# Life-Cycle Cost Analysis of Ohio Pavement Rehabilitation Demonstration Projects

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A suitable life cycle cost analysis procedure for comparing the economics of eight different projects that were treated with five different rehabilitation methods generally used in Ohio is described. Because the initial condition of each pavement included in the study was different, it was necessary to adjust for this condition so that different pavements could be compared on an equitable basis. Initial salvage value was used for this purpose. Also, the daily traffic was different on each project. Therefore, service cost index, defined as the ratio of daily traffic to life cycle cost (in multiples of $1,000) was used for comparing the benefits and costs of each project or rehabilitation method used in this study. Analysis of data used in this study indicated that composite overlays were more cost-effective than unbonded rigid overlays for pavements subjected to high levels of daily traffic. Unbonded rigid overlays were also relatively less cost-effective than asphalt concrete (AC) overlays for low levels of daily traffic conditions. Crack and seat with AC overlay was more cost-effective under medium-to-high levels than under medium-to-low levels of traffic. Concrete pavement restoration was most expensive. Results of the analysis indicated that the procedure described is a reasonable method of comparing the life cycle costs of various rehabilitation methods used in Ohio.

Section 110 of the 1982 Surface Transportation Assistance Act reaffirms congressional intent that federal-aid projects including 4R work shall be constructed to preserve and extend the service life of highway systems. In the absence of another AASHO Road Test and with an emphasis on rehabilitation procedures, the Ohio Department of Transportation (ODOT) and the FHWA proposed to construct some full-scale rehabilitation road test sections on existing rigid pavements. Ten different sites, which were identified to be in need of rehabilitation, were selected for this purpose. These sites are shown on the county map of the state of Ohio (see Figure 1). A brief summary of the rehabilitation strategies used in each project is presented in Table 1. In Figure 1, the project number corresponds to the order listed in Table 1.

Several rehabilitation strategies were selected that would yield information suitable for evaluating the effectiveness of the following rehabilitation methods:

1. Concrete pavement restoration (CPR)—Project 4;
2. Conventional asphalt concrete (AC) overlay—Projects 6 and 10;
3. Unbonded jointed concrete overlay—Projects 1, 2, and 3;
4. Composite overlay—Project 5; and
5. Crack and Seat (C&S) with AC overlay—Projects 7, 8, and 9.

All pavements except those slated for C&S procedures included other repairs such as grout undersealing and full-depth joint repair as indicated in Table 1.

A suitable life cycle cost analysis procedure can be used for comparing the economics of various rehabilitation strategies included in the study. The data available for this purpose consisted of the pavement condition immediately before and after rehabilitation and the project cost along with its length and number of lanes. Because these projects were completed recently, long-term performance data will not be available for some time in the future. However, the method illustrated will be applicable when such data become available.

## SELECTION OF PROJECTS

As stated earlier, 10 demonstration projects were selected by FHWA and ODOT for this study. Discussions with ODOT staff revealed that only a part of Project 8 (WYA-23-0.20) was given the listed treatment. Therefore, Project 8 is not included in the analysis. Also, Project 6 (MED-271-0.35/SUM-271-0.00), which included a 3-in. AC overlay, was not constructed according to plan (the project was readvertised for bids after it was terminated and was completed by the bonding company). As such, it was decided to exclude Project 6 from this analysis also. The remaining eight projects were selected for the cost analysis.

## LIFE CYCLE COST ANALYSIS

Life cycle cost analysis is generally performed to evaluate alternative designs of rehabilitation strategies. Although there is no unique method of calculating the life cycle cost of a pavement rehabilitation action, most highway agencies include initial cost, future maintenance, and rehabilitation costs in similar analyses. Some agencies consider user cost as an important component of life cycle cost analysis, but it is generally difficult to estimate. Salvage value is another component of life cycle cost that should be included in the analysis if there is substantial difference in this value (because of various alternative strategies) at the end of the analysis period.

Available literature on life cycle cost analyses was reviewed to select a suitable method of analysis for this study. The

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**FIGURE 1** Location of projects.

TABLE 1 OHIO PAVEMENT REHABILITATION DEMONSTRATION PROJECTS

| Project Number | Project Identification | Rehabilitation Strategy | Start Date | Comp. Date |
|---|---|---|---|---|
| 1 | CLA-70-20.92 | Undersealing and necessary joint repairs. 10-inch mesh-doweled PCC overlay with 60 foot joint spacing. | 04/12/84 | 10/15/84 |
| 2 | CLI-71-4.26 | Undersealing all joints. 9-inch mesh-doweled PCC overlay with skewed joints spaced at 27 feet. | 05/13/85 | 12/04/85 |
| 3 | ATH-33-13.31 | 8-inch plain PCC with skewed joints at variable spacing. | 04/02/85 | 10/15/85 |
| 4 | ATH-33-10.41 | CPR. Full-depth and bonded PCC repairs of failed areas. Adding tied PCC shoulders and resealing all joints and cracks. | 09/04/84 | 05/31/85 |
| 5 | FRA-70-0.02 | Undersealing and joint repairs. Composite overlay, 3-inch AC on 9-inch plain PCC, slurry seal bond breaker and saw/seal joint in overlay EB. | 04/02/85 | 11/01/85 |
| 6 | MED-271-0.35/ SUM-271-0.00 | Undersealing, joint repairs, tied PCC shoulder, 3-inch AC overlay. Saw/seal joints in overlay. | 03/18/85 | 09/23/86 |
| 7 | CLA-70-5.76 | Crack and seat existing PCC, and 7-inch AC overlay. | 08/06/84 | 07/31/85 |
| 8 | WYA-23-0.20 | Crack and seat existing PCC, and 6-inch AC overlay. | 08/13/84 | 01/08/85 |
| 9 | LIC-70-9.55 EB | Remove existing AC overlay, crack and seat PCC pavement, and 9-inch AC overlay. | 08/21/85 | 10/11/86 |
| 10 | HEN-24/6-9.61 | Minimum joint repair, 6-inch AC overlay. | 03/12/86 | 04/24/87 |

Alaska DOT, Pennsylvania DOT, and AASHTO analysis methods were reviewed for this purpose (*1–3*). Because of its simplicity, the Pennsylvania DOT analysis approach was used for this study. Figure 2 shows the use of this method for life cycle cost analysis of various rehabilitation strategies.

As indicated earlier, the life cycle cost of a given rehabilitation alternative generally consists of the following components:

1. Construction cost of rehabilitation,
2. Salvage value at the end of analysis period,
3. Routine maintenance cost during the analysis period, and
4. Rehabilitation cost (if required before the end of analysis period).

To estimate the life-cycle cost, these cost components are combined in the following manner:

Life cycle cost [Cost of major rehabilitation (initial)]

+ (Routine maintenance cost during the analysis period)

+ (Cost of any rehabilitation during the analysis period)

− (Salvage value of pavement at the end of the analysis period) (1)

Equation 1 is applicable to those cases for which life cycle costs of various alternatives are to be determined for the same pavement or project. In these cases, the initial condition of pavement and future traffic on the pavement are the same for all alternatives. Therefore, the total life cycle cost of each alternative represents its relative economics when compared with the life cycle costs of other alternatives. However, this comparability was not present for this study because different pavements were rehabilitated with different actions. The initial conditions of these pavements were not the same and the future traffic on these pavements will not be the same. Therefore, this study provided reasonable means of accounting for differences in the life cycle cost analyses so that costs could be compared on an equitable basis.

Two new terms that are specific to this study were introduced in this analysis to address these issues. Initial condition of each pavement was converted into its dollar value and called "initial salvage" of the pavement. By adding this value to the total cost estimated by Equation 1, all pavements were brought to a common starting point of so-called "zero value." The life cycle cost thus obtained represented the total amount of dollars spent on the pavement during the analysis period. Further, because each pavement was expected to serve a different amount of traffic [measured in terms of 18-kip equivalent single-axle loads (E−18s)] during the analysis period, it was assumed that the life cycle cost of each pavement was used to serve the traffic expected on the pavement during the analysis period. Therefore, an index called "service cost index" (SCI) was used to determine the relative benefits derived from each rehabilitation action. This index was defined as follows:

SCI = (Total number of E−18s served by the pavement during the analysis period)/(Total life cycle cost estimated for the pavement) (2)

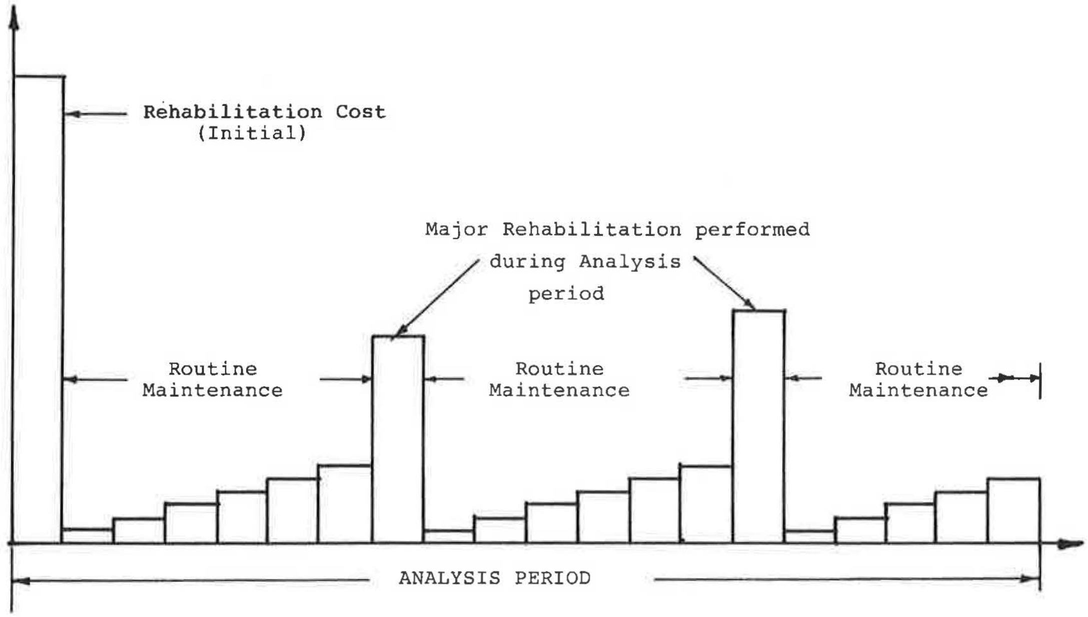


**FIGURE 2 Typical distribution of yearly costs of maintenance and major maintenance during the analysis period.**

If it is assumed that the traffic growth rates in the future of all pavements included in this analysis are the same, then the total number of E–18s served by each pavement is proportional to its daily E–18s. Therefore, daily E–18s were used in the numerator of Equation 2. Also, in order to limit SCI values to less than 100, the cost in the denominator was divided by 1,000.

Any period of analysis could have been used for the purpose of this analysis. However, a period of 20 years was selected and used in this analysis. Brief descriptions of each cost component are given in the following subsections.

### Construction Cost of Rehabilitation

Construction costs for various rehabilitation actions were obtained from ODOT records. The costs of each project in terms of dollars per lane-mile are presented in Table 2 along with the year each project was completed. The data presented in Table 2 are important when comparing final project costs.

Projects 1, 2, and 3 used portland cement concrete (PCC) as the rehabilitation method. If all other factors were equal, Table 2 would imply that 10-in. PCC cost significantly less (per lane-mile) than 8-in. and 9-in. PCC. This conclusion is unreasonable; not all factors were equal between the projects. That is, each project was bid according to the specific requirements of the project so the contract price per lane-mile was peculiar to the project, the project's conditions, and the rehabilitation method.

The same sort of situation existed between Projects 7 and 10. A first look at Table 2 may imply that C&S and 7-in. AC overlay (of Project 7) generally is less costly per lane-mile than the conventional 6-in. AC overlay of Project 10. This conclusion is not correct generally, but is a result of the conditions involved in each project and not solely because of the rehabilitation method.

### Salvage Value at the End of Analysis Period

Salvage value is the residual value of the pavement or its reusable material at the end of an analysis period (*3*). Because there are no well-defined formulas available to estimate the salvage value of a given pavement, it was proposed to use a simple method that was based on the remaining life of the pavement. For this purpose, it was assumed that a new pavement had a salvage value of 100 percent and a pavement with no remaining life had a salvage value of 0 percent. Thus, the salvage value at the end of the analysis period was estimated by the following relationship:

$$\text{Salvage value} = (NR/ND) \times (\text{Cost of new pavement}) \quad (3)$$

where

NR = remaining life of pavement in terms of E–18s, and
ND = design life of pavement in terms of E–18s.

After considering several alternatives, it was decided to use the AASHTO design equations for estimating the design life, ND (*3*). Remaining life, NR, was estimated by the following relationship:

$$NR = ND - [\text{Number of E–18s estimated for the analysis period (20 years) from traffic data collected at the beginning of the rehabilitation}] \quad (4)$$

The cost of new pavement is the average cost of new construction per lane-mile as determined by the Ohio DOT for the construction year 1988. A summary of salvage value estimates is presented in Table 3.

TABLE 2 INITIAL COST PER LANE-MILE

| Project | Rehab. | Contract Cost per Lane-Mile ($) | Project Length (Miles) | No. of Lanes | Year Completed |
|---|---|---|---|---|---|
| 1. CLA-70-2 .92 | 10 PCC | 238,143 | 4.2 | 4 | 1984 |
| 2. CLI-71-4.26 | 9 PCC | 321,057 | 3.0 | 4 | 1985 |
| 3. ATH-33-13.31 | 8 PCC | 299,141 | 2.2 | 4 | 1985 |
| 4. ATH-33-10.41 | CPR | 70,478 | 2.8 | 4 | 1985 |
| 5. FRA-70-0.02 | 3AC/9PCC | 254,913 | 3.4 | 6 | 1985 |
| 7. CLA-70-5.76 | C&S*/7AC | 167,976 | 5.2 | 4 | 1985 |
| 9. LIC-70-9.55EB | C&S*/9AC | 213,649 | 6.4 | 2 | 1985 |
| 10. HEN-24/ 6-9.61/16/43 | 6" AC | 168,743 | 4.9 | 4 | 1987 |

*C&S: Crack and Seat

TABLE 3 SUMMARY OF SALVAGE VALUE ESTIMATES AT THE END OF ANALYSIS PERIOD (COST PER LANE-MILE)

| Project Number | PSI Measured Immediately After Rehab. | Design Life Estimated from AASHTO Equation, ND ($10^6$) | Number of E-18 Expected During 20 yrs., N ($10^6$) | **Salvage at the End of 20 yrs., (%) | **Salvage in 1988 Dollars ($) |
|---|---|---|---|---|---|
| RIGID PAVEMENTS | | | | | |
| 1 | 3.6 | 62 | 45 | 27 | 111,375 |
| 2 | 3.9 | 43 | 37 | 14 | 57,750 |
| 3 | 4.3 | 10 | 6 | 40 | 165,000 |
| 4 | 3.4 | 5 | 5 | 0 | 0 |
| 5 | 4.2 | 88 | 65 | 26 | 107,250 |
| FLEXIBLE PAVEMENTS | | | | | |
| 7 | 4.6 | 21 | 14 | 33 | 136,125 |
| 9 | 4.2 | 35 | 35 | 0 | 0 |
| 10 | 3.9 | 7 | 13 | 0 | 0 |

* % Salvage = 100 (ND-N)/ND
** Based on cost of new pavement @ $412,500/lane-mile

### Initial Salvage

As mentioned earlier, initial salvage is the dollar value of each pavement just before the major rehabilitation was applied to the pavement. A method similar to the mentioned method was used to estimate this value for all pavements. The design lives for these pavements were determined from the AASHTO (*3*) design equation using the original design thicknesses (before new overlays) and their material properties. Remaining lives for these pavements were determined by subtracting the estimated number, $N$, of E–18s to reach the PSI before rehabilitation from the design number, ND, of E–18s. A summary of initial salvage value calculations is presented in Table 4.

### Routine Maintenance Cost

The routine maintenance cost for each pavement during the analysis period was estimated by the ODOT Bureau of Maintenance from its records. According to these estimates, routine maintenance cost increased from zero immediately after major rehabilitation repair to about $4,000 per lane-mile after 20 years. Thus, a stepwise increase of $200 per year was assumed for this purpose. For example, routine maintenance cost 1 year after rehabilitation is $200 per lane-mile, after 2 years it is $400 per lane-mile, and so on. Although these costs should differ for flexible and rigid pavements, it was decided to use the average values in this analysis; the results are not expected to be significantly affected by this assumption.

A maintenance schedule for each project was prepared by ODOT engineers using their previous experience in this area. These schedules are shown in Figure 3. Routine maintenance costs for each project were estimated from this schedule. Table 5 presents the yearly maintenance costs for Project 1. Similar tables were prepared for other projects.

### Rehabilitation Cost

A schedule of routine maintenance and rehabilitation was developed for each project with the help of ODOT engineers

TABLE 4 SUMMARY OF ESTIMATES OF INITIAL SALVAGE VALUE BEFORE REHABILITATION (COST PER LANE-MILE)

| Project Number | ND, 18K-ESAL, ($10^6$) | PSI before Rehab. | N, 18K-ESAL ($10^6$) | NR =ND-N ($10^6$) | Salvage NR/ND, (%) | *** Salvage Value (1988 dollars) ($) |
|---|---|---|---|---|---|---|
| 1 | 5.7 | 3.1 | 2.5 | 3.2 | 56 | 231,000 |
| 2 | 5.7 | 1.9 | 4.9 | 0.8 | 14 | 57,750 |
| 3 | 2.5 | 2.6 | 1.7 | 0.8 | 32 | 132,000 |
| 4 | 5.7 | 3.2 | 2.2 | 3.5 | 61 | 251,625 |
| 5 | 5.7 | 2.5 | 3.7 | 2.0 | 35 | 144,375 |
| 7 | 5.7 | 2.7 | 3.3 | 2.4 | 42 | 173,250 |
| 9 | NA* | NA* | NA* | NA* | 30** | 123,750 |
| 10 | NA* | NA* | NA* | NA* | 30** | 123,750 |

* NA - not available
** Estimates based on condition of existing structure
*** Based on cost of new pavement @ $412,500/lane-mile

as shown in Figure 3. This schedule included a period of 20 years after rehabilitation for each project. Rehabilitation actions recommended for each project during this period represent the best estimates of ODOT engineers experienced in similar projects. Costs of proposed rehabilitation actions were estimated using current ODOT cost records. Actual costs for each type of rehabilitation used in this study are presented in Table 6.

### Inflation and Discount Rates

Because most of the costs were available in 1988 dollars, it was decided to convert each cost component into 1988 dollars. In order to convert the money spent in years other than 1988, an inflation rate of 4 percent was assumed. Two typical discount rates of 6 and 10 percent were used to estimate the present worth of future costs.

## ANALYSIS OF DATA

Life cycle cost analysis of each project was performed with the help of Equation 1 and the data described in the previous sections. The cost of initial salvage, as described earlier, was added to Equation 1 for estimating the life cycle cost for the analysis period (20 years). An example of typical calculations performed for Project 1 is presented in Table 5. Similar calculations were performed for the remaining projects selected for this analysis and the results are summarized in Table 7.

Estimates of E–18s per day, as calculated by the ODOT, were obtained for each project and are presented in Table 7. These values along with the life cycle cost estimates were used to calculate SCI values for each project with the help of Equation 2. The SCI values obtained are listed in Table 7. Using these values, each project was ranked from 1 to 8 (Rank 1 represented the highest SCI and Rank 8 represented the lowest). A summary of all calculations performed for this analysis is presented in Table 7.

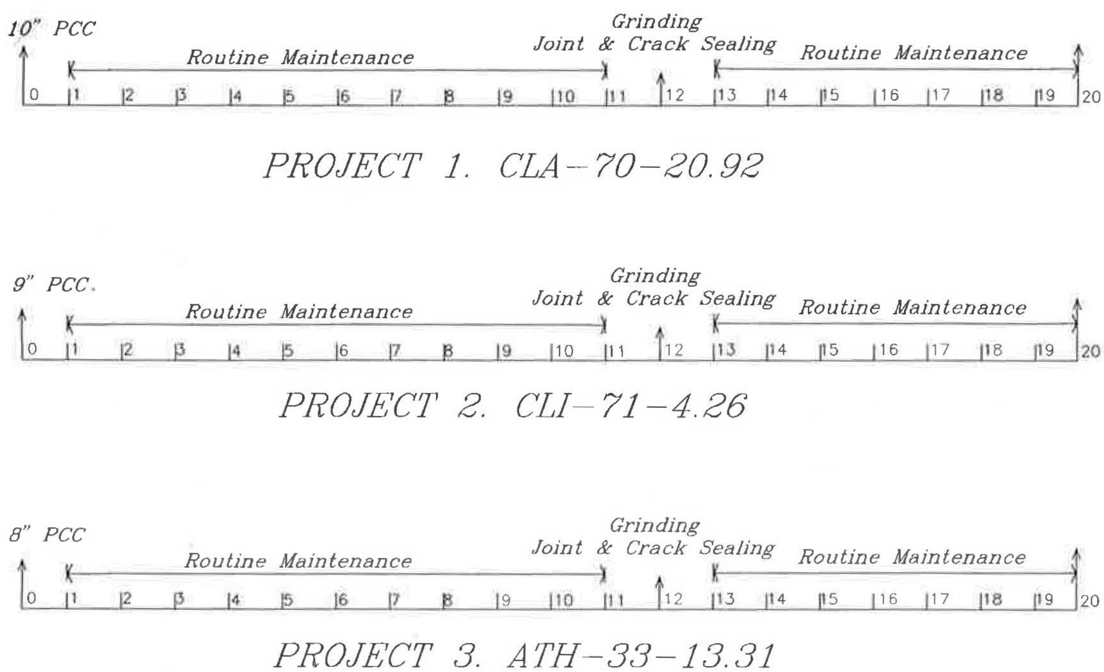


**FIGURE 3** ***(continued on next page)***

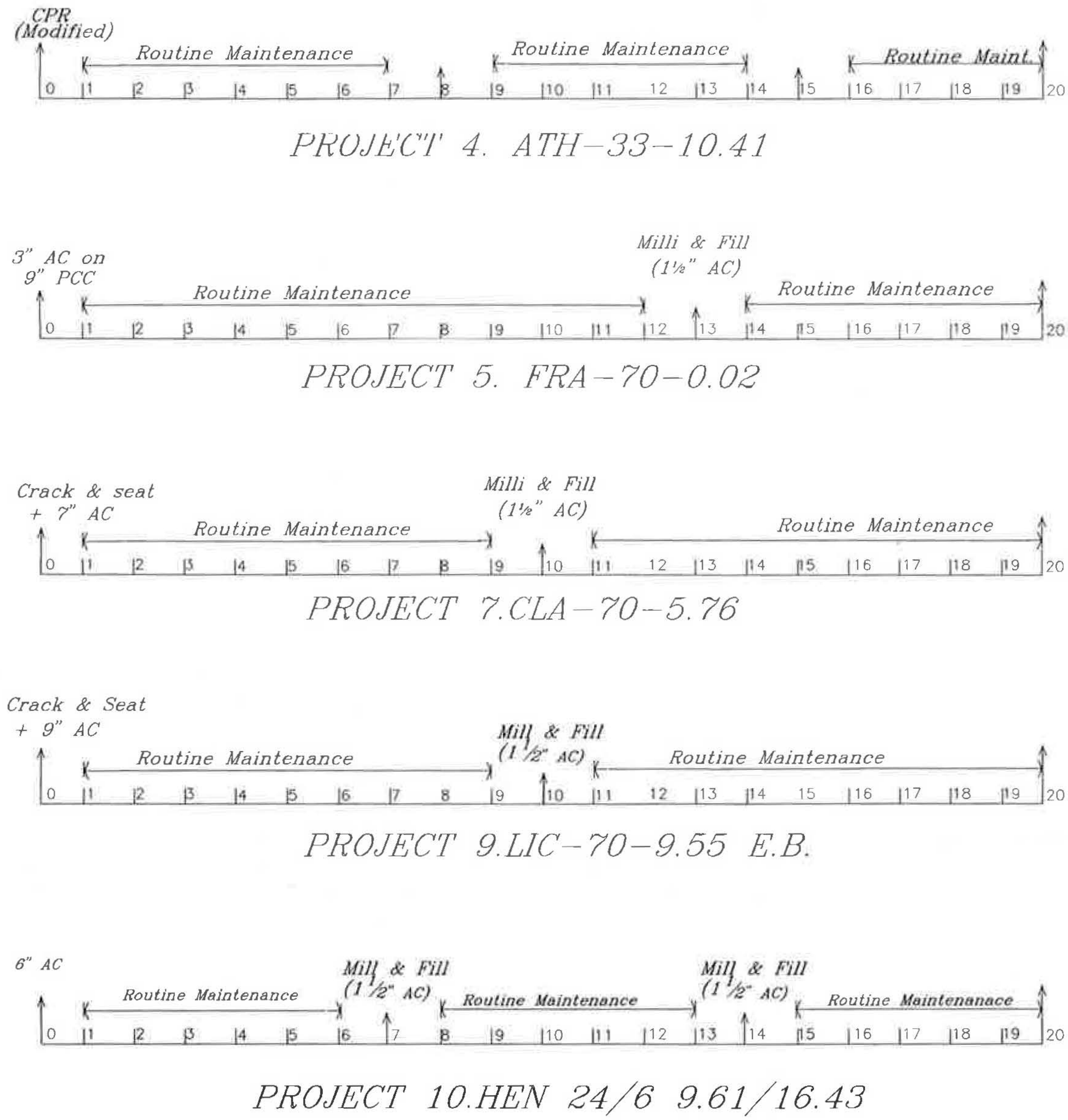


**FIGURE 3 Schedule of routine maintenance and rehabilitation.**

## DISCUSSION OF RESULTS

A straightforward method for the life cycle cost analysis of various rehabilitation actions used in existing pavements has been described. However, data to verify the various assumptions used in this analysis will not be available for several years because the projects have been rehabilitated only recently. Keeping the limitations and the assumptions used in this analysis in mind, the results of this analysis are discussed in the following paragraphs. It is important to note here that the discount rates of 6 and 10 percent did not change the rankings of projects based on SCI; therefore, the following discussions will not mention this further.

Project 5 ranks first in cost-effectiveness (SCI) according to Table 7 although it was not lowest in its initial cost (see Table 2). Alternatively, Project 4, which used a CPR action because of its better initial condition and low daily traffic, was lowest in cost at the beginning of the period but it was last in cost-effectiveness at the end of the analysis period.

Project 1, which used 10-in. PCC overlay, was second behind Project 5 in cost-effectiveness at the end of the period. The results in Table 7 indicate that a savings in rehabilitation cost may be realized by using PCC overlays (either 9 or 10 in.) for pavements of high traffic volume.

Projects 7 and 9, which were rehabilitated with C&S plus AC layers, ranked 5th and 4th, respectively, according to Table 7. The 9 in. of overlay used in Project 9 served significantly more E-18s per $1,000 than the 7-in. overlay used in Project 7.

It is interesting to compare Projects 7 and 10. According to the SCI values of Table 7, the 6-in. overlay of Project 10 was not as economical as the treatment for Project 7. That is, although traffic was about the same for both projects, Project 7 was superior to Project 10 in daily service per $1,000.

TABLE 5 LIFE CYCLE COST ESTIMATE OF PROJECT 1, CLA-70-20.92

| Year | Maintenance Actions | Cost per Lane-Mile (1988 dollars) | Cost Inflated @ 4% | Present Worth (1988 dollars) | |
|---|---|---|---|---|---|
| | | | | Disc. @ 6% | Disc. @10% |
| 0 | 10" PCC | 398,220* | 398,220 | 398,220 | 398,220 |
| 1 | Routine Maint | 220 | 208 | 196 | 189 |
| 2 | Routine Maint | 400 | 433 | 385 | 358 |
| 3 | Routine Maint | 600 | 675 | 567 | 507 |
| 4 | Routine Maint | 800 | 936 | 741 | 639 |
| 5 | Routine Maint | 1,000 | 1,217 | 909 | 755 |
| 6 | Routine Maint | 1,200 | 1,518 | 1,070 | 857 |
| 7 | Routine Maint | 1,400 | 1,842 | 1,225 | 945 |
| 8 | Routine Maint | 1,600 | 2,190 | 1,374 | 1,022 |
| 9 | Routine Maint | 1,800 | 2,562 | 1,516 | 1,087 |
| 10 | Routine Maint | 2,000 | 2,960 | 1,653 | 1,141 |
| 11 | Routine Maint | 2,200 | 3,387 | 1,784 | 1,187 |
| 12 | Grinding J&C Seal | 67,370 | 107,862 | 53,604 | 34,368 |
| 13 | Routine Maint | 200 | 333 | 156 | 96 |
| 14 | Routine Maint | 400 | 693 | 306 | 182 |
| 15 | Routine Maint | 600 | 1,081 | 451 | 259 |
| 16 | Routine Maint | 800 | 1,498 | 590 | 326 |
| 17 | Routine Maint | 1,000 | 1,948 | 723 | 385 |
| 18 | Routine Maint | 1,200 | 2,431 | 852 | 437 |
| 19 | Routine Maint | 1,400 | 2,950 | 975 | 482 |
| 20 | Routine Maint | 1,600 | 3,506 | 1,093 | 52 |
| | Total | 485,990 | 538,449 | 486,392 | 443,965 |

*Cost (1988 dollars) = Initial salvage + construction cost of rehabilitation - salvage at the end of analysis period
= $(231,000 + 238,143 \times 1.04^4 - 111,375)$
= 398,219

TABLE 6 UNIT COST OF VARIOUS REHABILITATION ACTIONS USED IN THIS STUDY (1988 DOLLARS PER LANE-MILE)

| ACTION | COST/Lane-Mile |
|---|---|
| 1. Reconstruction with rigid | $ 412,500 |
| 2. CPR | $ 183,000 |
| 3. Joint and Crack Sealing | $ 46,250 |
| 4. Grinding | $ 21,120 |
| 5. AC Overlay (3" or less) | $ 71,750 |
| 6. Mill and Fill (1 1/2" Overlay) | $ 71,750 |
| 7. Routine Maintenance Calculated by the formula: cost = 200 n, where n is the number of years after rehabilitation and cost is the dollar amount per lane-mile. | $ 200n |

This may suggest that the C&S action before overlay may have an influence on rehabilitation techniques under appropriate conditions in the future. However, this possibility must be considered in the context of the limitations under which this study was performed.

Project 3 was overlayed with 8-in. PCC. Projects 1 and 2 were overlayed with 10- and 9-in. PCC, respectively, because of expected higher traffic requirements compared with those of Project 3. The cost-effectiveness of Project 3 compared with that of either Project 1 or 2 is low and thus it appears that PCC overlay on pavements with light traffic may not be economical. An AC overlay may be more economical for low-trafficked pavements (compare Projects 3 and 10).

Finally, according to Table 7, Project 4, which used a modified CPR initially and an additional subsequent CPR with a nonstructural overlay during the analysis period, was estimated to be the least cost-effective among all rehabilitation strategies. Good original pavement condition (PCR = 64 and PSI = 2.6) and low traffic (700 daily 18-K ESALs) normally permits the use of such actions. Although such actions cost less initially, the cost of future repair and maintenance may lead to more expenses than are likely on other rehabilitation options that are more expensive initially.

In summary, the procedure used to estimate life cycle costs of various rehabilitation strategies seems to be reasonable but is only one of many methods currently used by others. The results obtained using this method appear acceptable within the context of current engineering practice. Future applicability will be established when field data become available.

## CONCLUSIONS

On the basis of the information obtained in this study, the following conclusions can be drawn:

1. An estimate of pavement rehabilitation life cycle cost involving alternative actions can be obtained by combining the following cost components:

- Initial cost of the rehabilitation action,
- Rehabilitation cost during service life,
- Routine maintenance cost, and
- Salvage value before initial rehabilitation action and at the end of the service life period.

TABLE 7 SUMMARY OF LIFE CYCLE COST ANALYSIS

| | | | Discounted @ 6% | | | Discounted @ 10% | | |
|---|---|---|---|---|---|---|---|---|
| Proj. No. | Rehab. Action | Estimated E-18 per day | Life-Cycle Cost, $1,000 (in 1988 $) | SCI | Ranking Based on SCI | Life-Cycle Cost, $1,000 (in 1988 $) | SCI | Ranking Based on SCI |
| 1 | 10" PCC | 6,100 | 468.4 | 13.0 | 2 | 444.0 | 13.7 | 2 |
| 2 | 9" PCC | 5,000 | 431.3 | 11.6 | 3 | 407.0 | 12.3 | 3 |
| 3 | 8" PCC | 850 | 373.7 | 2.3 | 7 | 349.2 | 2.4 | 7 |
| 4 | CPR | 700 | 552.5 | 1.3 | 8 | 486.1 | 1.4 | 8 |
| 5 | 3" AC/ 9" PCC | 8,950 | 397.2 | 22.9 | 1 | 370.1 | 24.2 | 1 |
| 7 | C&S/ 7" AC | 1,850 | 301.3 | 6.14 | 5 | 277.7 | 6.7 | 5 |
| 9 | C&S/ 9" AC | 4,800 | 439.3 | 10.9 | 4 | 415.7 | 11.5 | 4 |
| 10 | 6" AC | 1,800 | 427.2 | 4.2 | 6 | 387.5 | 4.6 | 6 |

Suitable inflation and discount rates can be used for this analysis.

2. In order to compare life cycle costs of various rehabilitation actions, a service cost index (SCI) based on the number of E-18s served per $1,000 of life cycle cost per day can be used.

3. Using the SCI values obtained for this study, it was found that PCC overlays with or without AC overlay are cost-effective under conditions of high traffic (5,000 to 8,950 E-18s per day, see Projects 1, 2, and 5). For low traffic conditions, 8-in. PCC overlay was relatively expensive.

4. AC overlays with C&S are slightly less expensive (measured by SCI) than AC overlay without C&S (Projects 7 and 10).

5. Costs of AC overlays effectively decrease with increasing AC thicknesses for moderate-traffic (4,800 ESAL/day) compared with low-traffic (1,800 ESAL/day) conditions (Projects 7, 9, and 10).

6. CPR is least expensive in initial cost but most expensive in life cycle cost for the low-traffic conditions under which the project was built (see Project 4).

## RECOMMENDATIONS

It is recommended that the ODOT continue to collect performance data every year for use in further evaluation of the maintenance and rehabilitation procedures that have been used in this study. Long-term performance of these pavements will enable them to determine the effectiveness of the rehabilitation techniques and develop guidelines for future actions.

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