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Cost and Benefit Analysis of Rigid and Flexible Pavement: A Case Study at Chancho –Derba-Becho Road Project

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Abstract: Road construction projects have been implemented all over Ethiopia as part of the national development plan. Roads are one of the country's basic infrastructural facilities where high amounts of budget allocated every fiscal year planning period. Since the cost comprises of a large portion of government investment, a careful evaluation of the alternatives is utmost importance to make the right choice for a particular project. In the history of Ethiopia road development program, almost all of the road pavements are flexible, and it demands high foreign currency for asphalt material importing from abroad. In addition, flexible pavement needs to be maintained and rehabilitated within a few years after its initial construction. In view of the emerging cement factories and the availability of cement in Ethiopia, it is practical to consider rigid pavement as one of the alternatives. Relative to this, the research project was conducted with the main objective of identifying the cost and benefit of rigid and flexible pavements at Chancho-Derba-Becho road project, North Showa Zone in Oromia. The research work had been focused on the specific objectives to determine and compare the life cycle costs of rigid and flexible pavements and to investigate all other qualitative merits of rigid and flexible pavement. To achieve these objectives, a review of related literatures, design and specifications, observations and investigations of the actual pavement construction projects, evaluation of life cycle costs, future value of money and present worth calculation were undertaken with an analysis period of 40 years. While the data considered was gathered through investigation at the actual rigid and flexible pavement projects, examination of specifications, drawings and pavement design, Ethiopian Road Authority manuals, rehabilitation and maintenance strategy. In this regard, the cost parameters investigated are initial construction cost, maintenance cost, rehabilitation cost, user's cost and salvage value, in addition to other qualitative and quantitative data. Based on the results of the research project, it revealed that the initial cost of rigid pavement was almost twice of the flexible pavement, but in the long run, the cost of flexible pavement per kilometer was found out to have 7.9 Million ETB more than the rigid pavement because of the incurring costs of maintenance through its design life. Therefore, it is suggested that Portland Cement Concrete Pavement (PCCP) shall be used in pavement construction to cater local material requirements.

Index Terms— Cost and Benefit Analysis, Initial Construction, Flexible and Rigid Pavement, Life Cycle Cost, Roads, Manitenance and Rehabilitation, Pavement Alternative

1 Introduction

In many countries with developed road networks, new road construction typically accounts of more or less 50% of the road budget. While the remainder of national road budgets is spent on maintenance and rehabilitation of existing roads. Long-life Pavements (LLP) project is approved if the costs of future maintenance, rehabilitation and the resulting road user delay costs are economically justified [8].

There has been historically difference of opinion as to whether Hot Mix Asphalt (flexible) pavements are more economical or less economical over time, than Portland Cement Concrete (rigid) pavements. Even experienced state highway agencies and highway engineers disagree on the subject [9].

Ethiopian has been undertaking massive development programs to eradicate the country's poverty problems and to bring up the country to the level of middle income countries in 2025 G.C. Aware of the road infrastructure development as the backbone and the blood artery for all economic, social progress, due emphasis has been given to the implementation of the Road Sector Development program (RSDP) since 1997 .

To execute such a very crucial project, large amount of budget will be allocated for the surfacing of pavements. Hence, it is important to go for careful evaluation of the alternatives in order to make the right choice before implementation of such projects.

In Ethiopia very few and short kilometer lengths of road projects are constructed with rigid pavement viz; in Oromia (Chancho-Derba-Bocho and Beseka road), Addis Ababa (Rehabilitation projects) and Tigray (Michew –Adigudem), of which Beseka and Addis Ababa rehabilitation projects were completed [10].

Even though there are newly emerging cement and reinforcement production factories in Ethiopia that can avoid foreign currency to buy materials for flexible pavement, only few and small scale concrete pavement projects have been undertaken in the country. Among these projects, Beseka Road, a one kilometer long which was considered the first cement concrete pavement in the history of the Ethiopian road construction project. In the last seventeen years (1997-2014 G.C), the total length of rigid pavement constructed was only 2.3 kilometers while about 99.9%

or 12,640 kilometers are flexible pavement [10].

Over the past 17 years, 41.2% of the total Ethiopian Road, Sector Development Program (RSDP) expenditures was allocated for the rehabilitation and upgrading roads, 28.8% for construction of link roads, 5.7% for maintenance of Federal roads, 8% of Regional road and 11.7% of Woreda roads, 2.8% of Institutional support projects, and other activities at the Federal level. During the last four years (2010-2014 G.C) RSDP accomplishment expenditure showed that 4.3 billion for rehabilitation, 4.8 billion for periodic and 0.7 billion for routine maintenance were utilized to Federal and Regional flexible pavement roads [4].

2 RESEARCH METHODOLOGY

2.1 Study Area

The project area is located in Oromia Regional State North of Showa zone. The project started at Chancho with coordinates of 472639E, 1028068N and 2608m above mean sea level, located at approximately 38 km from Addis Ababa. The project road branches to the left from main trunk road (Addis Ababa – Gohatsion) towards the entrance of Chancho town. The road is an existing gravel road which starts from Chancho and terminates at Becho near Derba cement factory area with an additional 2.3 km drive road from Derba junction to Muger Cement passing through Derba village.

Due to rapid economic growth of the country, there is a high demand for cement and the existing Chancho – Derba – Becho road is a potential corridor for cement production. There are existing cement factories which are under operation and also new cement factories are underway. Among the new cement factories under construction is Derba Midorc Cement Plc, the biggest cement factory in Ethiopia. This factory is expected to produce 7000 Tons of cement per day. Apart from cement factories, there are other ongoing development projects like flower farming and related development projects. From these, the socioeconomic developments in the area will generate too much traffic, in which the existing road will not be able to accommodate the current and future transport smoothly and satisfactorily. In order to satisfy the demand of the emerging economy for huge transport of cement and other productions, it is therefore required to upgrade the existing road to a higher standard.

Figure 2.1: Map of the Project Area

2.2 Climate

The area through which the project road traversed can be classified as "Weina Dega" with the altitude ranging from 2300m to 2600m above mean sea level. While, the project area has a mean annual temperature between 5 to 20 degrees Celsius, and mean annual rainfall between 10 to 400mm.

2.3 Existing pavement condition

The road condition survey showed that the existing gravel wearing course is affected by pavement distresses like potholes, rutting, corrugation, and loss of camber and oversize materials. The pavement distresses are observed poor riding quality from the first 18kms towards Derba village. The existing pavement condition is summarized and presented in the table 2.1 and figure 2.2, respectively.

Table 2.1: Existing Pavement Condition

Road Section	Observed Distresses	Pavement Rating	Recommended Remedial Measures
0+000 to 7+000	Potholes, and loss of camber	Poor	Scarify, reshape and re-compact
7+000 to 18+700	Potholes, corrugation, rutting and loss of camber	Poor to very poor	Scarify, reshape and re-compact
18+700 to 28+830	Oversized materials, potholes, and loss of camber	Fair to Poor	Scarify top 15 – 20 cm, reshape and re-compact

Figure 2.2: Pavement Condition Rating

2.4 Research design

The research project is a case study type which was conducted on the selected road projects. The methods used in order to achieve the objective are:

- Literature review
- A case study on Chancho-Derba-Becho road project through site investigation, field observation, data collection and review of drawing and design documents
- Evaluating initial construction cost for one kilometer of both flexible and rigid pavement,
- Estimating of future maintenance, rehabilitation, fuel cost and time saving costs of secondary data,
- Life cycle cost analysis (LCCA) for both pavements by present worth method for 40 year analysis period.

2.4.1 Steps in determining Life Cycle Cost

1. Determine the initial construction cost

□ For asphalt pavement and concrete pavement (both pavement segments have been undertaken for the study).

□ Quantity Take-off prepared, Cost break down, and Initial cost was estimated for 1km 2 lane road for both pavement types as per the typical road section of the project (Chancho-Derba-Becho)

2. Determining schedule (frequency) of activities

□ Analysis period

□ Maintenance schedule and frequency in years

□ Rehabilitation schedule and frequency in years

3. Estimate agency costs and User costs

□ Exclude elements that are same for all alternatives

□ Agency costs – construction costs

□ User costs –vehicle time savings and fuel costs

4. Compute life-cycle costs (Present Worth) Present worth of Costs

□ Computations using formula(future value of money)

□ Discounts all future costs and benefits to the present value

5. Analyze the results

In table 2.2, it shows the parameters used in the study.

Table 2.2: Parameters considered for the LCCA

Parameters	Remarks
Construction cost	For pavements, sub base, base course and capping layer
Maintenance cost	-
Rehabilitation cost	-
User Cost (fuel and time savings)	-
Salvage Value	-
Traffic Direction	(2-directions) Two lane -Two way
Analysis Period (Years)	40 years
Beginning of Analysis Period	End of 2015
Discount Rate (%)	10.23%
Inflation Rate (%)	(11.6%), August 2015 data
Interest rate (%)	(5%),Commercial Bank Of Ethiopia
Number of Alternatives	(2),Concrete(JRCP) and Asphalt(HMA)

2.5 Data source and collection

During data collection, data were collected from the following sources

□ Road maintenance & rehabilitation data from Ethiopian Road Authority (ERA), Ethiopian Road Construction Corporation(ERCC)and ERA manuals.

□ Field inspection of Chancho-Dreba-Bocho road project design and specifications.

□ Informal Interviews to road project consultants and contractors.

□ Primary and secondary data were also collected from literatures, pre road feasibility studies, internets and websites

2.6 Data processing and analysis

After cost determination of pavement initial, maintenance, rehabilitation, salvage value and users' costs for one kilometer, the present worth of rigid and flexible pavements is calculated.

The Net Present Worth formula which was

used, is shown below:

$$NPW = Ic + \left[\sum_{n}^{N} Mc\right]\left[\frac{1}{(1+dr)^n}\right] + \left[\sum_{n}^{N} Rc\right]\left[\frac{1}{((1+dr)^n)}\right] + \left[\sum_{n}^{N} Uc\right]\left[\frac{1}{(1+dr)^n}\right] - Sv\left[\frac{1}{(1+dr)^n}\right] \quad (1)$$

Where: Ic = initial construction cost
Mc =maintenance
Rc=Rehabilitation cost
Uc = User cost (User time and fuel saving cost)
S = salvage value
n = number of years.
N= analysis period in years (40)
Dr = discount rate (10.23%);

Since all the costs other than initial construction will occur in the future analysis years, future value of money should be determined by considering the inflation rate.

$$Fc = PV[1 + if]^n \quad (2)$$

Where:
Fc=Future cost at time of n years
PV= Present Value of Money in Birr
if= inflation adjusted interest rate

3 ANALYSIS, RESULTS AND DISCUSION

3.1 Analysis Period

The Life Cycle Cost Analysis(LCCA) analysis period should have to be sufficiently long to reflect long-term cost differences associated with reasonable design strategies. Generally, the analysis period should always be longer than the pavement design period, except in the case of extremely long-lived pavements. As a rule of thumb, the analysis period should be long enough to incorporate at least one rehabilitation activity. The FHWA's September 1996 Final LCCA Policy statement recommends an analysis period of at least 35 years for all pavement projects, including new or total reconstruction projects as well as rehabilitation, restoration, and resurfacing projects [12].

As per the above recommendation period of 40 years, it was considered for the analysis to include one rehabilitation time for the rigid pavement (JRCPCCP). The design periods, 40 years and 15 years for the respective pavements were taken from the design documents of Chancho-Derba-Becho road project.

3.2 Determination of Agency Costs

3.2.1 Initial construction Cost of pavements

The cost was calculated after determining the quantity and cost breakdown for 1km and 7meter road width based on the typical road section of both pavement types particularly to Chancho-Derba- Becho Road project.

Table 3.1: Summary of Initial Cost for Flexible Pavement

Item No	Description	Total Cost (ETB)
1	Sub base, Road Base	959,630.00
2	Bituminous Surfacing	5,342,008.47
	Cost per km	6,301,638.47

Table 3.2: Summary of Initial Cost for Rigid Pavement

Item No	Description	Total Cost (ETB)
1	Sub Base materials	842,590.00
2	Concrete Pavement	10,066,914.20
3	Texturing and Curing	510,400.00
4	Joints	35,165.52
5	Reinforcement Bars	3,332,671.15
6	Separation Membrane	350,787.50
	Cost per km	15,138,607.72

3.3 Maintenance Cost of Pavements

3.3.1 Routine Maintenance of Flexible Pavement

Based on the data gathered, monthly rainfall in the study area have high intensity for June, July, August and September [11]. Hence, it is practical for this project area to consider and carry-out Routine Maintenance before and after these rainy months.

Table 3.3: Flexible Pavement Routine Maintenance Schedule

Frequency in a year	Month of a Year	Routine Maintenance activities	Remarks
1st	March	Activity Code 210-215,18 & 19 [6]	Twice(2) a year before and after the rainy season
	April		
	May		
2nd	October		
	November		
	December		

3.3.2 Periodic Maintenance for Flexible Pavement

The Periodic Maintenance is to be conducted once a year before the rain comes as per the experience of the Ethiopian Road Construction Corporation (ERCC) and Ethiopian Road Authority(ERA).

Table 3.4: Schedule of Periodic Maintenance for Flexible Pavement

Frequency in a year	Month of a Year	Periodic Maintenance activities	Remarks
Once a year	March	Activity Code 309-216 [6]	Once every three years before the rainy season
	April		
	May		

3.3.3 Rehabilitation of Flexible Pavement

Considering two(2) times rehabilitation of the flexible pavement in 40 years of the analysis period, the cost was calculated for full replacement asphalt bitumen after scarifying the pavement [2]. Since Routine Maintenance was scheduled two times and periodic once a year, Hot Mix Asphalt(HMA) Overlay is enough and feasible without scarifying the layers below the base course. For one(1) kilometer road stretch, rehabilitation activity is scheduled in table 3.5.

Table 3.5: Schedule of Rehabilitation for Flexible pavement

Year	G.C	Activities	Remark
0	2015	Construction	2 times Hot Mix Asphalt(HMA) Overlay in the analysis period
15	2030	HMA overlay	
30	2045	HMA overlay	
40	2055	Salvage Value	

On the other hand, the total cost of rehabilitation for 15 and 30 years would become 2,558,500.84 ETB per kilometer of the road. This cost is about 35% of the initial construction cost in the respective year.

3.3.4 Salvage Value

$$\text{Salvage Value} = CC * \frac{ERL}{TEL} \quad (3)$$

Where,
LC = Last construction or rehabilitation project costs
ERL = Expected remaining life of the last construction or rehabilitation project
TEL = Total expected life of the last construction or rehabilitation project

Table 3.6: Agency Cost of Flexible pavement

S/No	Activity	Cost (ETB)	Remarks
1	Construction Cost	6,301,638.47	
2	Routine Maintenance Cost	673,176.26	Twice every year
3	Periodic Maintenance Cost	681,856.38	Once every three years
4	Rehabilitation Cost	2,558,500.84	At 15th and 30th years
5	Salvage Value	1,705,667.23	After 40th years

3.4 Maintenance and Rehabilitation of Rigid Pavement

The major routine maintenance activities were scheduled to be conducted at every 8 years and periodic activities at 12 years. At 40 years after construction, rehabilitation has to be scheduled for the particular project.

Table 3.7: Schedule of Maintenance and Rehabilitation of Rigid Pavement

Maintenance Type	Activity	Frequency
Routine Maintenance	Joint Sealing	Every 8 years
	Crack Sealing	
Periodic maintenance	Partial Depth repair	Every 12 years
Rehabilitation	Full depth repair	At 40 years

3.4.1 Salvage Value of Rigid Pavement

Table:3.8: Agency Cost of Rigid Pavement

Description	Cost in ETB
Initial construction	13,398,607.72
Routine Maintenance cost	300,000.00
Periodic Maintenance cost	119,000.00
Rehabilitation cost	1,191,000.00
Salvage value	794,000.00

a. Determination of User Costs

The Cost- Benefit analysis of the road project measures the capital cost in monetary terms, and the benefits that accrue in the form of travel time and the vehicle operating cost savings on the other. The major considerations in the measurement of costs and benefits for the economic appraisal of this road project are: the travel that incurs costs to road users such as the time spent on travelling; costs arising from the direct costs of fuel, maintenance and depreciation.

3.5.1 Vehicle Time Savings

This is the benefit of the pavements gained after the construction when the condition of the pavement is improved. For minimum, one (1) minute saved per kilometer and valued to one(1) Birr per one(1) minute saving. It means 40km/HR to 80km/HR speed of travel.

Table 3.9: Calculation of Time Saved

Vehicle Type	AADT (2014-2028)	Composition	No. of Vehicle	Time savings /day/km	Time savings/ day
Small Bus	429	37%	158	0.29	45.82
Medium Bus	429	2%	9	0.29	2.61
Large Bus	429	1%	4	0.29	1.16
Medium Truck	429	25%	109	0.29	31.61
Heavy Truck	429	24%	101	0.29	29.29
Truck Trailer	429	11%	48	0.29	13.92
Total time saved in a minute /per day					124.41

The total annual saved time = [124.41minutes/day] *365days = 90,885.00 minutes.

Therefore, the total annual benefit of time savings in Birr becomes = [90, 885.00 minutes] *1 Birr/minutes = 90, 885.00 Birr.

For rigid pavement the annual saved time is beneficial for a period of 37.5 years (40 years, -2.5 years) after deducting the years of maintenance and rehabilitation, where the saving time becomes dis-benefit, delay due to maintenance and rehabilitation activities and lane closures for the remaining 2.5 years.

□ Total value in Birr for time delay (dis–benefit) during the analysis period of 40 years becomes ,
90,885.00 Birr/year *37.5 years=3,408,187.50 Birr

□ Total value in Birr of time savings during the analysis period of 40 years becomes ,the total benefit = 3,408,187.50-(90,885*2.5) = 3,180,975.00 Birr/km

Likewise, for flexible pavement, the annual saved time is beneficial for a period of 26 years (40 years, -14 years) after deducting the years of maintenance and rehabilitation, where the saving time becomes dis- benefit, delay due to maintenance and rehabilitation activities and lane closures for the remaining 14 years.

The total value of Birr of time savings during the analysis period of 40 years becomes,

□ Total value in Birr for time delay (dis–benefit) during the analysis period of 40 years. Also, this becomes,
90,885.00Birr /year*14years=1,272,390.00 Birr/km

□ Total benefit= [90,885*26] -[1,272,390.00] =1,090,620.00 Birr/km

3.5.2 Cost of Fuel for Vehicles

Most of the types of fuel that are being used for all types of vehicles are petrol and diesel. Ethiopia's consumption of fuel is largely attributed to transport industries rather than some other economic sectors in the country.

Vehicles consume an average of 0.33 liters/km (in Ethiopia, on average 1km consumes about one(1)liter) and price of Fuel is 16.82 ETB, the annual fuel consumption becomes:

Cost of fuel per day
=[0.33lit/km] * [1km*429] * [16.82Birr/lit] = 2,381.21 Birr/day

The annual cost of fuel on the assumption of daily operation basis = 2, 381.21 Birr/day *365 days = 869, 140.70 Birr/km/year

Rigid pavement reduces 0.8% fuel [3] consumption for a period of 37.5 years (40 years, -2.5 years) after deducting the years of maintenance and rehabilitation, where such reduction is not considered due to maintenance and rehabilitation activities and lane closures for the remaining 2.5 years.

□ Total fuel cost during the analysis period of 40 years once applying 0.8% reduction in consumption for 37.5years:
869,147.70 Birr/year*37.5 years*(1-.008)=32,332,034.04 Birr/km

□Total fuel cost during maintenance and rehabilitation activities and lane closures during the analysis period of 40 years becomes without applying the percentage reduction for 6years becomes,
869,140.70 Birr/year*2.5 Years=2,172,851.75 Birr/km

□ Therefore, the total fuel Cost = 34,765,628.00 Birr/km

Flexible pavement reduces 1.8% fuel [3] consumption for a period of 26 years (40 years, -14years) after deducting the years of maintenance and rehabilitation, where such reduction is not considered due to maintenance and rehabilitation activities and lane closures for the remaining 14years.

□ Total fuel cost during the analysis period of 40 years when applying 1.8% reduction in consumption for 26years,

869,140.70 Birr/year*26 years*(1-.018)=22,190,900.35 Birr/km

□ Then, the total fuel cost during maintenance and rehabilitation activities and lane closures in the analysis period of 40 years without applying the percentage reduction for 14 years becomes,

869,140.70 Birr/year *14 years =12,167,969.80 Birr/km

□ Total fuel Cost=34, 350,384.40 Birr/km

3.5.3 Present worth Calculations

The net present worth formula used was the following:

$$NPW = Ic + \left[\sum_{n}^{N} Mc\right]\left[\frac{1}{(1+dr)^{n}}\right] + \left[\sum_{n}^{N} Rc\right]\left[\frac{1}{\left((1+dr)^{n}\right)}\right] + \left[\sum_{n}^{N} Uc\right]\left[\frac{1}{(1+dr)^{n}}\right] - Sv\left[\frac{1}{(1+dr)^{n}}\right]$$

Table 3.10: Present Worth (PW) of Pavements (ETB/Km)

Description	Rigid(ETB)	Flexible(ETB)	Difference(ETB)
Initial Construction Cost (ETB)	13,398,607.72	6,159,851.60	7,238,756.12
Routine Maintenance Cost (ETB)	262,688.40	4,751,072.46	4,488,384.06
Periodic Maintenance Cost (ETB)	56,849.86	2,095,019.25	2,038,169.39
Rehabilitation Cost (ETB)	30,505.96	806,517.58	776,011.62
Salvage Value	-20,337.31	-43,688.51	-23,351.20
Fuel Cost	9,384,726.90	8,721,417.57	663,309.33
Time Savings(benefit)	-8,826,941.34	-276,903.81	-8,550,037.53
Total, Cost in 40 Years (ETB)	**14,286,100.19**	**22,213,286.14**	**7,927,185.95**

3.6 Time and Material requirement

3.6.1 Time requirement

To execute one(1) kilometer pavement stretch, the major time required for critical activities was determined based on the performance output of Standard Crew and the actual output for Chancho – Derba- Becho road project.

As per the table below, flexible pavement requires 5 days, while for rigid pavement requires 42 days to execute the construction, respectively.

Table 3.11: Time Required for the Execution of 1km Pavements

Type	Critical Activities	Unit	Quantity of work	Required Calendar day	Performance
Flexible	Dense Bitumen Macadam	Cu.M	1,015	3	345m3/day
	Asphalt surfacing	Cu.M	350	2	173m3/day
Total calendar days				**5**	
Rigid	Placing of Rebar	Kg	6,677.44	7	1179kg /day
	Casting of C-35 Concrete	Cu.M	2,400	21	119m3/day
	Curing of concrete (14 minimum curing days)	SQ.M	7,000	14	700m2/day
Total calendar days				**42**	

3.6.2 Material requirement

To execute one(1) kilometer pavement stretch, major material required for critical activities was determined based on the performance output of standard crew and actual output for Chancho –Derba- Becho road project.

The aggregate requirement for flexible pavement is more than twice that of rigid pavement. Also, it requires more material for sub base and base course than rigid pavement.

Table 3.12: Materials required for the Execution of 1km Flexible Pavement

S/no	Description	Unit	Qty	Remark
1	Bitumen 80/100 (for Asphalt and Macadam)	Kg	175,490	156kg/m3 +117kg/m3
2	Aggregate (gravel) for Asphalt	Cu.M	805	2.3/m3
3	Aggregate for Base course	Cu.M	1,750	
4	Sub base Material	Cu.M	1,400	

Table 3.13: Materials required for the Execution of 1km Rigid Pavement

S/no	Description	Unit	Qty	Remark
1	Portland Cement	Ton	9,596	4qnt/m3
2	Aggregate (gravel)	Cu.M	360	0.15/m3
3	River sand	Cu.M	960	0.40/m3
4	Sub base Material	Cu.M	3,045	

3.6.2 Foreign currency saved

After the material requirement per kilometer length of each pavement type was multiplied by the corresponding cost and converted to US Dollar. A total of $105,526.13 USD per kilometer will be saved if the roads used a rigid pavement alternative to date.

Bitumen/km=175, 490 (kg) *25 (ETB) =4, 387,250.00ETB

Cement/km=9, 596 (Qnt) *225 (ETB) =4, 387,250.00ETB

Difference=2, 228,150.00ETB [105,526.13USD)

4 CONCLUSION

Based on the results of the research study, it was found out that the rigid pavement has longer service life (more than twice) than the flexible pavement. For one (1km) kilometer road length, the life cycle cost of the rigid pavement is lower by a value of 7.9 Million ETB than the flexible pavement in forty (40) year analysis period. Routine and periodic maintenance costs for the period of 40 years are 1.1 times greater than the initial construction cost of the same one kilometer stretch for flexible pavement and requires 7.3 million Birr higher for maintenance and rehabilitation as compared to rigid pavement.

Also, it showed that the rigid pavement has lower maintenance and rehabilitation cost when compared with the flexible pavement. On the other hand, the rigid pavement which is wholly constructed with local materials, such as cement and aggregates without the requirements of importing construction materials from abroad. A total of $105,526.13 USD will be saved per kilometer if the road will be utilized rigid pavement as an alternative.

In the history of road construction in Ethiopia, concrete(rigid) pavement comprised only of about 0.10% of the total road network due to lack of construction technology and practice in spite of its advantage.

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