INVESTIGATING THE REASONS FOR QUARRY SHUT-DOWN IN PLATEAU STATE, NIGERIA: A CASE STUDY OF AFRI-MINE QUARRY AND JOLEX CONSTRUCTION

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ABSTRACT

Background: Quarry operation is one of the surface mining activity carried out in Nigeria. It involves different stages of operation such as blasting, crushing and lots more but due to financial loss, many quarry business has shut down while very few is still in operation. This research aim at identifying the reason(s) behind the incessant folding up of quarry business in Nigeria through comparative study between Afrimine Quarry and Jolex Construction.

Results: Data was obtained through interactive interview with the staff in the quarry and after collation and data analysis, the following results were observed. Afrimine sells granite within the price range of 3,300 to 5,200 for sizes of 1/2 inch, 3/4 inch, 3/8 inch, stone dust and makes a monthly profit of 436, 484,859.375 with a total volume of 15,000 tons per month and a unit price of 2,291.61 /ton while Jolex Construction sells her granite within the prices of 7,500 to 80,000 and makes a monthly profit of 295,000 at total volume of 9,000 tons per month with a unit price of 5,200 for sizes of 1/2 inch, 3/4 inch, 3/8 inch, stone dust and makes a monthly profit of 4.75 mm sieve and also, are predominately retained on the 75μm sieve.

Conclusions: Quarry business is quite capital intensive but with the right managerial scheme, it can be a very profiting business.

Keywords: Quarry, Surface Mining, Crushing, Blasting, Aggregate.

BACKGROUND

According to Ashmole & Motloung (2008), Quarry operation is a common surface mining activity in both Nigeria and all over the world. This involves the production of aggregates and dimension stones for the purpose of construction, ornamental and interior decoration. Rocks such as granite, limestone, marble, dolomite etc. are exploited for extraction of material into a vehicle for transport (hauling), processing and economical working of granite quarries depends on the reason(s) behind the incessant folding up of quarry business in Nigeria through comparative study between Afrimine Quarry and Jolex Construction.

The successful a granite quarry layout, equipment productivity, alternative production schedules, and quarry operating requirements. These requirements include the explosive usage per year, the number of person required, and the fuel usage per machine per operating hour. This component of a quarry plan will be unchanged whether project is economical or not as they basically referred to as the fixed input.

The technical component as explained by (Dolley, 2008) also defines all of the important elements required for the implementation of a quarry project but (Jamie, 2000) narrowly focused on the economic component which includes the operating and capital cost to the technical schedules in a quarry. The alternative schedules and alternative equipment in economic terms can be seen from the price per tonnage in production of aggregates in a quarry. It also builds up and examines unit costs, such as the fuel cost per liter, annual fuel cost for the whole mine, and labor cost per person per year.

Granite Quarrying Operations

The successful and economical working of granite quarries depends upon an intelligent application of knowledge of the structure of the rock and its natural divisions in the mass, as well as upon improved methods, tools, and machinery for quarrying. The topographical location of the quarry and its relation to facilities for transportation are important factors that affect the productiveness and greatly modify the actual cost of operations in a given place (Alaba and Agbalajobi, 2012).

Classification of Aggregate

According to Zongjin (2014), aggregates can be divided into several categories according to different criteria.

In accordance with sizes:

Coarse aggregate: The coarse aggregate is on the 4.75 mm sieve. For mass concrete, the maximum size can be as large as 150 mm.

Fine aggregate (sand): The fine aggregates are those that pass through the 4.75 mm sieve and also, are predominately retained on the 75μm sieve.
In Accordance with Sources:

Natural aggregates: This kind of aggregate is taken from natural deposits without changing their nature during the process of production.

Manufactured aggregates: This is man-made materials produced as a main product or as an industrial by-product. Examples are blast furnace slag, lightweight aggregate.

Stages Involved in Aggregate Production

The sequence of unit operation is utilized to accomplish mine exploitation and this is also called the cycle operation (Sharma, 2012). Aggregate production involves various stages which includes the following:

1. The development of the quarry by taking the coordinate of the site
2. Stripping Operation
3. Drilling Operation
4. Stemming Operation
5. Blasting (its accessories)
6. Mucking and loading

Development and Planning of the Mine

Mine development involves the excavations needed to establish the infrastructure necessary for stope production and to prepare for the future continuity of operations. The planning of the mine site is done by the Mine Engineer and other partnering professionals involved in the process.

Stripping Operation

Sharma, (2012) explains Stripping Operation as the process of removing overburden (waste material) from the surface of the mine site in order to reveal the underlying ore body. If the overburden is much and the cost of removal is at the high side, such operation is seen as unprofitable for the miner. The overburden is stripped with an excavator and is placed in large dump trucks known as haul trucks. Haul trucks are designed for earth moving across rugged environment.

Overburden is a waste rock consisting of consolidated and unconsolidated material that must be removed to expose the underlying ore body. It is desirable to remove as little overburden as possible in order to access the ore of interest.

Drilling Operation

Drilling can be define as an artificial creation of cavity or hole in an ore body for sample collection, further analysis, casing sinking and for placement of explosives. Drilling is very important in mining and it determines the cost of production. Some factors influencing the rate of bit penetration includes: type and size of drill, bit size; bit type and condition, drill mounting torque capacity, compressor pressure, flushing medium, lubrication, thrust, rotational speed, rock type and structure. (Sharma, 2012)

Blasting Operation

Sharma, (2012) reported that Blasting is defined as a fragmentation of rock by means of explosives and its accessories for the subsequent extraction or process. After the blast holes have been drilled to the requirement, the next operation is to charge the holes with explosives and blast. The size of the drilling bit is a major factor in the choice of explosive to be used.

Loading

After blasting operation has been carried out, the fragmented rock materials are usually loaded into dump trucks and tippers. Both front-end loader and backhoe shovel are used for loading fragmented rock materials into dump trucks for haulage.

Haulage of Material

The fragmented rocks are transported by haulage truck (primarily horizontal movement) to the primary crusher. As the blasting cannot be absolutely perfect, boulders bigger than the normal requirement (1.5m) are kept aside for secondary blasting so that they can pass through the hopper to the jaw crusher.

Crushing Process

Crushing is the process of reducing blasted rocks into smaller sizes needed for use such as in construction of bridges, tunnels, roads and building activities (Hadin, 2001). Crushing of fragmented rocks are unit of comminution and particle sizing. The crushing plant is an assemblage of primary crusher and secondary crusher. The following product sizes (granite) can be obtained by methods of screening immediately after crushing.

Development of the Quarry

In order for quarrying operations to be actively productive, the quarry needs to be well developed such as the introduction of a good watering / de-watering system. A good electrical system, various offices which stand as the administrative wing, a good magazine and other needed infrastructure.

METHODS

Reconnaissance Survey of the Study Area

The reconnaissance survey of the study area was carried out to obtain information by visual observation and use of administered questionnaire to explore site conditions. The main purpose of this survey is to determine the geology, topography, agricultural trends, weather conditions and terrain and accessibility of the study areas.

Location and Accessibility

Afri-Mine quarry is located at Jos-South, Plateau State around Mararaba’n Jama’a. It has coordinates between latitudes N09º 40’00” – N09º 44’00” and longitude E08º 51’00” – E08º 55’00”. (Offiah et al, 2011). Jolex construction company is located at Bassa L.G.A between latitude N10º 02’44”-N10º 02’44” and longitude E08º 51’20”-E08º 51’24”. The both quarries have good accessibility. Figure 1 shows the study area below.

Instrument / Materials Used for data Collection

The instrument and materials used for this research include:

1. A Global Positioning System (GPS) was used for taking coordinates
2. Recording notebook was used for jotting down various observations in the quarry.
3. Digital camera

Methods

Determination of the Unit of Operation in Both Quarries

The unit of operation in this research was obtained through daily observation and the use of questionnaire that was administered to the various staff in both Afrimine quarry and Jolex Construction; data that concerned each unit was obtained through the company’s administration. The units of operation include drilling unit, blasting unit, loading and hauling unit, crushing unit, processing and sales unit. The obtained data from each unit was analyzed using tables and charts.

Determination of Overall Production

At Afrimines quarry, production of aggregate is 625 tons per day, and they work for six (6) days in a week, hence in a week they produce:

\[
625 \text{tons/d} \times 6 \text{days/wk} = 3750 \text{tons/wk}
\]
In a month; 
\[ 3750(\text{tons}) \times 4(\text{weeks}) = 15,000\,\text{tons/month} \]

At Jolex quarry, production of aggregates is 375 tons per day, they work for six (6) days in a week, hence in a week they produce:
\[ 375(\text{tons}) \times 6(\text{days}) = 2,250\,\text{tons} \]

In a month;
\[ 2,250(\text{tons}) \times 4(\text{weeks}) = 9000\,\text{tons/month} \]

Determination of the Overall Production Cost of Aggregates in Both Quarries

The determination of the various production in both Afrimine and Jolex construction was calculated on 15,000 tons of aggregate production from Afrimine quarry per month and 9,000 tons of aggregate production from Jolex construction per month. The mathematical equations used for the calculation of unit production of aggregates per month are:

**Average Production Cost Per Ton (APCT):** This helps to give an average of the prices of various aggregates produced in the quarry.

\[ \text{APCT} = \frac{\text{Production Cost}}{\text{Total number of Output}} = 3.1 \]

**Average Production Cost of total aggregate in a month (APCTAM):**
This equation helps to tell the total amount of aggregate produced in a month. It is gotten by multiplying the cost per ton by the total amount of aggregates produced in a month.

\[ \text{APCTAM} = \text{TCPT} \times \text{TAAM} - 3.2 \]

Where TCPT= Total Cost Per Ton

TAAM= Total Amount of aggregates produced in a month

**Positive Contributions per month (PCM):** This gives the profit made in a month from a quarry. It is calculated using the equation below:

\[ \text{PCM} = \text{TPV} - \text{TMEQ} - 3.3 \]

Where TPV = Total Production in Volume

TMEQ = Total Month Expenses in a Quarry

**Cost Estimate and Profit/Loss Calculation**

Let Overall Cost = Production Cost + Government Revenue

\[ \text{Cost per tonne} = \frac{\text{Production Cost}}{\text{Total Output}} \]

Hence; Total Revenue = Output per annum \times Selling price per ton

Profit = Total revenue - Production Cost \[ \text{Percentage Profit} (PP) \]: This gave the percentage profit made by the both quarries in a month.

\[ PP = \frac{\text{Profit}}{\text{Cost profit}} \times 100 = 3.5 \]

**Percentage of particulars:** This gave the percentage difference of each particulars made by both quarries in a month. It helps to compare where each company spends more or less.

\[ \text{pop} = \frac{\text{particulars}}{\text{total production cost}} \times 100 \]

--- 3.6

Determination of the unit cost production of granite

The unit cost production is the total amount of expenses incurred by a company to produce a certain quantity of goods or services and then divide the total amount by the quantity produced i.e;

\[ U\text{COP} = \frac{\text{Total amount of expenses for production}}{\text{Total amount of quantity produced}} = 3.7 \]

The unit cost production is a crucial cost measure in operational analysis of a company. Identifying and analyzing a company’s unit cost is a quick way to check if a company is producing efficiently, which in turn helps to check/investigate the company viability.

**RESULTS**

The data obtained from Afrimine quarry and Jolex construction were critically analyzed, examined and processed. Statistical tools such as Bar chart, and tables were used to present the data and information as seen in Table 1, 2, 3, 4, 5, 6 but Figure 1 shows the location of the study area.

Using Eqn. 3.1 under Materials and Method,

\[ \text{APCT} = \frac{\text{Production Cost}}{\text{Total No. of Output}} \]

1 ton of aggregate = \[ \frac{\$5,200 + \$6,200 + \$5,200 + \$3,200}{4} \]
\[ = \$4,725 \]

From equation 3.2, \[ \text{APCTAM} = \text{TCPT} \times \text{TAAM} \]

For 15,000 tons produced by Afrimine per month

\[ = \$4725 \times 15,000 \text{tons} \]
\[ = \$70,875,000 \]

**Table 1: Income on Aggregate Production per month in Afrimine quarry**

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount for Afrimine (₦)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ton of aggregate</td>
<td>4,725</td>
</tr>
<tr>
<td>15,000 tons of aggregate</td>
<td>70,875,000</td>
</tr>
</tbody>
</table>

From equation 3.3 \[ \text{PCM} = \text{TPV} - \text{TMEQ} = \$6,485,859.375 \]

**Table 2: Positive Contribution on Aggregate Production per month in Afrimine**

<table>
<thead>
<tr>
<th>Items</th>
<th>Amount (₦)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Production Volume in Value</td>
<td>70,875,000</td>
</tr>
<tr>
<td>Less direct expenses and less cost of asset usage</td>
<td>34,389,140.625</td>
</tr>
<tr>
<td>Positive Contribution</td>
<td>36,485,859.375</td>
</tr>
</tbody>
</table>

But from \[ \text{Equation 3.5}, \text{PP} = \frac{\text{Profit}}{\text{Cost profit}} \times 100 \%

\[ = 36,485,859.375 \]
\[ = 106\% \]

**Afrimine Salary Structure**

Laborers are paid ₦60, 000 - ₦120,000 depending on the number of years in service and rank. The technical personnel are paid ₦50, 000 - ₦40,000, 000 monthly as salary but the total cost of man power on a monthly basis is ₦1,700, 000.

**Positive Contribution of Aggregates Production against its prices**

Figure 2 shows operating expenses on aggregate production per month against prices,

Figure 3 below shows the positive contribution of aggregates production against its prices while Figure 4 shows the prices of different aggregates
crushed in Afrimine. Figure 5 and 6 talks about salary structure in both Afrimine and Jolex quarry while Table 3, 4, and 5 shows different operating expenses in Jolex quarry.

Figure 2: Operating expenses on aggregate production per month against prices in Afrimine

Figure 3: Positive Contribution of Aggregates Production against its prices in Afrimine

Figure 4: Prices of Different Aggregates Crushed in Afrimine

AFRIMINE SALARY STRUCTURE

Table 3: Operating expenses on aggregate production per month at Jolex (2021 Expenses Break Down)

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Jolex (₦/month)</th>
<th>Percentage of particulars to total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salary</td>
<td>1,000,000</td>
<td>10.86</td>
</tr>
<tr>
<td>Drilling and Blasting</td>
<td>3,000,000</td>
<td>32.60</td>
</tr>
<tr>
<td>Diesel</td>
<td>1,763,000</td>
<td>19.15</td>
</tr>
<tr>
<td>Av. Maintenance</td>
<td>957,000.00</td>
<td>10.39</td>
</tr>
<tr>
<td>Land Rental</td>
<td>166,666.67</td>
<td>1.81</td>
</tr>
<tr>
<td>Lubricant</td>
<td>580,000.00</td>
<td>6.30</td>
</tr>
<tr>
<td>Cost of Equipment</td>
<td>1,000,000</td>
<td>10.86</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>300,000.00</td>
<td>3.26</td>
</tr>
<tr>
<td>Total (VAT)</td>
<td>8,766,666.67</td>
<td>95.24</td>
</tr>
<tr>
<td>5% VAT</td>
<td>438,333.33</td>
<td>4.76</td>
</tr>
<tr>
<td>Total</td>
<td>9,205,000.00</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4: Jolex Construction prices for different sizes of aggregate in Jolex

<table>
<thead>
<tr>
<th>Aggregate type</th>
<th>Jolex (₦/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4 inch</td>
<td>8000</td>
</tr>
<tr>
<td>½ inch</td>
<td>8000</td>
</tr>
<tr>
<td>3/8 inch</td>
<td>7000</td>
</tr>
</tbody>
</table>
Table 5: Income of aggregate per month in Jolex

<table>
<thead>
<tr>
<th>Items</th>
<th>Amt of Tons of aggregate for Jolex Constr. (₦)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ton of Aggregate</td>
<td>7500</td>
</tr>
<tr>
<td>9,000 tons of aggregate</td>
<td>67,500,000</td>
</tr>
</tbody>
</table>

Table 6: Positive Contribution on Aggregate Production per month in Jolex

<table>
<thead>
<tr>
<th>Items</th>
<th>Amount for Jolex(₦)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total prod. in value</td>
<td>67,500,000</td>
</tr>
<tr>
<td>Less expenses</td>
<td>9,205,000.00</td>
</tr>
<tr>
<td>Positive contribution</td>
<td>58,295,000</td>
</tr>
</tbody>
</table>

Using equation 3.3, \( PCM = TPV - TMEQ = ₦58,295,000 \)

Table 7: Afrimine prices for different sizes of aggregate

<table>
<thead>
<tr>
<th>Items</th>
<th>Prices (₦)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 inch</td>
<td>5,200</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>5,200</td>
</tr>
<tr>
<td>1 1/2</td>
<td>5,200</td>
</tr>
<tr>
<td>Stone Dust</td>
<td>3,300</td>
</tr>
</tbody>
</table>

DISCUSSION

Figure 2, Figure 3, Figure 4, Figure 5 and Figure 6 shows the operating expenses on aggregate production per month at Afrimine Quarry and Jolex Construction which includes; salary paid to the workers per month, Explosive used per month for blasting operation, lubrication used for the equipment, Diesel used for the equipment, Average cost of maintaining the quarry site, Land rental of the quarry, plotted prices of different aggregate in Afrimine and 5% VAT, which are used to derive the cost incurred or less direct expenses from the operating expenses per month. Table 4 and Table 7 shows the various prices of the different aggregate sold in Afrimine and Jolex Construction.

CONCLUSIONS

This research examines the unit production cost of granite in Afrimine Quarry and Jolex Construction sited in Plateau State Nigeria. The results revealed that the total production of aggregates in value is ₦70,875,000 for every 15,000 tons crushed per month at Afrimine Quarry but the positive values of profit made in a month sums up to ₦36,484,859.375 which was observed that the unit production cost for Afrimine quarry is ₦2,291.61/ton but Jolex Construction makes the sum of ₦67,500,000 for every 9,000 tones crushed per month but has a monthly positive profit of ₦102,778 N/ton.

After the research on both quarries it was observed that the unit production cost of Afrimine quarry was ₦2,291.61/ton and that of Jolex as ₦102,778/ton, and the total production cost of Afrimine quarry was ₦1,022.78/ton.
34,389,140.63/month and that of Jolex was ₦9,205,000/month. For every 15,000tons of aggregate, Afrimine quarry spends ₦70,875,000 and gets a profit of ₦36,485,859.38 whereas Jolex Construction quarry spends ₦67,500,000 to produce 9,000 tons of aggregates and get a profit of ₦58,295,000.

Therefore, one can conclude that Jolex construction quarry makes more profit than Afrimine quarry due to lower production cost on drilling and blasting but they can make more if they also increase production while Afrimine spends more money on drilling and blasting because they give this operation to a third party thereby splitting their profit.

Quarries if properly managed, can be a very profitable business.

**RECOMMENDATIONS**

Some of the recommendations suggested after the research include:

i. Quarrying activity would yield more if there are better managerial approach to the operation.

ii. Increase in man-power leads to increase in productivity

iii. Jolex construction Quarry should consider increasing their production in order to increase profit.

iv. Drilling and blasting operation in a quarry should be done in-house by the staff instead of inviting a third party hence creating room for more expenses.

**List of abbreviations:**

(a) APCT: Average Production Cost Per Ton  
(b) APCTAM: Average Production Cost of total aggregate in a month  
(c) PCM: Positive Contributions per month  
(d) TPV = Total Production in Volume  
(e) TMEQ = Total Month Expenses in a Quarry  
(f) PP: Percentage Profit Declarations  
(g) UCOP: Unit cost of production

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**Availability of data and materials:** Not applicable

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