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Development of a Model for Capacity Building and Optimal Utilization of Manufacturing Cost in Cement Production Planning Process

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Abstract
This study introduces the development of a model for determining the manufacturing cost of cement in its production planning process, and the goal is to develop a faster and better means of determining cement-manufacturing cost. The developed model will be particularly of great assistance to new comers who are not familiar with the field and will facilitate them in gaining a better understanding of the manufacturing parameters for production process and in making decisions about any necessary actions. The developed model is versatile in the sense that it quickly generates results, which hasten decision making process

Keywords: cement, manufacturing cost, capacity building, planning process

INTRODUCTION

In recent years, concurrent engineering has emerged as a key practice in enhancing the competitiveness of a product. Most people agree that the cost and quality of a product are "locked" into the layout design. Many companies are actively pursuing means to integrate the life-cycle values of the product early in its development.

The manufacturing scene today is undergoing a revolution. Infact the technology that had the greatest impact on the production system over the last decades is computer modeling. Modeling have important role to play in job shop and batch production manufacturing plants, which constitute an important portion of the total manufacturing activity. It may be remembered that traditional batch manufacturing suffers from drawbacks like low equipment utilization, long lead times, inflexibility to market needs, increased indirect cost and high manufacture cost. It is estimated that in conventional batch production methods, only 5 to 10% time is utilized on machines and the rest is spent on moving and waiting. Out of the total time on machine, only 30% is on machining, rest being on positioning, loading, gauging and idling.

Consequently, a need exists for adequate modeling cement production process in the manufacturing sector using feedback control, process control, planning and decision making to support manufacturing activities (Jain, 2001). Market demands have changed towards higher quality, shorter delivery times and lower product cost. To be competitive, it is necessary to reduce or completely eliminate material wastage in order to keep the manufacture cost as low as possible, hence the need to model the production process of cement. The objectives of this research are to ascertain the relevant manpower parameters related to the planning of cement production process and develop a mathematical model for expert system in the planning of cement production process.

Case Study: West African Portland Cement (WAPCO)

The company used as case study is West African Portland Cement (WAPCO), the oldest cement factory in Nigeria, established in 1959 and is involved in the manufacture and wholesale of cement and building products. Major shareholders include Blue Circle of the UK, O'dua Investment Company, and the Nigerian government. WAPCO has two cement factories, both in Ogun State, precisely in Ewekoro and Shagamu, established in 1960 and 1978 respectively. The former was replaced by a new plant in 2003, and is the largest cement producer in Nigeria, with an effective annual production capacity of approximately 1 million tons (WAPCO Cement, 2010) with a workforce of about 1,750 employees in its labour force (WAPCO Cement, 2010)

Ewekoro cement factory is located in Ewekoro Local Government Area, Ogun State in southwestern Nigeria (Figure 1; Maps 1–4). The cement production facility, located about 5 km north of Ewekoro town ($6^{o}55`N$, $3^{o}12`E$), lies within the tropical rainforest vegetation belt of Nigeria. The production facility is surrounded by settlements which predate the cement company. The settlements include Olapeleke and Itori to the north and Elebute Alaguntan to the east of the factory (Figure 1; Map 3). The climatic conditions prevailing over the cement production facility riparian ecosystems were mainly those of the tropical rainforest, typified by an average annual temperature of 30 ± $10^{o}C$, relative humidity of 65 ±

10% and an average annual rainfall of 1500 ± 120 mm (Oguntoyinbo et al. 1983).

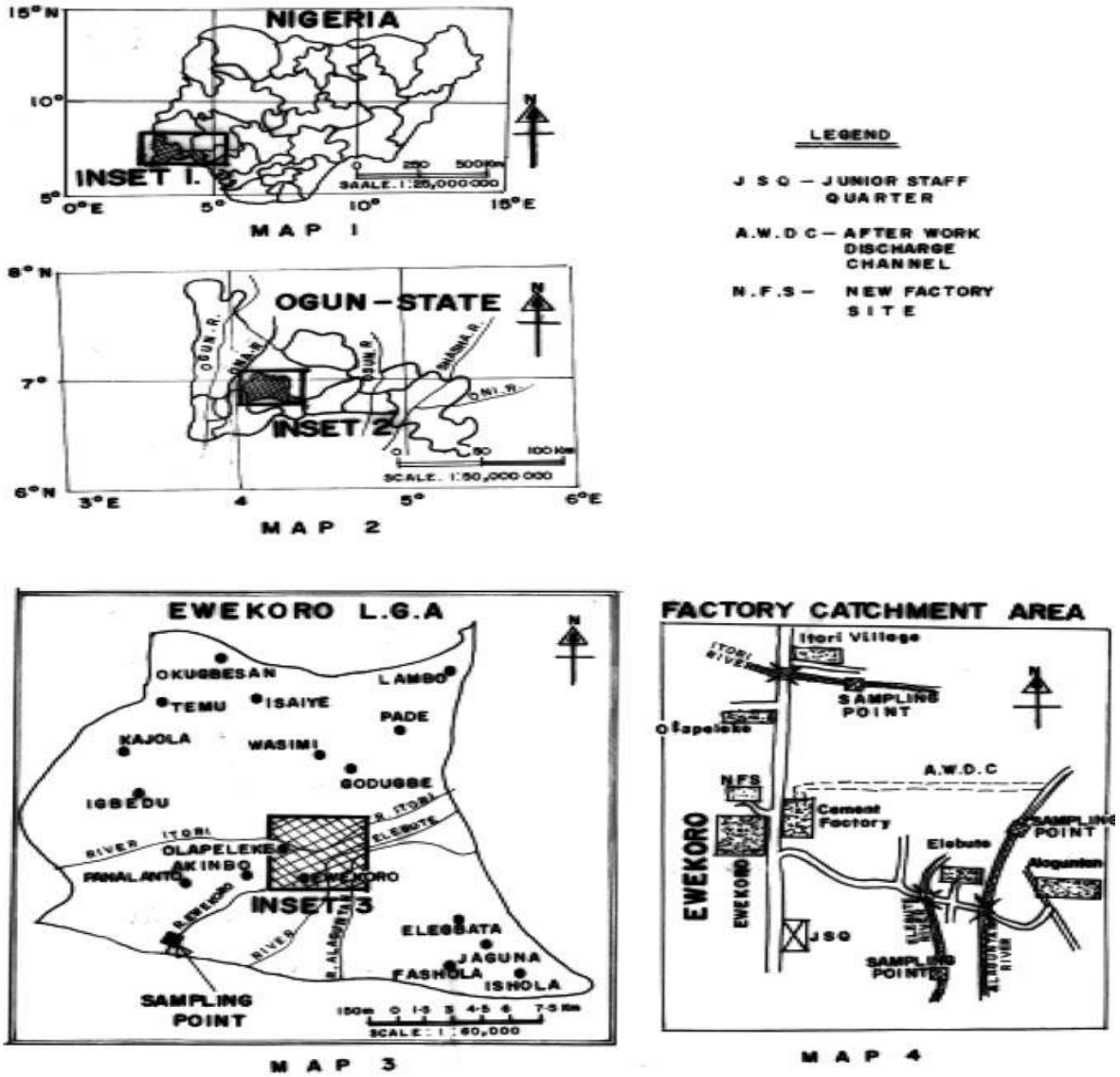

Figure 1. Maps Showing the Location of Ewekoro Cement Factory Within Ogun State, Nigeria and The Location of the Sampled Rivers With The Factory Catchment Area.
Source: (Oguntoyinbo et al. 1983)

The manufacturing cost of cement is as shown in table 1, as obtained from west African Portland cement, 2010, the cost diferes from the one obtained using the developed model showing an improvement.

Table 1: Data on Manufacturing Cost of Cement

Cost Component	Manufacturing Cost (₦)
Direct machine cost	921,000,000
Direct labour cost	710,499,970
Direct expenses	536,099,970
Machine hour rate	25,900,000
Overhead cost	403,840,000
Cost per unit bag	₦ 1,279.67K

Source: (WAPCO Cement, 2010)

Manufacturing Cost of the Processed Cement

Manufacturing cost, C_g^{f*}, of the processed cement is computed using Eqn. 1.

$$C_g^{f*} = \sum_{j=1}^{u} C_j^{f*} \quad (1)$$

Where j is the cost elements such as direct material cost, direct labour cost, direct expenses machine hour rate, energy cost, overhead cost, etc.

Manufacturing cost per tonne of cement, C_o^t is estimated using Eqn.2

$$C_o^t = {C_j}/{C_g^m} \quad (2)$$

from which cost per bag of processed cement is estimated as $C_o^t / 20$

PERFORMANCE EVALUATION

Post decision-making for cement production is evaluated based on break-even point analysis. Break-even point, β of the cement production processes is evaluated using expression in Eqn.3, which is based on ratio of Overhead cost, $C_j^{overhead}$ and profit margin, ρ, as

$$\beta = \frac{C_j^{overhead}}{\rho} \quad (3)$$

and ρ is measured as:

$$\rho = C_R - C_V \quad (4)$$

where,

C_R, is the average monthly revenue per tonne of output cement

C_V, is the average monthly variable cost per tonne of output cement.

The value of β in Eqn. 3.19, determines whether production process is economically viable or not. It also determines whether to continue production process or stop the process. The smaller the value of β is for the production process, the better is its economic viability. The value of β is, also varied with the types of cement one is intended to produce.

Modeling Cement Production Processes

The identified critical elements of cement production includes: the proportion of materials used for cement production; proportion of energy used for the production; capacity of the machines used for cement production and manpower required for the operations. But for the purpose of this study, effort will be concentrated on the machine capacity development using a model.

The summary of the savings in the whole plant manufacturing cost is shown in the table below. It shows that the developed model had a savings of (₦)426.56 over the one obtained from WAMPCO

Table 2: Savings Results on Manufacturing Cost of Cement for the Entire Plant

Cost Component	Actual Cost(₦) (WAPCO)	Expected Cost (₦) (Model Developed)	Savings (₦)
Direct machine cost	921,000,000	672,237,439	248,762,561
Direct labour cost	710,499,970	518,593,594	191,906,376
Direct expenses	536,099,970	392,758,920	143,341,050
Machine hour rate	25,900,000	18,904,397	6,995,603
Overhead cost	403,840,000	294,762,614	109,077,386
Cost per unit bag	1,279.67K	853.11	426.56

Expert system would assist tremendously in the syncronisation and effective planning of the cement production process in order to avoid these wastage of manpower. This development will bring about savings in additional cost of procuring unsuable resources in the cement production process. Savings in manufacuring cost of cement will definetly reduce the price per tonne of processed cement in Nigeria.

The developed model has helped to identify and ascertain the right proportion of the requirements of manpower and parameters related to the cement production process and have proved to be very consistent in its decision making process during verification of its results by using test cases, based on relevant data collected from the case study, Ewekoro cement company

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