MININFRA

WFEO / FMOI

UNESCO-Africa Engineering Week with Africa Engineering Conference
*Kigali Convention Center– Rwanda 25th– 29th September2017*

THEME: "EFFECTIVE WASTE MANAGEMENT IN AFRICA"

**AEC 217 29**

# Utilization of Waste Glass Powder and Rice Husk Ash for Development of Eco-friendly Reactive Powder Concrete

Presented By: Belachew Asteray Demiss
Pan African University Institute for Basic Science, Technology and Innovation hosted at Jomo Kenyatta University
**email: belachewcm.mtu@gmail.com**
**Belachew Asteray, Prof.(Eng.) Walter O. Oyawa, Prof. (Eng.) Stanley M. Shitote**

**September, 2017**
**Kigali, Rwanda**

# Presentation outline

1) Introduction
2) Objectives
3) Materials and Methods
4) Results and Discussion
5) Conclusions

# 1) Introduction

- Currently, innovations on sustainable materials has been encouraged as a result of
  - continual accumulation of different local wastes and
  - their consequent environmental complications due to urbanization, population growth, global energy need and excess materials use in Civil Engineering projects.
- Globally, 90 billion tons of solid wastes are expected to be generated annually by the year 2025 [Ajnavi S., 2008].
- Based on the urban community consumption, the composition of wastes generated in East African urban centers is mainly solid waste materials [O. Okumu J., 2012].
- Among theses solid wastes, construction wastes are vast in Africa and has led to serious environmental effects which needs crucial management.

# 1) Introduction…

- In recent times, a new generation concrete called reactive powder concrete is under development as an ultra-dense mixture of water, Portland cement, silica fume, fine quartz sand, quartz powder, superplasticizer and steel fibers [4–6].
- However, it is noticed that high silica fume content (between 20% and 30% as per Chan and Chu, 2004) is one of the characteristics of reactive powder concretes which is uneconomical for local constructions.
- In most African Countries, silica fume for local concrete work is imported from Middle East, Asian and other foreign suppliers which are too expensive and time-taking.
- Furthermore, application of RPC for local construction activities has limitations due to its energy-consuming during the heat curing process and the milling of quartz sand [Gu CP et al., 2015].

# 1) Introduction…

- In this study, finely dispersed waste glass powder as well as waste ceramic powder from construction sites; and rice husk ash from factories were proposed as a result of continual accumulation of wastes in the East African region to develop recycled reactive powder concrete.

## 2) Objectives

- To examine the pozzolanic properties of the local wastes based on known standards;
- To develop RRPC and to investigate the effect of local wastes on hardened properties of RRPC

MININFRA

# 3) Materials and Methods

## Materials

- Portland cement (Type I 42.5 N),
- fine sand (600µm),
- waste ceramic powder (300µm),
- finely dispersed waste glass powder (150µm),
- rice husk ash,
- steel fibers,
- Superplasticiser,
- water
- MasterRoc MS 610 type densified Silica fume (control mix, )

**Raw Material Preparation**

- Collection of Local Wastes from construction sites and factories
- crushing by a sludge hammer and milling machine to produce pozzolanic powder
- sieved using standard sieve (150µm, 300µm)
- XRF Analysis

**Specimen Preparation**

- Mix Proportions based on preliminary labs and previous studies
- Standard Mould preparation (100X100X100 $mm^3$ cube moulds [BS EN 12390-1:2000]
- specimens preparation [BS EN 12390-2:2000]
- Hand mixing, uniform water-binder ratio of 0.216
- standard curing till testing days 14 days in water at a temperature of 20° instead of steam curing at high temperature in conventional RPC.

**Performance Testing and Evaluation**

- Pozzolanic Property of proposed local wastes
- compressive strength (BS EN 12390-3:2002) by automatically controlled universal testing machine at constant rate of loading (rate of 0.500 KN/Sec and start load of 0.250 KN with 15% stopping load)

**Conclussion**

- Conclussion based on laboratory investigations

# 3) Materials and Methods…

- Finely dispersed waste glasses and rice husk ash were proposed to replace silica fume fully; as well, quartz powder was replaced by finely dispersed local waste ceramic powder.
- Since the mix design was employed using this three local waste materials together with other core raw materials, the name **"Recycled Reactive Powder Concrete"** was given for the concrete mixture.

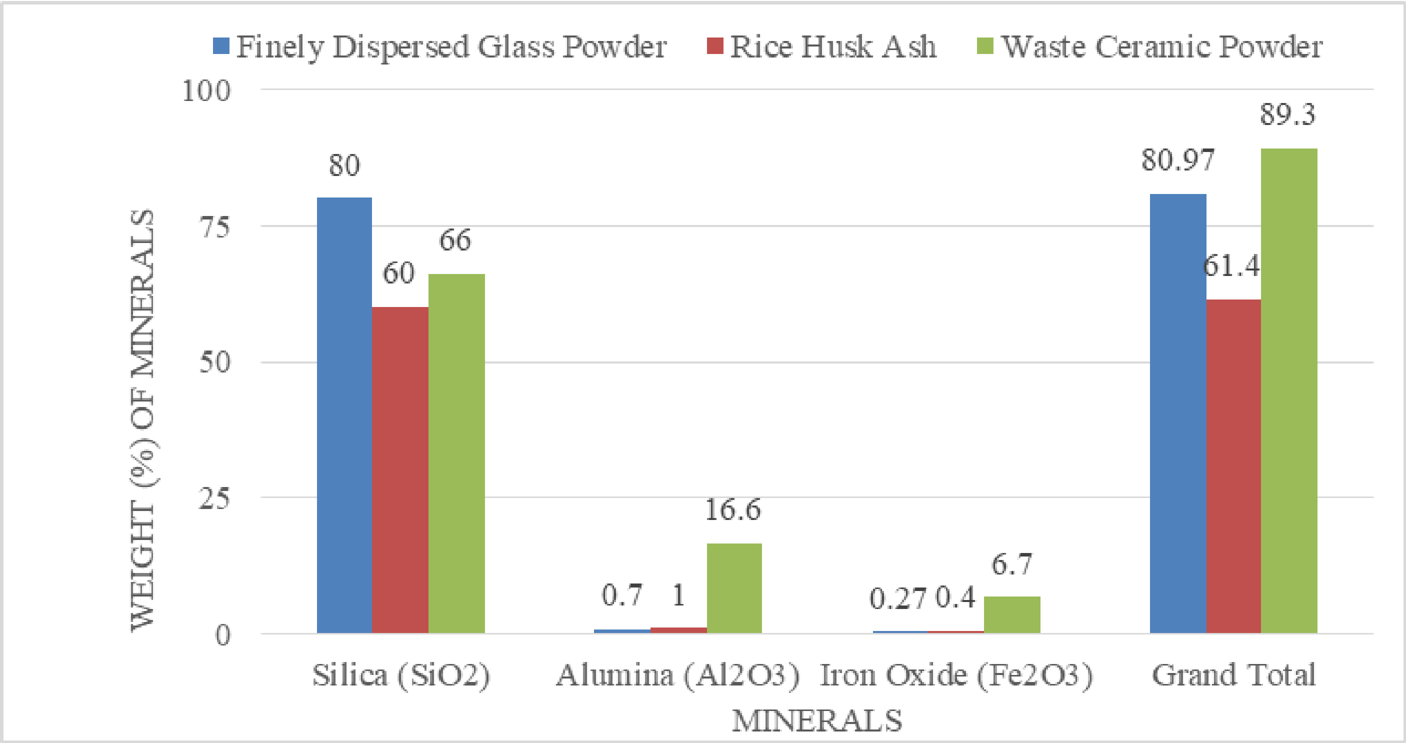
**Mix Proportions for 9 Cubes (100x100x100 $mm^3$ )**

| Mix Series | Cement $Kg/m^3$ | Waste Ceramic Powder $Kg/m^3$ | Waste Glass Powder $Kg/m^3$ | Rice Husk Ash $Kg/m^3$ | Fine Sand $Kg/m^3$ | Superplastcizer $Kg/m^3$ | Water $Kg/m^3$ | Steel Fibers $Kg/m^3$ | Silica Fume $Kg/m^3$ |
|---|---|---|---|---|---|---|---|---|---|
| **Control** | 7.58 | 1.52 | | | 8.34 | 0.23 | 1.52 | 1.04 | 1.89 |
| **Series 1** | 7.58 | 1.52 | 1.52 | 0.38 | 8.34 | 0.23 | 1.52 | 1.04 | |
| **Series 2** | 7.58 | 1.52 | 0.95 | 0.95 | 8.34 | 0.23 | 1.52 | 1.04 | |
| **Series 3** | 7.58 | 1.52 | 0.47 | 1.42 | 8.34 | 0.23 | 1.52 | 1.04 | |

# 4) Results and Discussion

## 4.1) Pozzolanic Property of Local Waste materials in the study

- ASTM C618 prescribes that a pozzolan should contain $SiO_2 + Al2O_3 + Fe2O_3 \geq 70$ wt.%.




- Except rice husk ash, the chemical compositions are greater than 70 (by weight %).
- Hence, the local waste materials used in this study specifically finely dispersed glass powder and waste ceramic powder were revealed a wonderful pozzolanic property that can greatly affect the long-term performance of the concrete product.

# 4) Results and Discussion…

## 4.2) Compressive Strength

- As a major parameters to identify the long term mechanical performance of the produced RRPC, the compressive strength was evaluated by replacing different percentages of the proposed waste materials.

Mean Compressive Strength after 14 days standard curing


- series 1 produced a maximum compressive strength using 20% RHA and 80% GP.
- maximum compressive strength gained from the first mix series were raised by 5.72% and 35.57% as observed in mix series 2 and 3 respectively.
- Compared to the control mix, higher compressive strengths were attributed in the first and second mix series.
- In this regard, 5.97% rise of compressive strength was observed in the first mix series compared to the control mix.

# 4) Results and Discussion …

## 4.2) Compressive Strength…

- However, this compressive strength was very low compared to the conventional RPC that was produced by Silica fume, quartz powder, very fine steel fibres using machine mixing and stem curing at high temperature.
- Beyond the raw material modification, this study were used hand mixing, long steel fibers(55mm) from local factories, standard curing.
- But, as per the glass powder content, the result obtained by the most scholars is also true for this study with respect to the ratio of glass powder.
    - There was higher compressive strength with respect to using higher amount of finely dispersed glass powder.

# 5) Conclusions

- This study tries to use local wastes for the development of Recycled Reactive Powder Concrete (RRPC). Based on the experimental results, the following conclusions can be drawn.
  - finely dispersed glass powder and waste ceramic powder revealed a wonderful pozzolanic property that can greatly affect the long-term performance of RRPC product;
  - the optimal values to get higher compressive strength for waste glass powder is 80% and for rice husk ash is 20%;
  - a maximum mean compressive strength of 49.695 MPa at 14$^{th}$ days standard curing age can be produced using optimal values using high GP and low RHS within the desired mix.
- In general, a culture of using local waste raw materials in the African construction sector will be an interesting approach to solve
  - raw material shortage,
  - to fulfil the market demand of eco-friendly concrete products,
  - to reduce waste disposal cost and
  - related environmental issues in Africa.

# *Thank you!*