ECONOMIC APPRAISAL OF RIGID PAVEMENT IN ROAD CONSTRUCTION

(A Case Study of Investment appraisal of concrete grade 40 as a pavement material)

By Michael A.A. Okae Adow, Boris K. Sasraku-Neequaye and Seth Emmanuel Allotey.

All Lecturers of Department of Building Technology, Accra Polytechnic, Accra.

Correspondence: bsasrakuneequaye@yahoo.com

ABSTRACT

Roads and Highways are vital lifelines. Roads are needed for accessibility and for transporting of people, goods and services. Roads are therefore needed for socio-economic purposes. This research aims at assessing the suitability of concrete grade 40 as a suitable pavement material. The objectives of the research are as follows; to carry out investment appraisal on road project undertaken using concrete pavement, to determine the initial cost of concrete grade 40 pavement and to determine the lifecycle of cost of concrete grade 40 pavement. Findings were as follows; the initial cost of rigid concrete grade 40 is GH¢1,416,809.10/Km and the lifecycle cost is GH¢1,511,189.84/Km. Investment appraisal methods gave the following results; Simple payback period is 3.105 years, Discounted payback period is 10years 3months, Net Present value is GH¢4.11 million, Average Rate of Return is 32.02%, Profitability Index is 1.0726 and Present Worth is GH¢ 60.4457 million.

Keywords: Road, Highway, Economic Appraisal, Pavement.

INTRODUCTION

Road is a hard surface built for vehicles to travel on (Oxford Advance Learner’s Dictionary, 2001). Road is also defined as a specially designed hard surface for cars, buses, bicycles, etc to travel on. The new Encyclopaedia Britannica (2003), defined the term street, road and highway as those travelled ways on which people, animals and wheeled vehicles have moved throughout recorded history.

The World book Encyclopaedia (1988), defined a road as a strip of land that provides routes for travel by automobiles and other wheeled vehicles.

World books Encyclopaedia (1988), roads usually connect urban areas with each other and rural areas. Roads are needed for accessibility. Farmers use them to ship their products to the markets. Trucks can carry manufactured products from one area to another. Good roads carry millions of automobiles that travel on business and pleasure.
Robinson et al (2004), most roads are built to facilitate the transport of people and goods, and so as to promote development. Road forms an important part of the social safety net facilitating the distribution of wealth through trade and employment opportunities in both rural and urban communities. Road also facilitates the movement of people, goods and services in all sectors for the economy, including tourism, mining, health, trade, education and agriculture. Roads are needed for socio-economic purposes. Economies and society depend heavily on efficient roads.

In the European Union, 44% of all goods are moved by trucks over roads and 85% of all people are transported by cars, buses or coaches on roads according to the European Commission (2007). Road transport remains one of the strategic sectors of Ghana’s economy (Ghanaweb, 2013). Emmit and Gorse (2003), Stated that the principal requirements of a facility includes; shelter, safety and comfort, ease of use and operation, ease of maintenance, periodic repair and replacement, adaptability and durability, ability to recycle materials and components.

The overall goal is to achieve these goals in an economic, safe and timely fashion using the most appropriate resources available.

Most roads are constructed by Government. Government include Central government, Local government and Government agencies. Most roads are constructed and cared for by the state. Government helps the states and agencies pay the cost of building and improving the roads. In Ghana, the Ministry of Road and Highway is the Government of Ghana ministry responsible for road construction and maintenance. The vision of the ministry is to provide and maintain and integrate, cost effective, safe and sustainable road network responsive to the need of users, supporting growth and poverty reduction.

In Ghana, roads are classified as national roads, regional roads and inter-regional roads. The roads are also classified based on the department managing them. These are Highways, Urban roads and feeder roads. Roads can also be classified as first class roads, second class roads and third class roads.

World book Encyclopaedia (1988), classified roads as surfaced and unsurfaced roads based on the type of surface. Roads are also classified as local and secondary roads and primary highways. Local roads carry traffic within a local area.

Secondary roads link small communities and connect local roads to main highways leading to distant places.

Primary highways are the most important roads. Generally, primary highways are the main roads and connect the larger communities. Other classifications of roads are free ways (super highways) and express ways. Roads within towns and cities are called streets.

Road surface or pavement is the durable surface materials laid down as an area intended to sustain vehicular or foot traffic, such as a road or walkway (Wikipedia, 2015).

Pavement is the surface of a road, or a flat part at the side of a road for people to walk or any area of flat stones on the ground. (Oxford Advanced Learner’s Dictionary, 2001). Pavement materials include concrete, asphalt, stone such as flagstone, cobblestone, and sett, artificial stone, bricks, tile and wood. (Seeley, 1993).
Seeley (1993), classified pavement into two categories, flexible pavement and rigid pavement. Paquette and Wright (1987), categorised pavements into rigid, flexible and composite.

**AIM**

The research aims at assessing the suitability of using concrete grade 40 as a pavement material.

**OBJECTIVES**

i. To determine the initial cost of concrete grade 40 pavement

ii. To determine the lifecycle of cost of concrete grade 40 pavement

iii. To carry out investment appraisal on road project undertaken using concrete grade 40.

**METHODOLOGY**

Primary and secondary sources of data were employed. This was achieved through informal interviews with professionals at Ghana Highways Authority, Department of Feeder Roads, and Urban Roads, Literature review of previous theses, journals and books.

As part of the data collection to determine the cost of rigid pavement (concrete grade 40 pavement), a road of length one kilometre (1km) and width 10 meters was used as basis for the analysis. The profile of the road was based on a design. Measurement of the road was done and bill of quantities produced. The cost of the road project is then determined from the Bill of Quantities.

**DETAILED APPROACH**

A. Quantities Obtained from the measurement

1. Oversite Excavations – 3,000m$^3$

2. Disposal of Excavated materials offside – 3000m$^3$

3. Compacting buttons of excavations – 10,000m$^2$

4. Crushed rock/stone base 150mm thick – 10,000m$^2$

5. Compacting crushed stone base – 10,000m$^2$

6. Blinding layer - 10,000m$^2$

7. Polythene layer - 10,000m$^2$

8. Concrete Grade 40, 150mm thick – 1500m$^3$

9. Dowel bars - 4,465kg
10. Fabric Reinforcement  - 10,000m²

11. Toppings 25mm thick  - 10,000m²

12. Power Float  - 10,000m²

13. Wood for expansion Joint  - 6m³

14. Sealant for expansion joints  - 6m³

15. Formwork  - 303m²

**COST OF RIGID PAVEMENT USING CONCRETE GRADE 40**

The cost is obtained by multiplying the various quantities by their respective rates and summing.

**Amount in GH¢**

1. Oversite excavation 300m² @ GH¢4/m²  ..........  12,000.00
2. Disposal of excavated materials 300m² @ GH¢10/m²  ..........  30,000.00
3. Compacting bottoms of excavation 10,000m² @GH¢2/m²  20,000.00
4. Consoled stone base 10,000m² @ GH¢10.50/m²  105,000.00
5. Blinding layer 50mm thick, 10,000m² @ GH¢ 6.00/m²  60,000.00
6. Polythene sheet 10,000m² @ GH¢3.00/m²  30,000.00
7. Concrete Grade 40, 1,500m³ @ GH¢450/m³  675,000.00
8. Dowel bars (20mm bar) 4,465kg @ GH¢3.80/m²  16,967.00
9. Fabric Reinforcement 10,000m² @ GH¢3.80/m²  160,000.00
10. Taping 25mm thick mater 10,000m² @ GH¢19/m²  190,000.00
11. Power floating of concrete bed 10,000m² @ GH¢2/m²  20,000.00
12. Wood for expansion Joint 6350m @ GH¢3/m  19,050.00
13. Sealant for expansion Joint 6m² @ GH¢120/m²  720.00
14. Formwork 303m² @ GH¢35/m²  10,605.00

Sub – Total  1,349,342.00

Add 5% for Preliminaries  67,467.10

**TOTAL COST**  GH¢1,416,809.10
Cost per kilometre = \[
\frac{\text{Total cost}}{\text{Total length}} = \text{GH¢ 1,416,809.10}
\]

Cost per kilometre = \text{GH¢ 1,416,809.10}

**B. To determine the lifecycle costs of concrete Pavement (per kilometre)**

*Using concrete Grade 40*

**Data**

i. Initial cost = \text{GH¢1,416,809.10}

ii. Lifespan = 40 years

iii. Interest rate = 30% per annum

iv. Maintenance cost per kilometre = 2% of initial cost per annum

\[
\text{Maintenance cost per kilometre} = \frac{2}{100} \times \text{GH¢1,416,809.10} = \text{GH¢28,336.18 per annum}
\]

v. Summation of all Present values (ΣPV)

\[
\Sigma PV = 1 + \frac{1}{1.30} + \frac{1}{1.30^2} + \frac{1}{1.30^3} + \frac{1}{1.30^4} + \ldots + \frac{1}{1.30^{40}}
\]

\[
\Sigma PV = 3.33075
\]

v. Lifecycle cost per kilometre = annual maintenance cost x ΣPV lifecycle cost per kilometre = \text{GH¢28,336.18 x GH¢3.33075} = \text{GH¢94,380.74 per kilometre}

vii. Total lifecycle cost = initial cost + lifecycle cost (per kilometre)

\[
\text{Total lifecycle cost} = \text{GH¢1,416,809.10} + \text{GH¢94,380.74 (per kilometre)} = \text{GH¢1,511,189.84 (per kilometre)}
\]

**C (i) Cost of constructing the Highway (motorway) using Grade 40 concrete as pavement material.**

The Highway is 20km long, Dual carriageway and in both directions

\[
\text{Cost of Road} = 2 \times 20\text{km} \times \text{GH¢1,416,809.10/km} = \text{GH¢56,672,364.00}
\]
(ii) Maintenance cost per annum = 2% Total cost

Maintenance cost per annum = \( \frac{2}{100} \times \text{GH\c¥56,672,364.00} \)

Maintenance cost per annum = GH\c¥1,133,447.28

(iii) Return on Investment

Annual revenue (income) from Road Toll (A)

A = Number of vehicles \times \text{charge per vehicle} \times \text{Number of days}

A = 50,000 \times \text{GH\c¥1.00} \times 365

Annual Revenue (A) = GH\c¥18,250,000.00

D. Investment Appraisal

(i) Using the Simple Payback method

Number of years = \( \frac{\text{Initial Investment}}{\text{Annual returns}} \)

Number of years = 3.105 years = 3 years 1 month

(ii) Using the Discounted Payback Method (i = 30% P.a.) Table 1

<table>
<thead>
<tr>
<th>Year</th>
<th>Returns (GH\c¥ millions)</th>
<th>D.C.F.</th>
<th>NPV (GH\c¥ millions)</th>
<th>Cumulative NPV (GH\c¥ millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(56.672)</td>
<td>1.0000</td>
<td>(56.672)</td>
<td>(56.672)</td>
</tr>
<tr>
<td>1</td>
<td>18.25</td>
<td>0.76923</td>
<td>14.0384</td>
<td>(42.6336)</td>
</tr>
<tr>
<td>2</td>
<td>18.25</td>
<td>0.59172</td>
<td>10.7989</td>
<td>(31.83471)</td>
</tr>
<tr>
<td>3</td>
<td>18.25</td>
<td>0.45517</td>
<td>8.30685</td>
<td>(23.52786)</td>
</tr>
<tr>
<td>4</td>
<td>18.25</td>
<td>0.35013</td>
<td>6.38987</td>
<td>(17.13799)</td>
</tr>
<tr>
<td>5</td>
<td>18.25</td>
<td>0.26933</td>
<td>4.91527</td>
<td>(12.22272)</td>
</tr>
<tr>
<td>6</td>
<td>18.25</td>
<td>0.20718</td>
<td>3.78103</td>
<td>(8.44169)</td>
</tr>
<tr>
<td>7</td>
<td>18.25</td>
<td>0.15937</td>
<td>2.9085025</td>
<td>(5.5331875)</td>
</tr>
<tr>
<td>8</td>
<td>18.25</td>
<td>0.12259</td>
<td>2.23727</td>
<td>(3.2959175)</td>
</tr>
<tr>
<td>9</td>
<td>18.25</td>
<td>0.09430</td>
<td>1.720975</td>
<td>(1.5749425)</td>
</tr>
<tr>
<td>10</td>
<td>18.25</td>
<td>0.072538</td>
<td>1.3238185</td>
<td>(0.251124)</td>
</tr>
<tr>
<td>11</td>
<td>18.25</td>
<td>0.05580</td>
<td>1.01835</td>
<td>0.767226</td>
</tr>
<tr>
<td>12</td>
<td>18.25</td>
<td>0.042922</td>
<td>0.7833265</td>
<td>1.5505525</td>
</tr>
<tr>
<td>13</td>
<td>18.25</td>
<td>0.033017</td>
<td>0.60256025</td>
<td>2.15311275</td>
</tr>
</tbody>
</table>

Payback period (Time) = 10 years + \( \frac{0.251124 \times 12 \text{ months}}{1.01835} \)

www.ijaert.org
Payback period (Time) = 10 years + 2.96 months

Payback period (Time) = 10 years 3 months

(iii) **Net Present Values**

For a period of 40 years, the summations of all the present values = 3.33075. Given that interest rate is 30% p.a.

Total NPV = Gross present values – Initial investment

Total NPV = [(3.33075)(GH¢18.25m) – GH¢56.672m]

Total NPV = [GH¢60.786m – GH¢56.672m]

Total NPV = GH¢4.11 million

(iv) **Average Rate of Return (ARR)**

\[
\text{A.R.R.} = \frac{\text{Average returns} \times 100\%}{\text{Initial investment}}
\]

\[
\text{A.R.R.} = \frac{\text{GH¢18.25m} \times 100\%}{\text{GH¢56.672m}} = 32.203\%
\]

(v) **Profitability Index**

\[
\text{Profitability Index} = \frac{\sum \text{Benefits}}{\sum \text{Initial investment}}
\]

Profitability Index = \[
\frac{\text{GH¢60.786m}}{\text{GH¢56.672m}} = 1.0726
\]

(vi) **Present Worth (PW)**

Present worth = Initial cost - Present values of all maintenance of 40 years

\[
\text{PW} = \text{GH¢56.672m} + \text{GH¢1.133m}(3.33075)
\]

\[
\text{PW} = \text{GH¢56.672m} + \text{GH¢3.7737m} = \text{GH¢60.4457m}
\]

**Comments and Analysis.**

<p>| Table 2 |
| --- | --- | --- | --- |
| item | Description of works | Amount (GH¢) | Percentage of Total (%) |
| 1 | Oversite excavation | 12,000.00 | 0.85 |
| 2 | Disposal of Excavated material | 30,000.00 | 2.12 |
| 3 | Compaction of bottoms of Excavations | 20,000.00 | 1.41 |</p>
<table>
<thead>
<tr>
<th>4</th>
<th>Crushed Stone base</th>
<th>105,000.00</th>
<th>7.41</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Blinding layer</td>
<td>60,000.00</td>
<td>4.24</td>
</tr>
<tr>
<td>6</td>
<td>Polythene Sheeting</td>
<td>30,000</td>
<td>2.12</td>
</tr>
<tr>
<td>7</td>
<td>Concrete Grade 40</td>
<td>675,000.00</td>
<td>47.64</td>
</tr>
<tr>
<td>8</td>
<td>Dowel bars</td>
<td>16,967.00</td>
<td>1.20</td>
</tr>
<tr>
<td>9</td>
<td>Fabric Reinforcement</td>
<td>160,000.00</td>
<td>11.29</td>
</tr>
<tr>
<td>10</td>
<td>Toppings 25mm thick mortar</td>
<td>190,000.00</td>
<td>13.41</td>
</tr>
<tr>
<td>11</td>
<td>Power Floating</td>
<td>20,000.00</td>
<td>1.41</td>
</tr>
<tr>
<td>12</td>
<td>Wood for expansion Joint</td>
<td>19,050.00</td>
<td>1.34</td>
</tr>
<tr>
<td>13</td>
<td>Sealant for expansion Joint</td>
<td>720.00</td>
<td>0.05</td>
</tr>
<tr>
<td>14</td>
<td>Formwork</td>
<td>10,605.00</td>
<td>0.75</td>
</tr>
<tr>
<td>15</td>
<td>Preliminaries (5%)</td>
<td>67,457.10</td>
<td>4.76</td>
</tr>
<tr>
<td>16</td>
<td><strong>Total</strong></td>
<td><strong>1,416,809.10</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The analyses of the breakdown of the cost of works are given in Table 2 above. The major constituents are concrete works, toppings, fabric reinforcement, washed stone base, preliminaries. These constitute 47.664%, 13.41% 11.29%, 7.41% and 4.24% of the total cost of construction respectively.

**FINDINGS**

(i) Using Grade 40 concrete, the initial cost of one kilometre length of road is GH₵1,416,809.10

(ii) The lifecycle costs of concrete grade 40 pavement is GH₵1,511,189.84/km

(iii) The investment appraisal for the road project gave the following results:

(a) Using the simple payback method, the payback period is 3 years 1 month.

(b) Using the Discounted payback method, the payback period is 10 years 3 months

(c) The total Net Present value for the road project is GH₵4.11 million

(d) Using the average rate of return, the average rate of return is 32.203%

(e) The Present Worth (PW) for the road project is GH₵60.4457 million

**CONCLUSION**

All the objects have been met successful and the results were satisfactory. Hence the road project using concrete grade 40 is viable.

**RECOMMENDATION**

Hence the road project using concrete grade 40 can be undertaken and will be profitable.
REFERENCES


