



**BUSITEMA
UNIVERSITY**
Pursuing Excellence

**FACULTY OF ENGINEERING
DEPARTMENT OF MINING AND WATER RESOURCES
ENGINEERING
INVESTIGATING THE EFFECTIVENESS OF USING SUGARCANE
BAGASSE ASH AS A PARTIAL REPLACEMENT OF CEMENT IN
CONSTRUCTION OF CONCRETE WATER STORAGE TANKS**

BY

NACHIMULI TAMISI

BU/UG/2016/1720

tamykigozi@gmail.com

supervisor: Dr. NIBIKORA IDEPHONSE & Mr. TIGALANA DANIEL

*A research proposal 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*

DECLARATION

I **NACHIMULI TAMISI**, hereby declare to the best of my knowledge, that this project report is an outcome of my original work and it has not been presented to this university or to any other institution of learning for an academic award.

BU/UG/2016/1720

Signature:

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

APPROVAL

Am presenting this report to the department of mining and water resources engineering for examination with the approval of my supervisor.

SUPERVISOR

Dr. NIBIKORA IDEPHONSE

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

MR. TIGALANA DANIEL

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

ACKNOWLEDGEMENTS

Above every one, I praise the Almighty God for his blessing, always being with me in all my activities and for giving me the strength to carry out this study.

I would like to convey my honest gratitude to my advisors Dr. NIBIKORA IIDEPHONSE & Mr. TIGALANA DANIEL for their useful comments, suggestions, kind support, and guidance to supervise my research work. Special gratitude to my class mates, friends & other lecturers for their practical help during the synthesis of the work.

In addition, I am extremely thankful to SCOUL sugar factory for providing me the research material sugarcane bagasse ash and for their support.

Finally, I would like to acknowledge my families for their endless encouragement, patience and friends who have shared all the pain in coming up with this study. I also acknowledge everybody who helped me in one or another way during my study.

ABSTRACT

Bagasse is the fibrous by-product of sugarcane stalks after they are crushed to extract their juice. Sugarcane bagasse ash is a byproduct of the sugar factories found after burning sugarcane bagasse. The disposal of this material i.e. SCBA is already causing environmental problems around the sugar factories (**Basika, Kigozi and Kiggundu, 2021**). Due to the boost of the construction activity in the country, a huge shortage is created in most of the construction materials especially cement, resulting in steady increase of price. Cement industry also creates environmental problem by emission of carbon dioxide during manufacturing of cement and consumes lot of raw materials. This research was therefore, conducted to investigate the effectiveness of using sugarcane bagasse ash as a partial replacement of cement in construction of concrete water storage tanks.

Initially, bagasse ash samples were collected from SCOUL sugar factory and its mineralogical and chemical analyses were performed with two samples of ash i.e. raw SCBA and calcined at a temperature of 900°C for 24h. After these analyzes, it was observed that the calcined SCBA presented a greater tendency of material in the amorphous state, which possibly made the material the most reactive. For this reason, only the calcined SCBA was used. Also, Sucrose is the chemical name for sugar that comes from the cane and beet sugar plants. Chemically sugar consists of carbon, oxygen and hydrogen atoms and is classified as a carbohydrate. Sugar used in this study as a retarder was sucrose crystals ($C_{12}H_{22}O_{11}$) (**Kandhari, 2017**). It was obtained from the local market.

Sugarcane bagasse ash was sieved with 150 μ m sieve size. M25 grade strength of concrete was designed with nine different proportions of concrete mixes. Sugarcane bagasse ash ranging from 5% to 25% in an increment of 10% and sugar ranging from 0.2% to 1.0% in an increment of 0.4% by weight of cement respectively including the control mix was prepared with a water cement ratio of 0.5. For each substitution ratio, 3 sets (a total of 60) concrete specimens were prepared for compressive strength test conducted at the age of 7 and 28 days and 20 concrete specimens for water absorption test were casted. The results of the compressive strength of concrete work have shown that up to 15% replacement of the ordinary Portland cement by bagasse ash is possible. In addition, compressive strength value of concrete with 15% SCBA replacement and 0.2% sugar was showing a higher strength improvement of about 8.9%. The water penetration depth was found to increase as the bagasse ash content increases and all the blended concretes showed a higher maximum penetration depth than the control concrete.

Table of contents

Contents

DECLARATION	i
APPROVAL	ii
ACKNOWLEDGEMENTS	iii
ABSTRACT	iv
List of Figures	vii
List of Tables	viii
List of acronyms/ abbreviations	ix
CHAPTER ONE: INTRODUCTION	1
1.1 Background	1
1.2 PROBLEM STATEMENT	2
1.3 OBJECTIVES	3
1.3.1 Main objectives	3
1.3.2 Specific objectives	3
1.4 Significance of the Study /Justification	3
1.5 Scope and limitation of the study	3
CHAPTER TWO: LITERATURE REVIEW	4
2.1 Water tanks	4
2.2 Concrete production	5
2.2.1 Cement	5
2.2.2 Hydration	8
2.3 Main properties of concrete	10
2.4 Admixtures in concrete	12
2.4 Sugarcane	16
2.4.1. Sugarcane bagasse ash	17
2.4.2 Usage of sugarcane bagasse in concrete	18
2.4.2 Utilization of SCBA as a partial replacement of cement	18
CHAPTER THREE: MATERIALS AND METHODS	20

3.1 INTRODUCTION	20
3.2 MATERIALS	20
3.3 Methodology	22
3.3.1 SCBA preparation	22
3.5.1 Specific objective one: To characterize SCBA.	23
3.3.2 Specific objective two: To establish the concrete mix design ratio of ingredients.	24
3.3.3 Specific objective three: To determine the effect of SCBA and sugar on the mechanical properties of concrete	32
3.3.4 Specific objective four: To determine the cost effectiveness between SCBA concrete and OPC concrete	35
CHAPTER FOUR: RESULTS AND DISCUSSIONS	37
4.1 MATERIALS AND PROPERTIES	37
4.1.2 Sieve Analysis and fineness modules	40
4.1.2 Moisture content	44
4.1.3 Relative density and water absorption	45
4.2 Setting time of cement paste	46
4.3 SLUMP TEST	47
4.4 Compressive strength test	48
4.5 Water absorption test	51
4.6 Cost effectiveness analysis	52
CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS	59
5.1 CONCLUSIONS	59
5.3 RECOMMENDATIONS	60
REFERENCES:	61
APPENDIX	64
APPENDIX A: PHOTOPLATES	64
APPENDIX B: LABORATORY TEST SHEETS	65
APPENDIX C: GENERAL LAY OUT OF THE TANK	67
APPENDIX D: STATISTICAL ANALYSIS OF CONCRETE CUBES COMPRESSIVE STRENGTH	67

List of Figures

Fig 2.1 workability Vs strength of concrete	12
Fig 2. 2 production process of sugar and alcohol	16
Fig 3.1 Shows the arrangement of sieves.....	21
Fig 3. 2a Putting Raw SCBA in the furnace. Fig 3.2b Raw SCBA in the furnace. Fig 3. 2c SCBA burnt under 900⁰C	23
Fig 3. 3a VEGA 3 SBU No. 118-0015 1300VA. Fig 3.03b SEM image analysis.....	24
Fig 3.4 Mixing of aggregates	30
Fig 3.5 Moulding/casting of concrete cubes	31
Fig 3.6a De-Moulding cubes Fig 3.6b concrete cubes Fig 3.6 c curing of cubes	31
Fig 3.7 Performing setting time experiement	33
Fig 3.8 Performing slump test.....	34
Fig 3.9 compressive strength	35
Fig 4. 1a Raw SCBA 393X magnification Fig 4.1b SEM image at HV:30.0KV	37
Fig 4. 2a controlled SCBA SEM MAG:777X Fig 4.2b SEM MAG: 2.33KX	38
Fig 4. 3 Elemental composition for Raw SCBA.....	39
Fig 4.4 Elemental composition for treated SCBA	40
Fig 4.5 particle size distribution curve coarse aggregates	42
Fig 4. 6 particle size distribution curve fine aggregates	43
Fig 4.7 initial setting time	46
Fig 4. 8 final setting time	46
Fig 4.9 workability of concrete.....	47
Fig 4.10 compressive strength at 7 days.....	49
Fig 4.11 compressive strength at 28 days.....	49
Fig 4.12 water absorption.....	51

List of Tables

Table 2. 1 General features of the main types of Portland cement (Mutua, 2017)	7
Table 2.2 Typical composition of ordinary Portland cement (Ajoro,A,S 2015).....	7
Table 2.3 ASTM C 618 chemical requirement for Pozzolan	15
Table 2.4 Chemical composition of sugar cane bagasse ash (U.R. Kawae, et al 2013).....	17
Table 3.1 Estimated percentages of SCBA and Sugar	24
Table 3.1 2Test runs from the software	25
Table 3.3 Correction in water content	27
Table 3.4 for Correction in water content	28
Table 3.5 design mix ratio	29
Table 3.6 Design quantities for 0.03M³	30
Table 3.1 7aggregate weights for setting time	32
Table 4.1Elemental composition (%) by EDS analysis	39
Table 4.2 sieve analysis coarse aggregates	41
Table 4.3 Sieve analysis fine aggregates	42
Table 4.4 Moisture content	44
Table 4.5 Relative density and water absorption	45
Table 4.6 Setting time	46
Table 4. 7 SLUMP TEST	47
Table 4.8 Compressive strength test results	48
Table 4.9 Water absorption test results	51
Table 4.10 Material quantity analysis for normal concrete	56
Table 4.11 Cost effectiveness of the materials used in normal concrete	56
Table 4.12 Material quantity analysis for Concrete with SCBA & Sugar	57
Table 4.13 Cost effectiveness of the materials used in Concrete with SCBA & Sugar	57

List of acronyms/ abbreviations

SCBA	sugarcane bagasse ash
GBA	ground bagasse ash
ECC	engineered cementitious concrete
OPC	ordinary Portland cement
PPC	pozzolan Portland cement
PE	Polyethylene
PP	Polypropylene
BPA	Bisphenol,
HDPE	High Density Polyethylene,
PET	Polyethylene Terephthalate
SCOUL	sugar corporation of Uganda limited
IS	Indian standards
BS	British standards
EAS	East African Standard
ACI	American concrete institute
SCMs	supplementary cementitious materials
ASTM	American Society for Testing and Materials
ANOVA	Analysis of Variance

CHAPTER ONE: INTRODUCTION

1.1 Background.

Due to the rapid population growth rate in the world today, there has been temporal variation in water to serve different activities (**Population institute 2010**). This is because human population growth is a major contributor to global warming, given that humans use fossil fuels to power their increasingly mechanized lifestyles, this means that there will be variation in water tables due to climatic changes (**Hall *et al.*, 2017**). To overcome the problem of water shortages, water storage tanks should be put in place to ensure water availability in the periods of scarcity.

Water is one of the most integral and important aspects of daily life for every human being (**WHO, 2020**). Therefore, water storage tanks are a must to preserve water for different uses. Water storage tanks can be built in different shapes depending on the choice, and the area provided they also come in different sizes depending on purpose it's to serve.

In Uganda, the common types of reservoir tanks used are plastic reservoir tanks, steel and concrete tanks that are used both as water storage tanks and rain water harvesting tanks. Steel tanks can rust and corrode over time and have a low resistivity to high temperatures. Plastic reservoir tanks are made up of Polyethylene (PE), Polypropylene (PP), Bisphenol (BPA), High Density Polyethylene (HDPE), Polyethylene Terephthalate (PET) etc. These chemicals start mixing with water when used for a long time, high temperature as well as from natural breakdown. When these plastic tanks are exposed to strong heat, especially in the long summer months when the mercury rises above 40oC, the chemicals start to melt down and mix with water. Therefore, Normal Concrete tanks have relatively high resistivity to UV radiations. Concrete has also been investigated however it is more permeable, has a poor workability and poor bonding between steel and concrete thus reinforcement is not Concrete is composed of cement, fine aggregates(sand), coarse aggregates (natural gravel). (**Revanna *et al.*, 2020**). These constituent materials proportioned are properly mixed together with water to form the concrete. The cement serves as the binder to the aggregates while the aggregates serve as the filler materials that give strength to concrete.

Concrete production utilizes cement as its major ingredient. Cement production is an important consumer of natural resources such as limestone, chalks, marl etc. and energy. Furthermore, the cement industry is a significant CO₂ producer which is harmful to the environment and the