ECONOMIC ANALYSIS OF FLEXIBLE PAVEMENT IN ROAD CONSTRUCTION

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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 economic suitability of asphalt pavement in road construction. The objective of the research is to carry out investment appraisal on road project undertaken using asphalt pavement and to determine its lifecycle costs and initial cost of construction. The findings were as follows ; the initial cost of the asphalt pavement was cheaper GHS 1,283,700.00 per kilometer. The lifecycle costs of asphalt pavement was GHS 1,931,807.12 per Kilometer. Investment appraisal methods were in favour of the asphalt pavement.

Keywords: Road, Highway, Investment Appraisal, Pavement.

I. 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 he 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.

Roads are constructed of either Bitumen(asphalt) or Concrete. In Ghana most roads are constructed with Bitumen, with the exception of the Accra-Tema motorway which is constructed with concrete.

AIM

The research aims at assessing the economic viability of using asphalt pavement in road construction.

II. OBJECTIVES

i. To determine the initial cost of asphalt pavement in roads.
ii. To determine the lifecycle costs asphalt pavement in road.
iii. To carry out investment appraisal on road project undertaken using asphalt pavement in roads.

III. 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 flexible pavement (asphalt 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.

The study compared the initial cost of asphalt pavement as well as their lifecycle costs.

IV. QUANTITIES OBTAINED FROM THE MEASUREMENT OF ASPHALT PAVEMENT.

1. Oversight Excavation – 3,000m^2
2. Compacting bottoms of Excavations - 10,000m^2
3. Crushed Stone base, 150mm thick – 1,500m^3
4. Asphalt pavement, 150mm thick – 10,000m^2
5. Wearing Course (asphalt), 25mm thick – 10,000m^2

V. COST OF ASPHALT PAVEMENT

Amount in GH₵

1. Oversite Excavation 3000m3 @ GH₵ 4.00/m3 - 12,000.00
2. Disposal of excavated material 3000m^3 @ GH₵ 10.00/m^2 - 30,000.00
3. Compacting bottoms of excavation 10,000m^2 @ GH₵ 2.00/ m^2 – 20,000.00
4. Crushed Rock/Stone base 10,000m^2 @ GH₵ 10.50/m2 –105,000.00
5. Asphalt pavement 150mm thick, 10,000m^2 @ GH₵70.00/m^2 – 700,000.00
6. Wearing course 10,000m^2@ GH₵30.00/m^2 – 300,000.00

Sub-Total GH₵1,167,000.00

Add 10% of Preliminaries GH₵ 116,700.00

Total Cost **GH₵1,283,700.00**

$$\text{Cost per Kilometer} = \frac{\text{Total Cost}}{\text{Total Length}} = \frac{\text{GH₵1,283,700.00}}{\text{1 Km}} = \text{GH₵1,283,700.00/km}$$

TO DETERMINE THE LIFECYCLE COST OF ASPHALT PAVEMENT (PER KILOMETER)

Data

(i) Initial cost – GH₵1,283,700.00/km
(ii) Lifespan - 20 years (with replacement)
(iii) Interest rate - 30% per annum
(iv) Maintenance cost per kilometer = 15% of initial cost per annum.

Maintenance cost per kilometer = 15/100 x GH₵1,283,700.00 per annum.

Maintenance cost per kilometer per annum = GH₵192,555.00

(v) Present value of the reconstruction cost

$$PV \quad \frac{\text{Cost of reconstruction}}{1.30^{20}} = \frac{\text{GH₵1,283,700}}{1.30^{20}} = \frac{\text{GH₵ 6,754.55}}{}$$

(vi) Summation of all Present values $\sum$ PV = 3.33075

(vi) Lifecycle cost = annual maintenance cost x ∑PV per kilometer
Lifecycle cost = GH₵192,555.00 x 3.33075
Lifecycle cost = GH₵ 641,352.57

(vii) Total lifecycle cost = initial + reconstruction + lifecycle
(Per Kilometer) cost cost cost per km
Total lifecycle cost = GH₵ 1,283,700.00 + GH 6,754.55 + GH₵ 641,352.57 (per km)
Total lifecycle cost = **GH₵1, 931,807.12 (per kilometre)**

VI. COST OF CONSTRUCTING THE HIGHWAY (MOTORWAY) USING ASPHALT

(i) Length of road = 20 kilometer, Dual carried way
Cost of motorway = 2 x length x cost per kilometer

Cost of motorway = 2 x 20 kilometer x GH₵ 1,283,700.00
Cost of motorway = GH₵51,348,000.00

(ii) Maintenance cost per annum = 15% of Total cost
Maintenance cost per annum = 15/100 x GH₵ 51,348,000.00
Maintenance cost per annum = GH₵7,702,200.00

(iii) Return on Investment
Annual revenue = Number of Vehicles x Charge per Vehicles x Number of Days
Annual revenue = 66,000 x GH₵1.50 x 365
Annual revenue = GH₵ 36,135,000.00 = GH₵ 36.135m

VII. INVESTMENT APPRAISAL OF ASPHALT PAVEMENT

(i) Using the simple pay back method
Number of years = Initial investment / Annual returns = GH₵ 51,348,000.00 / GH₵ 36,135,000.00

Number of years = 1.421years = **1 year 5months**

(iii) Using Discounted Payback method. (i = 30% per annum)

Table 1

YEARS	RETURNS (GH₵ MILLION)	D.C.F	NPV (GH₵ MILLION)	CUMULATIVE NPV (GH MILLION
0	(51.348)	1.0000	(51.348)	(51.348)
1	36.135	0.78923	28.5188	(22.8292)
2	36.135	0.59172	21.3818	(1.4474)
3	36.135	0.45517	16.4476	15.0002
4	36.135	0.35013	12.6519	27.6521
5	36.135	0.26933	9.7322	37.3843
6	36.135	0.20718	7.4864	44.8707
7	36.135	0.15937	5.7588	50.6295
8	36.135	0.12259	4.4298	55.0593

Payback Period = 2 years + (1.4474 / 16.4476 x 12 months)
Payback Period = 2 years + 1.056 months

Payback Period = **2 years 1 month**.

(iv) Net Present Values

For a period of 40 years, the summation of all present values is 3.33075. Given that i = 30% per annum.
Total NPV = Gross Present values – Total investments.
The Asphalt pavement has a life of 20 years, therefore in 20 years time, the pavement must be reconstructed.
Hence the present values of GH₵ 51.348 million given an interest rate 30% per annum is GH₵270,182.04.
Total NPV = Gross Present values – Total investments.
Total NPV = (3.33075) (GH₵36.135million) – (GH₵51.348million + 0.2701million)
Total NPV = GHS 120.357m – GHS 51.618m
Total NPV = GHS 68.739 million.

(v) Average Rate of Return (ARR)

$$ARR = \frac{\text{Average returns}}{\text{Initial investment}} \times 100\% = \frac{GH₵36.135m}{GH₵51.348m} \times 100\%$$

A.R.R. = 70.373%.

(v) Profitability index = $\frac{\sum \text{Benefits}}{\sum \text{initial investment}}$

$$\text{Probability index} = \frac{GH₵\ 120.357million}{GH₵\ 51.618million} = 2.33$$

Present Worth (P W)

(i) Present worth for first 20 years

P W 1 = GH₵ 51.348 million + GH₵ 7.7022 (3.3158)
P W 1 = GH₵ 76.887 million

(ii) Present worth of asphalt pavement and replacement (PW2) = GH₵ 76.887 million (0.005261783)
P W 2 = GH₵0.4046million

Total P W = P W1 + P W2 = GH₵ 76.887million + GH₵0.4046 million

Total P W = GH₵ 77.2916 million

FINDINGS

(i) Using Grade 30 concrete, the initial cost of one kilometre length of asphalt road is GH₵1,283,700.00 per Kilometer.

(ii) The lifecycle costs of asphalt is GH₵1,931,807.12/km.

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

(a) Using the simple payback method, the payback period for Asphalt pavement is 1 year 5 months.

(b) Using the Discounted payback method, the payback period for asphalt pavement is 2 years 1month.

(c) The total Net Present value for the asphalt road project is GH₵ 68.739 million.

(d) Using the average rate of return, the average rate of return for the asphalt road project is 70.373%.

(e) The Present Worth (PW) for the asphalt road project is GH₵ 77.2916million.

CONCLUSION

1. In view of the findings, the road project in Asphalt pavement is economically viable.

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