .....	British Standard
OPC.....	Ordinary Portland Cement
LWC.....	Light Weight Concrete
NC.....	Normal Concrete