ECONOMIC APPRAISAL OF CONCRETE PAVEMENT IN ROAD CONSTRUCTION (A CASE STUDY OF USING CONCRETE GRADE 30 AS A PAVEMENT MATERIAL)

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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 suitability of concrete grade 30 as a pavement material in road construction. The objectives of the research is to carry out investment appraisal on road project undertaken using concrete pavement, determine the lifecycle costs and their initial cost of road constructed using concrete grade 30. The findings were as follows ; the initial cost of the asphalt pavement was GHS 1,566,766.20 per kilometre. The lifecycle costs of concrete pavement was GHS 1,671,136.68. Investment appraisal methods were also favourable for the concrete 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. The cost of constructing asphalt roads continues to rise and this calls for alternative products which will serve the same purpose and function but will be less expensive and concrete has been suggested.

AIM

The research aims at assessing the suitability of using concrete grade 30 as a pavement material in road construction.

II. OBJECTIVES

i. To determine the initial cost of concrete grade 30 pavement and asphalt in roads.
ii. To determine the lifecycle cost of concrete grade 30 pavement.
iii. To carry out investment appraisal on road project undertaken using concrete grade 30 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 rigid pavement (concrete grade 30 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 concrete pavement as well as the lifecycle costs.

IV. QUANTITIES

Quantities Obtained from the Measurement of Concrete Pavement were as follows:

1.	Oversite excavation	-	3,000m^3
2.	Disposal of excavation material offsite	-	3,000m^3
3.	Compacting bottoms of excavations	-	10,000m^2
4.	Crushed Stone Base 150mm thick	-	1,500m^3
5.	Compacting of base		10,000m^2
6.	Blinding layer	-	10,000m^2
7.	Polythene layer	-	10,000m^2
8.	Concrete Grade 30, 150mm think	-	1,500m^3
9.	Dowel bars	-	4,465kg
10.	Fabric Reinforcement	-	10,000m^2
11.	Toppings 25mm thick (optional)	-	10,000m^2
12.	Power float	-	10,000m^2
13.	Wood for Expansion joint	-	6,350m
14.	Sealant for joint expansion	-	6m^3
15.	Formwork	-	303m^2

Cost of Concrete grade 30 Pavement	**Amount in GH¢**
1. Over site excavation 300m^3 @ GH¢ 4.00/m^3	12,000.00
2. Disposal of excavated material 300m^3 @ GH¢ 10/m^2	30,000.00
3. Compacting bottoms of excavations 10,000m^2 @ GH¢ 2/m^2	20,000.00
4. Crushed stone base 10,000m^2 @ GH¢ 10.50	105,000.00
5. Building layer 50mm thick 10,000m^2 @ GH¢ 6.00/m^2	60,000.00
6. Polythene sheet 10,000m^2 @ GH¢ 3.00/m^2	30,000.00
7. Concrete Grade 30, 15,000m^3 @ GH¢ 500.00/m^3	750,000.00
8. Dowel bar 4,465kg @ GH¢ 3.80/kg	16,967.00
9. Fabric reinforcement 10,000m^2 @ GH¢ 16.00/m^2	160,000.00
10. Toppings 10,000m^2 @ GH¢ 19.00/m^2	190,000.00

11. Power floating of concrete bed 10,000m^2 @ GH¢ 2.00/m^2		20,000.00
12. Wood for expansion joints 6,350m @ GH¢ 3.00/m		19,050.00
13. Sealant for expansion joint 6m^3 @ GH¢ 120.00		720.00
14. Formwork 303m^2 @ GH¢ 35.00		10,605.00
	sub - Total	GH¢ 1,424,342.00
	Add 10% preliminaries	GH¢ 142,434.20
	Total	**GH¢ 1,566,776.20**

Cost per kilometer = $\frac{\text{Total cost}}{\text{Total length}} = \frac{\text{GH¢ 1,566,776.20}}{\text{1km}}$

Cost per kilometer = GH¢ 1,566,776.20/km

To determine the lifecycle costs of the concrete pavement (per kilometer)

Lifecycle costs are the ultimate cost of the pavement.

Data

i. Initial cost = GH¢ 1,566,766.20(per kilometer)
ii. Lifespan = GH¢ 40 years
iii. Interest rate = 30% pa
iv. Maintenance cost per kilometer = 2% of initial cost
Maintenance cost per km = $\frac{2}{100}$ x GH¢ 1,566,766.20 = GH¢ 31,335,52
v. Summation of all present values ∑PV

$$\sum PV = \frac{1}{1.30^1} + \frac{1}{1.30^2} + \frac{1}{1.30^3} + \frac{1}{1.30^4} + \text{----------} + \frac{1}{1.30^{40}}$$

∑PV = 3.33075

vi. Total maintenance costs over 40 years = annual maintenance x ∑PV cost
Total maintenance costs over 40years = GH¢ 31,335.52 x 3.33075
Total maintenance costs = GH¢ 104,370.78 (per kilometer).
vii. Total cost = Initial cost + Total maintenance
Total lifecycle cost = GH₵1,566,766.20 + GH₵ 104,370.78
Total lifecycle cost = GH₵1,671,136.68 (per kilometer).

Cost of Constructing a Motorway using Concrete Grade 30

Cost of constructing a dual carriage motorway of length 20 kilometers

i. Cost of constructing concrete road (c)
C = 2 x 20 kilometers x GH₵1,566,766.20/km
C = GH₵62,670,648.00
ii. Maintenance cost per annum
Data
a. Maintenance cost = 2% of initial cost per annum
Maintenance cost = $\frac{2}{100}$ x GH₵ 62,670,648.00
Maintenance cost = GH₵1,253,412.96
b. Life of concrete pavement = 40 years
c. Interest on capital = 30% per annum

Returns on investment

Revenue per annum = Number of Vehicles x charge per Vehicle x number of days
Revenue per annum = 66,000 x GH₵1.50 x 365
Revenue per annum = GH₵36,135,000.00

Investment Appraisal

i. Simple Payback method

$$\text{Number of years} = \frac{\text{Amount invested}}{\text{Revenue per annum}} = \frac{\text{GH₵62,670,648.00}}{\text{GH₵ 36,135,000.00}}$$

Number of years = 1.73 years = **1 year 9months**

ii. Discounted Payback method

Table 1 : Interest rate = 30% per annum

Year	Returns (GH₵ millions)	D.C.F	NPV (GH₵ million)	Cumulative NPV (GH₵ million
0	(62.670)	1.0000	(62.670)	(62.670)
1	36.135	0.76923	27.7961	(34.8739)
2	36.135	0.59172	21.3818	(13.4921)
3	36.135	0.45517	16.4476	2.9555
4	36.135	0.35013	12.6519	15.6074
5	36.135	0.26933	9.7322	25.3396
6	36.135	0.20718	7.4864	32.826
7	36.135	0.15937	5.7588	38.5848
8	36.135	0.12259	4.4298	43.0146
9	36.135	0.09430	3.4075	46.4221

Payback period (Time) = 2 years + (13.4921 x 12 months)
16.4476
Payback period (Time) = 2 years + 9.84 months
Payback period (Time) = 2 years 10 months

iii. Net Present Values

For a period of 40 years, the summation of present values =3.33075. Given that interest rate is 30% per annum.
Total NPV = Gross present values – Initial investments
Total NPV = (3.33075) (GH₵ 36.1355m) - GH₵ 62.670m
Total NPV = GH₵ 120.357 - GH₵ 62.670m = **GH₵ 57.687m**

iv. Average Rate of Return (A.R.R)
A.R.R = Average returns x 100% = GH₵ 36.1355m x 100% = **57.66%**
Initial investment GH₵ 62.670m

v. Profitability Index
Profitability Index = ∑ Benefits
∑ Initial Investment

Profitability Index = GH₵ 120.357m = **1.92**
GH₵ 62.670m

vi. Present Worth (PW)

Data
a. Initial Cost = GH₵62.67 million
b. Lifespan = 40 years
c. Interest rate = 30% per annum
d. ∑ PV = 3.33075
e. Maintenance cost per annum = GH₵1.253 million
PW = initial cost + present values of all maintenance over 40 years
PW = GH₵ 62.67m + (GH₵1.253m) (3.33075)
PW = GH₵ 62.67m + GH₵ 4.1734m
PW = **GH₵ 66.8434 m**

V. ANALYSIS & COMMENTS

Construction of Rigid Pavement using Concrete Grade 30: **Table 2**

ITEM	DESCRIPTION OF WORKS	AMOUNT (GH₵)	PERCENTAGE OF TOTAL (%)
1	Oversite Excavation	12,000.00	0.77
2	Disposal of Excavation material	30,000.00	1.91
3	Compaction of bottoms of Excavation	20,000.00	1.28
4	Crushed Stone base	105,000.00	6.70
5	Blinding layer	60,000.00	3.82
6	Polythene Sheet	30,000.00	1.91
7	Concrete Grade 30	750,000.00	48.05
8	Dowel bars	16,967.00	1.08
9	Fabric reinforcement	160,000.00	10.21
10	Toppings	190,000.00	12.12
11	Power floating	20,000.00	1.28
12	Wood for Expansion Joint	19,050.00	1.22
13	Sealant for Expansion Joint	720.00	0.05
14	Formwork	10,605.00	0.68
15	Preliminaries (%)	142,434.20	9.09
16	Total	1,566,766.20	100.00

Analysis of the breakdown of the cost of construction is given Table 3 above.
The major components are concrete works, toppings, fabric reinforcement, crushed stone base and blinding layer. These elements constitute 48.05%, 12.12%, 10.21%, 6.70% and 3.82% respectively of the total cost of constructing the pavement.

VI. FINDINGS

(i) Using Grade 30 concrete, the initial cost of one kilometre length of road is GH¢1,566,766.20.
(ii) The lifecycle costs of concrete grade 30 pavement is GH¢1,671,136.68/km
(iii) The investment appraisal for the road project gave the following results:

(a) Using the simple payback method, the payback period for Concrete pavement is 1 years 9month.
(b) Using the Discounted payback method, the payback period for Concrete pavement is 2 years 10 months.
(c) The total Net Present value for the Concrete road project is GH¢ 57.687million .

(d) Using the average rate of return, the average rate of return for the Concrete road project is 57.66% .

(e) The Present Worth (PW) for the Concrete road project is GH¢66.8434 million.

CONCLUSION

1.In view of the findings, concrete grade 30 pavement can be used as a suitable pavement material.

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