IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X.
PP 64-68
www.iosrjournals.org

Techno-Economic Study of HVFAC Pavements

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Abstract : *Road transport is now the major transport mode in India. India has the second largest road network in the world (second only to U.S.A, with a network of 6.3 million Km). India's record of road safety is none too flattering, with 80,000 fatalities occurring every year. With the rapid and continuous increase in vehicular traffic flow on the road system in the country, there has been an ever increasing demand for the improvement of the existing roads on one hand and expansion of the road network on the other. All such demands cannot be met fully because of the scarcity of resources available. Economics plays an important role in deciding the pavement options. It is difficult to generalize which option will give maximum economic returns as it varies from case to case. So it becomes necessary to analyze the pavement options to check the economic viability and best pavement option. Life Cycle Cost analysis is an accepted tool for evaluating various options and selecting the most appropriate one. In the present study economics of flexible and Rigid Pavements (Both OPC and HVFAC) has been done and the best pavement option is recommended.*

Keywords : *Flyash, HVFAC, Life Cycle Cost, NPV, Schedule of Rates*

I. INTRODUCTION

Roads are considered as the lifeline to the infrastructure. For India as a developing country, investments on roads are being stepped up steeply. India is approximately 3,060,050 sq Km in area, has a road network of over 3,315,231 Km. The road system carries 87% and 65% respectively of passengers and freight traffic. At present Bituminous roads constitute a major portion of India's road network. This is because of low initial cost of construction and amenability to stage construction. Pavements constitute nearly half the cost of a highway. A right choice of the pavement type will ensure that the huge investments will be made on sound basis. The growth of Concrete Pavement usage has been continuous all over the world, over the past several decades. In India too concrete pavements are gaining importance because of their longer life, better design and durability. Concrete Roads have proven technical advantage over flexible pavements, but have higher initial costs. The use of high volume flyash concrete (HVFAC), may help to reduce significantly the initial cost of concrete roads, making them more attractive as an alternative to bituminous roads. A well designed and well-constructed HVFAC pavement has a life of 20 to 30 years. Even after this long life, another overlay can be laid, but just before cracks develop, and the life can be further prolonged. HVFAC pavements like ordinary cement concrete pavements are practically maintenance free. The only attention needed is at the joints where resealing have to be done whenever needed. Thus, there will be no potholes, no ruts, no cracking, and no resealing. The initial riding quality inbuilt in the concrete pavement at the time of its construction lasts for a long time. Cement Concrete road gives a light-coloured surface. Hence, its reflectivity characteristics are very good when compared to Asphalt surfaces. One of the major components in the construction of concrete is cement. The environmental concerns related to the production of cement in terms of the energy consumption and the emission of CO_2 lead to the search for more environmentally viable alternatives to cement. Using supplementary cementitious materials (SCMs), like Ground Granulated Blast Furnace Slag and Fly ash, in concrete mixtures for pavements can improve concrete workability, durability, and long-term strength.

Blended (or Pozzolanic) cements are being used worldwide to produce dense and impermeable concrete. They contain a blend of Portland cement clinker and a variety of natural pozzolanas or supplementary cementing materials such as blast furnace slag, fly ash, silica fume, etc. The use of these materials is also environment friendly because it contributes to reduce the CO_2 emission to the atmosphere.

Fly ash is the most common Pozzolana and is being used worldwide in blended cements. The dense interfacial zone between aggregate and the matrix is also a result of the use of fly ash. The concrete containing fly ash is, therefore, less susceptible to the ingress of the harmful chloride ions. It has been shown that the use of the finer fly ash results in a better mechanical properties of mortar and concrete as compared to the coarser ones. The use of finer fly ash also reduces the average pore size of the paste as compared to the coarser one, and this should further improve the resistance of concrete to the ingress of harmful solutions.

1.1 High Volume Flyash Concrete

In recent years economic and environmental considerations have increased the incentive to use fly ash at higher replacement levels than those traditionally used. The term high volume Flyash was coined in 1985 at CANMET. This concrete has minimum of 50% of flyash by mass of the cementitious materials. Low water content, generally less than 130 kg/m^3 is mandatory. Cement content, generally not more than 200 kg/m^3 is desirable. Use of super plasticiser is necessary. Water to cementitious content ratio is around 0.3. However certain precautions need to taken for HVFAC like Regular check on quality of fly ash (LOI, Fineness, Reactivity), Collection, Transportation and dozing arrangements of Dry Fly Ash from TPP to batching plant.

II. METHODOLOGY

It is difficult to generalize which option will give maximum economic returns as it varies from case to case. So it becomes necessary to analyze the pavement options to check the economic viability and best pavement option. Life Cycle Cost analysis is an accepted tool for evaluating various options and selecting the most appropriate one.

Life-Cycle Cost Analysis is a process for evaluating the total economic worth of a usable project segment by analyzing initial costs and discounted future costs, such as maintenance, user, reconstruction, rehabilitation, restoring, and resurfacing costs, over the life of the project segment. In present case LCCA has been performed considering initial costs and discounted costs, such as maintenance and resurfacing.

III. DATA ANALYSIS

Life Cycle Cost Analysis for the present case has been done assuming. Inflation of 10 % per annum, Discount rate of 12% , Analysis period of 20 years, Sealant renewal of concrete pavement once in every ten years, Overlay over the bituminous pavement once in every 10 years, Routine maintenance (pothole filling and patching) every year for the flexible pavement. The rate analysis has been done using schedule of rates. The cost of items has been calculated using MORT&H Standard Book. NPV (Net Present Value) i.e the total worth of the entity (pavement) is calculated for the design period. The design of the pavement for the project has been done on the following basis:

- Flexible Pavement is designed on the basis of IRC: 37 -2001.
- The Concrete pavement is designed on the basis of IRC: 58-2002.
- The CBR value of the soil has been taken as 10.
- The cumulative design traffic for the flexible pavement has been taken as 10 msa.
- For Rigid pavement, two design load have been taken
    (i) An axle load of 12 T for the less trafficked roads
- Design 28 day Concrete Strength: 40 MPa

For Design of Road cross section mainly CBR value and MSA (million standard axles) are required.

IV. OBJECTIVE OF STUDY

Objective of this study is to analyse the above stated LCC so that a conclusion can be made before a designer which pavement option is more economical. To do the comparative study of different pavement options, LCCA data along with soil CBR 10 and cost of different materials have been used.

V. RESULTS &DISCUSSIONS

Table 1 shows the thickness for flexible and concrete pavement. In table 2, the cost of materials is presented. Table 3 presents the estimate for flexible pavement.

Table.1. Thickness for Flexible and Concrete Pavement

	Flexible (in mm)	**Concrete (in mm)**
Sub-Base	250	- -
Drainage Layer	- -	150
WMM	250	- -
DBM	50	- -
BC	40	- -
DLC	- -	150
PQC	- -	220

Table.2. Cost of Materials

ITEM	Rate
Cement	Rs 4200 per MT
Bitumen	Rs 40,000 per MT
Stone Aggregates	Rs 500 per MT
Sand	Rs 250 per MT
Admixture	Rs 26 per liter
Polysulphide Sealant	Rs 175 per liter
Steel	Rs 49,500 per MT
Separation Membrane	Rs 15 per sq.m

Table.3. Estimate for Flexible Pavement (1.0 Km X 7.0 m Wide Road)

S.No	Description	No	L	B	H	Quantity	Unit	Rate (Rs)	Amount (Rs)
1.	Provision of Granular Sub-base -cum-drainage layer	1	1000	8.0	0.20	1600	cum	1,232	1,971,200
2.	Provision of Water Bound Macadam	1	1000	7.0	0.25	1750	cum	1,367	2,392,250
3.	Two Coat surface Dressing	1	1000	7.0		7000	sqm	100	700,000
4	Repair by Tack Coat	1	1000	7.0		7000	sqm	6	42,000
5	Provision of Dense Bituminous Macadam using 60/70 Bit.	1	1000	7.0	0.05	350	cum	6,207	2,172,450
6	Provision of Bituminous Concrete using Crumb-Rubber Modified Bitumen	1	1000	7.0	0.04	280	cum	7,591	2,125,480
								Total	9,403,380 Say 94 Lakhs

Table.4. Estimate For Concrete Pavement (220 Mm, With 50% Fly Ash) (1.0 Km X 7.0 m Wide Road)

S.No	Item	No	L	B	H	Quantity	Unit	Rate (Rs)	Amount (Rs)
1.	Provision of Geo fabric Drainage - cum - Separation Layer	1	1000	8.0		8000	sqm	100	800,000
2.	Dry Lean Concrete M-10 using 50% Fly-ash Replacement	1	1000	7.0	0.100	700	cum	1,616	1,131,200
3.	Repair to DLC damaged by crawler movement(considering 10% of area using epoxy/polymer mortar)	1	100	7.0	0.012	8.4	cum	5,000	42,000
4	Pavement Quality Concrete M-40 using 50% Fly-ash Replacement	1	1000	7.0	0.220	1540	cum	3,671	5,653,340
								Total	7,626,540

In Table 4, the estimate for concrete pavement is presented and using the above figures , the total amount calculated was Rs. 7,626,540. In Table 5, Life cycle cost analysis has been done.

Table.5. Life Cycle Cost Analysis

NET PRESENT VALUE (NPV) OF VARIOUS PAVEMENT ALTERNATIVES		
(Rs - Lakhs / km x 7 m wide)		
Year	Bituminous Pavement (CBR:10)	Concrete Pavement with 50% Flyash(220mm)
0	94	76.3
1	3.3	0
2	3.63	0
3	3.993	0
4	4.392	0
5	4.832	0
6	5.315	0
7	5.846	1.23
8	6.431	0
9	7.074	0
10	134.9	0
11	8.559	0
12	9.415	0
13	10.357	0
14	11.392	2.4
15	12.532	0
16	13.785	0
17	15.163	0
18	16.68	0
19	18.348	0
20	349.3	0
21	22.201	4.68
22	24.421	0
23	26.863	0
24	29.549	0
25	32.504	0
26	35.755	0
27	39.33	0
28	43.263	9.12
29	47.589	0
30	904.7	0
TOTAL FINANCIAL OUTGO	1945.418	93.73
NPV @ 12%	266.397	78.16

- Inflation is taken as 10% per annum
- Discount rate is taken as 12%

Note: - Maintenance & Repair Cost of Flexible Pavement per year for given traffic is Rs 3.3 Lakh/km[1].
An overlay is required every 10th year (5.5 cost of overlay, bituminous)
Cost of Bituminous Overlay is Rs 52 Lakh (Calculated Somewhere else, Jain 2009) [2]
Sealant renewal is required every 7th year for Concrete Pavement (Calculated Somewhere else, Jain 2009) [2]

VI. CONCLUSIONS

A Cement concrete road has several advantages over flexible pavement such as long life (over 30 years), practically maintenance free and better performance under heavy rainfall and poor drainage conditions. Since fly ash is available nearby the project site, it is possible to replace up to 50 percent of cement in the concrete pavement by fly ash. Besides resulting in economy, there are other advantages such as reduced heat of hydration, better workability, less segregation and bleeding, higher long-term strength and environmental benefits. Hence fly ash concrete pavement would be feasible. The initial cost of a fly ash concrete pavement is almost the same as that of a flexible pavement for a heavy duty road. The life-cycle cost analysis of a (i) flexible pavement (ii) fly ash concrete pavement shows that a huge saving in investment is possible if a fly-ash concrete option is adopted in preference of flexible pavement. It can be effectively used in structural and non-structural applications where normal concrete is used. HVFAC should be preferred over normal concrete as use of HVFAC is very suitable for tropical and hot climate countries like India.

REFERENCES

[1]. Kadiyali L.R and N.B Lal "Principles of Highway Engineering", 4th edition Khanna Publishers, Delhi 2006.
[2]. Jain, N, "Techno Economic Feasibility of HVFAC Pavements-A case study", M.Tech Thesis, PEC University, Chandigarh-2009
[3]. IRC : 37-2001 Guidelines for the design of Flexible pavements(Second Revision)
[4]. IRC : 58-2002 Guidelines for the design of Rigid pavements(Second Revision)
[5]. Dr Sharma Umesh and Jain N "Use of Flyash in Concrete Pavements-State of the art", National Conference on emerging trends in Civil Engineering,2011