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Optimization Modeling Of Partially Replaced Rice–Husk- Ash Gypsum Pop Boards

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ABSTRACT
Rice husk ash is in industrial waste that needs to be harnessed to create wealth. The waste poses problems such as climate change, global warming and ozone layer depletion and other environmental challenges. This research optimizes its use as partial replacement for gypsum in the production of POP boards. Graphical method of linear programming was used to develop an optimization model. Result showed that an optimization model of $Z_{Max} = X_1 + 2X_2$ *gave optimal point and solution of C (0,17) and* $X_1 = 0$, $X_2 = 17$ *and* $Z_{max} = 51{,}000$. *The optimization model developed showed that POP board manufactures can optimally produce durable POP boards with 20% RHA replacement at the cost of ₦ 17,000 per bag to maximize huge profit of ₦ 51,000. I recommend that federal and state ministry of works and environment should adopt this model in executing projects as it will optimally improve and sustain the work force and GDP.*

KEYWORD: Rice Husk Ash, Linear Programming, Optimization, Gypsum. Plaster of Paris

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I. INTRODUCTION

Rice husk ordinarily is an environmental nuisance both at milling point and at point of open burning which is the normal practice (Nagrale, 2012). Intensified pressure in massive industrial production of Rice husk ash (RHA) results in excessive waste generation for which our rice mill industry is a front liner. RHA is a common solid waste that caused so much pollution to the environment and this study is geared towards optimizing it to convert waste to wealth. This work optimises the solid waste material from rice mill industries for aesthetics and structural benefit thus enhancing its economic viability and usage. RHA which is a common solid waste in Rice mill industries was used to replace gypsum in POP board. The result obtained was consequently used to optimize its waste using graphical method of linear programming.

This research will help solve the environmental engineering problems caused by rice mill industries, minimize time and cost of disposing the industrial waste for optimal maximization of profit, and ultimately convert the industrial waste to wealth. The ash produced from rice husk was used to produce the best of boards with attractive atheistic of its component which include POP board, rozest and cornices. The model designed would help in optimization of solid waste (RHA) in the globe.

POP is a white cementations powder which set to a hard solid when mixed with water. Large deposits were officially found outside Paris in France hence its name. When gypsum is heated to about 150^0C it losses water and produces the powder used in making POP with chemical formula as $CaSO_4 \cdot ½H_2O$. (Donnelly, 2012).

Some benefits of POP include lending a smooth matta finish to interior ceiling, good aesthetics when painted, perfect ornamented design for ceiling when casted in different shapes, classic looks at interiors, creation of adornment of POP false ceiling, finishing of ugly structural elements of buildings, concealing of air condition ducts and production of composite structures when gelled with glass, wood and steal materials (Ezugwu C.N., Uneke L.A. and Akpan P.P., (2015). RHA has been widely used in various industrial applications such as processing of steel, cement, ceramic and other refractory industries, silica source, etc (Ajay,2012; Nagrale, 2012). Ramasamy, (2012) and Nagrale,

(2012) discussed so much on the physical and chemical properties of RHA. Research showed that RHA has High silica content when burnt at 650^0c-700^0c, reduces its carbon content and increases its surface area (Nagrale, 2012). In the view of Ramasamy, (2012) rice husk used as a replacement for cement can increase in compressive strength, decrease in chloride iron penetration as a result of reduction in the volume of large pores, Lower permeability when mixed with a superplasticizer, Improve resistance sulphate and alkali attack due to the presence of high amount of silica and increase resistance to acid attack, freezing and thawing).

RHA is used for the preparation of silica powder which is a good replacement for cement in concrete construction works with improved durability and reduce environmental impact (Ragini P., Rajendra, D. and Jyotsna M., 2014). The work of Mohamed R., Mkhalid A. and Barakat B. , (2015) showed that rice husk ash can also be used as a renewable source for the production of zeolite NaY, and high capacity lithium batteries.

II. MATERIALS AND METHODS

The materials and method adopted in this research was based on the work of Ezugwu C.N. et.al., (2015). A hypothetical case was used to formulate the model. Abakaleke Rice Mill is located at Izzii town, Abakaleke local government area in Ebonyi state of Nigeria with geographical coordinates of 6°20′N and 8°06′E. During the cause of carrying out field survey on the problems of solid waste management, it was discovered that the most recyclable options was to Optimize Rice Husk Ash which is one of the waste found within that area. Two basic ingredients A, and B are used to produce the options. The maximum availability of A is ₦ 17,000 which is the total production cost of the POP boards/bag while that of B is the maximum crushing strength of boards with respect to the ratio of the maximum strength obtained from the 0% and 20% RHA replacement . The requirements of the ingredients per bag of the RHA for developing the model to optimize the solid waste are summarized the table 1.

Table 1: Requirement of ingredient per bag of RHA to develop the optimization model

	Gypsum with 20% RHA replacement		Maximum resources and crushing strength availability (Thousand Naira)
	Gypsum with 0% RHA replacemtn(X_1)	Gypsum with 20% RHA replacement(X_2)	
Ingredient A	1	1	17
Ingredient B	3	1	40

Market survey revealed that the maximum cost of production using Gypsum with 0% RHA replacement option is limited to ₦ 7,000 per bag while gypsum with 20% RHA replacement option is limited to ₦ 6,000 per bag daily. The price per bag is ₦ 7,000 for boards with 0% RHA replacing and ₦ 6,000 for boards with 20% RHA. The benefit obtained for both POP boards with 20 % or 0% replacement of RHA is ₦ 8,000 . Table 2 below showed the cost of production in unit per bag and it relative benefit.

Table 2: Cost and benefit accrued in POP boards production in unit per bag

	Cost of production (Unit/bag in thousands of Naira)	Benefit (Unit/bag in thousands of Niara)
Gypsum with 0% RHA replacement(X_1)	7	8
Gypsum with 20% RHA replacement(X_2)	6	8

Firstly, mathematical representation of the linear programming model. This can be stated as: Maximized $Z= (8-7)\ X_1 + (8-6)\ X_2$. Base on the senero from the above table, the benefit that will accrue in producing the POP boards with maximum profit is $Z_{Max}= X_1 + 2X_2$

However there are two constrains.

1. The first constraint limits the total cost of production of POP boards with 20% RHA replacement to be below ₦17, 000 per bag.
2. The second constraint limits the total strength of the board developed to be less than 40Mpa.

Model Formulation
Maximize $Z = X_1 + 2X_2$
Subject to
Ingredient A: $X_1 + X_2 \leq 17$
Ingredient B: $3X_1 + X_2 \leq 40$
: $X_1 \geq 0, X_2 \geq 0$
Where X_1 is the gypsum board produced with 0% RHA replacement material and X_2 is the gypsum board produced with 20% RHA replacement material and Z is the profit maximized.
Secondly**,** putting the mathematical representation in standard form. This can be state as:

Maximize $Z = 2X_1 + 3X_2$
Subject to
Ingredient A: $X_1 + X_2 = 17$
Ingredient B: $3X_1 + X_2 =40$
: $X_1, X_2 =0$

For mapping and feasibility region for the constraint by graphical method we can have:
$X_1 + X_2 = 17$ when $X_1 = 0$, $X_2 = 17$ also when $X_2 = 0$, $X_1 = 17$
$3X_1 + X_2 =40$ when $X_1 = 0$, $X_2 = 40$ also when $X_2 = 0$ $X_1 = 13.3$
Graphical presentation of these parameters are presented in figure 1

III. RESULTS AND DISCUSSION

The result of the setting time, compressive strength and loading is same as that presented in the work of Ezugwu C.N. et.al., (2015).

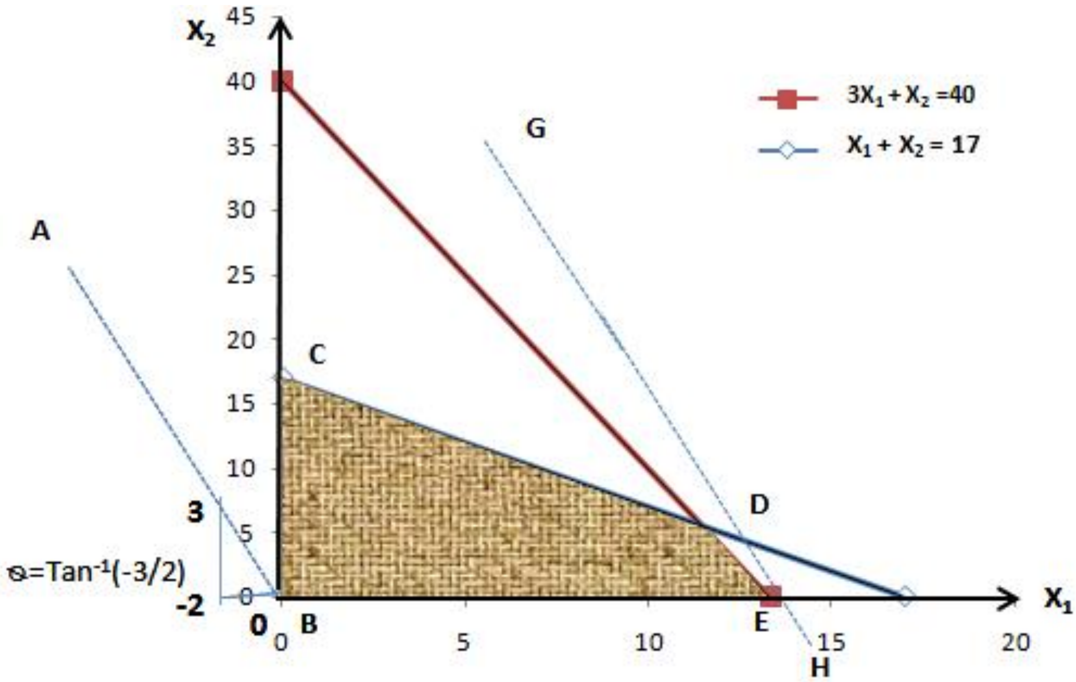

Figure 1. Graphical presentation of the developed model using linear programming

From the graph above, the feasible region is BCDE, any point within or on the boundary of the region is feasible solution. Solving the equation of the constrain $X_1 + X_2 = 17$ and $3X1 + X_2 =40$ simultaneously, we have X_1 and X_2 to be 11.5 and 5.5 respectively, resulting to $Z_{max} = 2X_1 + 3X_2 = 39.5$. But the vertex polygon from the feasible region in the graph at point B,C,D and E gave various Z_{maz} as 0, 51, 39.5 and 34 respectively. Hence the highest Z_{max} occurred at point C (0,17) with optimal point of 51. Therefore the optimum solution of the formulated model is $X_1 =0$, $X_2 = 17$ and $Z_{max}=51$.

This implies that investing ₦17,000 per bag to produce POP boards using gypsum with 20% RHA replacement will optimally accrue enormous benefit of ₦ 51,000

IV. CONCLUSION

The research optimizes solid waste materials from our rice mill industries to produce the best of ceiling board with good aesthetics and designs of the different components of the POP namely POP board, rosette and conies with RHA as alternative material. Durability, strength and aesthetics, reduced porosity, resistance to fire, chloride and sulphate attacks, should be reasonably high to achieve economic aims (Franz, 2012; Ramasamy, 2012).

It has been established experimentally that RHA is a good alternative to Gypsum. The work of Ezugwu C.N. et.al.,(2015) inferred that 40% RHA developed the highest strength and with the passage of time will exceed the strength of the 0% mix. The strength of the RHA in POP boards can exceed that of gypsum by up to 30% (Ezugwu C.N. et.al., 2015) . The aesthetics of the products are reasonably good. Improved b fire, sulphate and chloride resistance is expected. The optimization model developed showed that POP board manufactures can optimally produce durable POP boards with 20% RHA replacement at the cost of ₦ 17,000 naira per bag to maximize huge profit of ₦ 51,000.

V. RECOMMENDATION

We recommend that federal ministry of environment should invest in lucrative project like this as it will not only assist in creating an environmental friendly environment but it will also create wealth and satisfy ISO 14001:2018 requirements.

We recommend that state and federal ministry of works should use this developed model to optimally execute viable and productive project as it agrees with ISO 9001:2018 requirement.

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