

Feasibility Study of Changes to the Highway Maintenance and Operations Cost Index

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The highway maintenance and operations cost index, published annually by FHWA, was established in its current form in 1947 and has not been revised since. The purpose of this study was to evaluate the procedures used to develop the index, and to consider the feasibility of options—retaining it in its current form, revising, redeveloping, or discontinuing the index. This study included several tasks: a literature review of the theoretical aspects of price index development; a detailed survey of state department of transportation needs for the index, current uses, relationship to maintenance operations, preferences for change, and assessments of the utility of different options; a detailed review of other construction and maintenance indexes and related cost data; analyses of current maintenance index behavior, and comparison with construction indexes of various types; and recommendations to FHWA regarding the future of the index. On the basis of the findings of this study, the most favorable option is index redevelopment. A revised index will require collaboration between FHWA and the states for the critical tasks of identifying candidate items of labor, equipment, and materials for a simpler market basket; actually defining and building the market basket; redesigning forms (with clearer instructions) for states' submission of data; creating the weighting functions to translate state unit cost data into regional and national composites; and defining the regions that are to be encompassed. Furthermore, this collaboration must continue on a long-term basis to review the index periodically and revise it as needed.

Results of a study of the highway maintenance and operations cost index [hereafter referred to as “the maintenance (cost) index” or “the index”] are discussed. The objectives of the study were twofold:

- To evaluate the procedure now used to develop the maintenance index; and
- To perform a feasibility study of options: retaining the index in its current form, revising, redeveloping, or discontinuing it.

The index is published annually by FHWA (see Figure 1) (1). The index is based on a fixed market basket of 34 items of maintenance labor, equipment, materials, and overhead. Unit prices or costs are applied each year to these fixed

quantities of maintenance items; the resulting total cost is compared to the equivalent cost in a reference base year to compute the value of the index.

The procedures now used to compute the index involve a cooperative effort between FHWA and the states, in which the states compile their average unit costs of the 34 market basket items. These data are submitted annually to FHWA, which checks them and removes nonconforming entries. The cost data are then processed to compute the composite maintenance index, as well as subsidiary indexes for labor, equipment, materials, and overhead items.

The maintenance index serves as a price index, measuring the purchasing power of a maintenance dollar over time. Because the index is tied to a market basket, it does not reflect other conditions that also affect maintenance costs in the field, such as

- Shifting composition of the road inventory, reflecting evolution of road design standards, materials usage, and construction practices;
- Changes in maintenance policy, standards, or levels of effort (e.g., deferred maintenance, stopgap maintenance);
- Evolution of maintenance technology and practice;
- Differences in management techniques and their effectiveness;
- Effects of safety-related or other regulatory requirements (e.g., those affecting crew composition or work performance);
- Adjustments in maintenance productivity resulting from one or more of the previously mentioned items;
- Changes in need for maintenance that arise from increasing traffic, age of facility, or unusual environmental conditions.

HISTORY

The structure, composition, and analytic basis of the current maintenance index were established in 1947 to help assess cost trends in road maintenance prior to and following World War II. The index was based on the costs of maintaining a hypothetical, 10,000-mi sample of highways. This sample was composed of five types of roads: portland cement concrete, bituminous concrete, low-type bituminous, gravel-stone-soil, and nonsurfaced. The percentages of each type of road in the sample matched the actual distribution of surface types on state highways nationally in 1947.

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The annual maintenance requirements estimated for this 10,000-mi sample were decomposed into labor, equipment, materials, and overhead for six highway elements: road surface, shoulders and approaches, roadside and drainage, traffic services, snow and ice control by sand, and bridges. These maintenance requirements were then consolidated into 34 items of labor, equipment, materials, and overhead. These 34 items were priced each year, as discussed, using average costs provided by the states, with each state's cost weighted by FHWA to arrive at a national composite unit cost for each of the items. The result is the total cost of maintaining the hypothetical 10,000-mi road network. When this cost is divided by the corresponding cost computed in the reference base year, and the result multiplied by 100, the value of the maintenance index shown in Figure 1 is obtained.

In 1967, a report by NCHRP recommended changing the maintenance cost index to a unit maintenance expenditure index (2). The revised index was intended to track highway maintenance expenditures by centerline-mile and class of system.

A limitation of this proposed index was that it too would not reflect the potential variations in availability of maintenance funds, crew productivity, and other factors that affect actual maintenance performance. It would show the change in the states' expenditures from year to year, but would not take into account, for example, the reduced levels of service forced by insufficient resources. Thus, a substantial increase in the unit costs of labor, equipment, or materials might be hidden in the total yearly expenditures of the states if the levels of maintenance effort were reduced. For these reasons, FHWA management decided not to implement the recommended changes but rather to retain the maintenance cost index as originally established in 1947.

In 1987, FHWA determined that a new evaluation of the index was needed. As the era of Interstate highway construction draws to a close, the relative responsibilities of states has begun to shift from the construction of new facilities to the lifetime maintenance of facilities in place. Timely, effective maintenance is important to the ability of the highway system to safely and efficiently meet increasing traffic demands. Both the nationwide highway network and the maintenance methods used had evolved over 40 years; it was definitely time for a second look at the index. The result of this initiative was the feasibility study described herein.

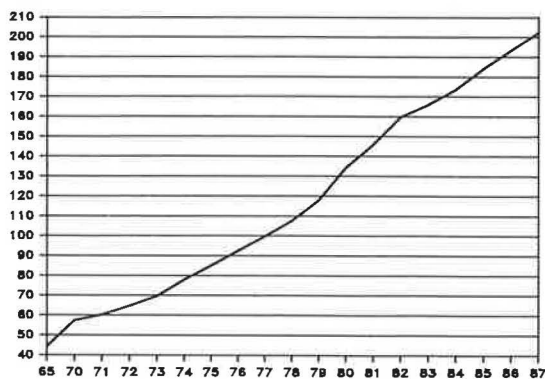


FIGURE 1 Trend of the highway maintenance and operations cost index.

OUTLINE OF STUDY

The scope of this study encompassed the current applications of the index, accuracy of its data, limitations of the data base, assumptions inherent in index calculations, and the degree to which the index reflects current maintenance and operations cost trends. Developments since 1947 in the road network itself, types and manner of data collection, changes in technical and financial record keeping, and maintenance management practices have provided the historical backdrop and current context within which revisions to the index were investigated.

This feasibility study addressed potential changes to the index to more accurately reflect prevailing conditions and trends. Data base development and data reporting requirements were examined to identify potential new sources of meaningful and measurable information, while not imposing a reporting burden on state highway agencies. Methods to assess this information for both statewide and nationwide perspectives were also examined. Costs and benefits were evaluated from perspectives of both data collection and analysis. From these findings, recommendations for future changes to the index were developed.

A close and continuing working relationship with highway maintenance practitioners was deemed necessary for the successful performance of this effort. A number of papers were prepared over the course of the study. A workshop was held to bring together representatives from state highway agencies and FHWA to exchange information and ideas on both the application of the current system and proposals for revision or redevelopment to better meet the needs of the highway maintenance community.

STATE PERSPECTIVES ON THE HIGHWAY MAINTENANCE INDEX

State departments of transportation (DOTs) represent the primary intended users of the FHWA maintenance cost index. Obtaining their opinions on the current use of the index, procedures for collecting and processing data, and options for revising the index was therefore important. Two mechanisms of contact with the states used were (a) survey of nine states, including site visits, and (b) establishment of a panel, or working group, of state representatives to offer advice and guidance during the course of this project. Both mechanisms proved to be extremely helpful and effective.

The survey of nine states constituted one of the major tasks of this project. In consultation with FHWA and the working group, nine states were included in the sample: California, Colorado, Florida, New Jersey, Ohio, Oregon, Pennsylvania, Texas, and Wisconsin. Each state designated a contact individual to oversee the completion of the survey forms and handle local arrangements for site visits. Limited by the small sample size permitted by survey guidelines, these states were not chosen randomly, but purposely, to obtain a mix of opinions regarding the index.

Two types of survey forms were prepared and distributed to each of the states:

1. A questionnaire soliciting information on the index regarding current uses, opinions, resources devoted to data

collection and processing, and elements of maintenance practice within that state that might affect the data provided for the index; and

2. A form allowing the states to assess the different options that might be taken in revising the maintenance index.

FINDINGS OF THE SURVEY

The results of the nine-state survey indicated divided opinions on the usefulness and retention of the current index. Those states that do not apply the index expressed apathy to its existence and use. Strong support came from those states that now use the index for a definite administratively or legislatively established purpose. The current composition of cost items that constitute the index remains controversial. Desired improvements suggested include (a) a simpler index, (b) regional or state indexes as well as a national statistic, and (c) updates in the labor, equipment, and materials items used to calculate costs.

Use and Usefulness of the Index

The sampled states were sharply divided on the use and perceived usefulness of the current maintenance index. The index is applied to some important functions (e.g., fuel tax determination); however, these applications appear to be limited to a few states. Four of the nine states reported not using the index at all. The other five indicated that they use it annually in various functions other than maintenance (e.g., planning, budgeting, finance, and construction). However, among these five, there are strong differences in the perceived usefulness of the index, with two of the five indicating that they could do without it. On the other hand, those favoring retention of the index identified it with important financial and budgetary responsibilities, such as its use in formulas to establish motor fuel tax rates, or in preparation and justification of maintenance budgets that, by implication, involve the state legislature as well as DOT.

Even though many states professed little or no use for the current index, they acknowledged the desire to be able to compare their cost trends with the composite trend nationwide. Thus, their position was not so much one of opposition, but more a judgment on the usefulness of the current index. This is evident in the questionnaire, where even those states suggesting elimination of the index acknowledged some uses of it, and are willing to contemplate potential changes.

The strengths of the current index, as seen by the reporting states, are the following:

- The index provides a mechanism for monitoring and comparing trends in maintenance costs.
- The index helps to prepare and defend maintenance budgets.
- The index is used in some states as a basis for road finance determinations (e.g., establishment of the fuel tax rate and apportionment of funds to local jurisdictions).

For one state, which uses the index to establish the motor fuel tax rate, the significant feature is that the index is outside the state's control, presumably lending an aura of objectivity

and impartiality to the inclusion of the index in the taxation formula.

Among the weaknesses of the index, as viewed by the states, are the following:

- The index is based on an outdated mix of technology, labor, and materials.
- Its development does not address the lack of uniformity from state to state with respect to how maintenance functions are defined, organized, managed, and performed.
- The index may embody inaccurate materials prices because of differences in units of measurement and the type of price being quoted.

Also mentioned were problems interpreting what data are needed for the index. States have found difficulty in matching their own classifications of resources to those listed on FHWA Form 1521. (Form 1521 is used annually by the states to transmit maintenance unit cost data to FHWA for the maintenance index.)

Comments during the interviews also revealed that the units specified on Form 1521 do not always reflect current pricing methods. For example, the unit price of cement is requested on Form 1521 in dollars/barrel; however, cement today is shipped either by the sack or in bulk (priced by the ton). Because bulk unit costs differ from the unit price per sack, requesting a cost in dollars/barrel is both vague and potentially distorting (depending on how the instruction is interpreted). A further problem noted during the interviews concerns cost items that are too inclusive (e.g., lumber, which includes structural and common grades, and pipe, which includes diameters from 18 to 30 in.). With so many grades or sizes of an item, which averaging procedures should be used is not clear.

Utility of a Revised Index

A second component of the state survey sought opinions on what revisions to the maintenance index would be most beneficial, and for what reasons. The responses again varied widely by state; nevertheless, when the ratings were summed and averaged to yield a global utility, clear groupings of alternatives emerged.

Alternatives having strongly positive utilities:

- Generate values that can be adjusted regionally or locally,
- Develop an index based on a limited set of maintenance data,
- Develop a composite index comprising many activities,
- Update the index annually (as opposed to more frequently),
- Base the index solely on price or cost trends,
- Maintain a federally developed index based on state input, and
- Maintain a state-developed index based on state input.

Alternatives having strongly negative utilities:

- Retain the current index with no changes,
- Update the index monthly (as opposed to less frequently),
- Incorporate other factors in the index (e.g., standards, productivity),

- Maintain a state-developed index based on input from external sources, and
- Abandon the index.

Alternatives having indifferent utilities:

- Maintain an index with a national composite value (as compared with allowing regional variations),
- Update the index quarterly or semiannually, and
- Build a federally developed index on the basis of input from external sources.

These findings support the conclusions developed earlier from the questionnaire responses. The strongly positive results may be interpreted as follows: states are looking for a simple index that includes local or regional variation, retains the credibility of a federally developed measure, but does not unduly burden the states with frequent data collection. On the negative side, states do not want to retain the current index, nor do they wish to abandon the idea of a maintenance index. Also falling into disfavor were frequent updates of the index, complicated indexes, and use of cost data from external sources (e.g., published construction cost files, or other cost indexes).

DIFFERENT INDEX FORMULATIONS

To better understand the options available in redeveloping the maintenance index, the following tasks were also undertaken by the study team:

1. A literature review of the theoretical aspects of price index development, including basic index forms (Laspeyres and Paasche index forms), mathematical formulation and calculation, the difference between shifts in index base period versus rebasing, chaining of index values, accounting for local or regional variations, mathematical properties related to behavior, and accounting for changes in quality, technology, and tastes.
2. A detailed review of other construction and maintenance indexes and related cost data, including those published by FHWA, Engineering News Record (ENR), Department of Commerce, Bureau of Reclamation, Environmental Protection Agency, Dodge Reports, R. S. Means, Leonard McMahon, Construction Labor Research Council, and Bureau of Labor Statistics.
3. A corresponding review of general economic indexes, the system of producer price indexes, and other data from the Bureau of Labor Statistics.
4. Analyses of current maintenance index behavior, comparison with construction indexes of various types, and behavioral aspects of different indexes. A partial summary of these analyses is presented in the following section.

ANALYSES OF THE CURRENT MAINTENANCE INDEX

Two major types of analyses of the current maintenance index were conducted. The first analysis investigated the distributions of unit costs submitted by states to FHWA for each of

32 direct cost items used to build the index (the set of 34 items discussed earlier, excluding the two overhead cost items). The second investigated the relative contribution of each of these 32 items to the values of the labor, equipment, and materials components of the index.

Distributions of Unit Costs

Distributions of unit costs were prepared for each of the 32 items of labor, equipment, and materials used in developing the index. Examples of two such distributions are shown in Figures 2 and 3, for bituminous mix and snow plows, respectively. Strong peaking and central tendency are evident in Figure 2 for bituminous mix, demonstrating agreement among a majority of the reporting states on unit costs in the \$20.00/ton to \$30.00/ton range. On the other hand, the distribution of costs for snow plows in Figure 3 tends to be more dispersed. Distributions of the other cost items generally fell between these extremes.

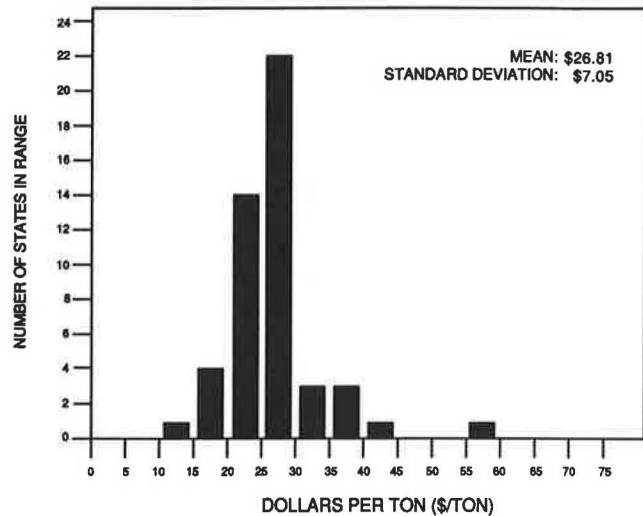


FIGURE 2 Distribution of unit costs of bituminous mix.

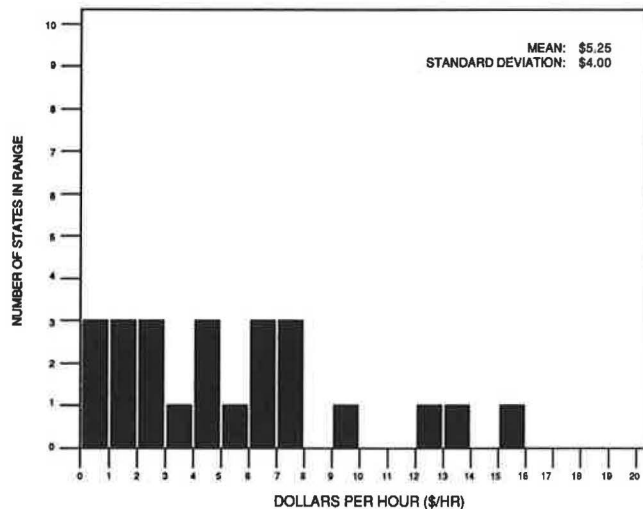


FIGURE 3 Distribution of unit costs of operating snow plows.

These data revealed patterns among the cost items. For example, those cost items whose distributions resembled Figure 2 indicated not only a similarity in unit cost values, but also agreement among states as to the description of the item for which costs must be provided, and the procedures of developing that cost. Cost items whose distributions resembled Figure 3 are either subject to greater variation in their unit costs or involve higher uncertainty or misinterpretation as to how these costs are calculated and reported. This finding indicates a need for greater uniformity in the submission of unit cost data, implying a need for clearer instructions and guidance in preparing and submitting unit cost data.

Relative Contributions of Cost Items

Cost items within each of the three major components of the index (labor, equipment, and materials) were analyzed to determine their relative contributions:

- The labor component of the index is dominated by the common labor class, whose contribution to the labor index value (about 55 percent) exceeds that of all other labor classes combined (despite the fact that common labor wages are the lowest of all labor unit costs). This dominance has remained fairly constant throughout the period analyzed (1974 to 1987), hence, the large weight given to common labor in the current index.

- The materials component of the index is dominated by three items: bituminous liquid, stone, and gravel. The dominance of these items, accounting for about 60 percent of the total materials index, has been sustained since 1974.

- The equipment component of the index is dominated by three classes: light trucks, heavy trucks, and graders, collectively accounting for 60 to 65 percent of equipment index value throughout this period. These items illustrate a fortuitous combination of weight and relative unit cost; for example, automobiles and pickups are assigned a much larger weight but their unit cost of operation is too low to influence the index by much.

The implication of these findings is that the value of the current maintenance index is essentially controlled by a handful of cost items. Rather than dealing with 34 items, the index could be based on the 10 to 20 most important items in highway maintenance, and still yield trends of comparable value and stability. Furthermore, the historical stability in the percentages, signifying the relative importance of items, implies a lack of volatility: within each index component, many of the items undergo price changes at approximately the same rate from year to year. If the most important maintenance cost items, or the ones that are trend setters in changing prices, could be identified, a reliable index based on this small set of items could be developed without sacrificing accuracy or credibility.

CONCLUSIONS AND RECOMMENDATIONS

Several of the basic assumptions around which the index has developed have evolved over time: the sample 10,000-mi network does not conform with the distribution of today's road-

way surface types; some of the classes of maintenance equipment in the index are obsolete; and both the types and units of measurement of several materials items do not conform to current practice. Although the index has provided a relatively stable picture of inputs to maintenance activities over a long period of time, these significant changes suggest discontinuing the index in its current form. FHWA is now studying this topic.

Nevertheless, the highway maintenance and operations cost index is one of but a few indexes devoted specifically to the price or cost of facility maintenance. As such, it is used for a number of purposes in tracking or projecting maintenance costs by FHWA, state DOTs, researchers, consultants, and others.

The conclusions of this study are as follows:

1. There is no compelling reason to discontinue the maintenance index entirely. This option was explicitly rejected by state DOTs in the utility assessment. The costs of producing the index are not excessive, and its existence enables tracking of maintenance price trends not only by state DOTs, but also by researchers and consultants in public policy studies of highway infrastructure. If the index were eliminated, it would be difficult to find a substitute measure that did not entail distortions now filtered out by the index.

2. The index in its current form should not be retained. This form has served well for 40 years, as indicated by the stability and consistency of its price trends. Nevertheless, it is acknowledged to be obsolete, and therefore has limited support.

3. A revised index, consistent with the desires of the surveyed state DOTs, is feasible from a technical and a policy standpoint. This conclusion is based on analyses of current index behavior, comparisons with other price indexes in construction, and theoretical considerations of index formulation. The design of an index was beyond the scope of this project; yet the following conclusions are warranted:

- The market basket of a revised index can be reduced to 10 to 20 items while maintaining the desirable behavioral properties of the current index.

- The sample highway network, which was used in 1947 to develop market basket composition and quantities, is outdated. Moreover, its use is optional in the index redevelopment, because current data on labor, equipment, and materials quantities actually used in maintenance should be available directly from state management systems.

- The current index uses an arcane system of weights to convert the unit costs submitted by states for each item to a composite national unit cost, which is applied in the index calculation. This weighting procedure should be completely revised.

- The unit cost data now submitted by states appears to vary in quality. Greater attention must be given to clarifying the items to be priced and the content of the cost or price figures in terms of what they should or should not include.

- A set of regional indexes desired by the states is feasible computationally, and involves negligible incremental costs. The main issue is policy related; states desire comparisons among regions, as opposed to simply data on trends within a given region.

- Periodic checking of the index's market basket is advisable (i.e., every 5 to 10 years). If significant differences exist (or are anticipated), the index should be rebased or the weighting functions revised.

A revised maintenance index will require collaboration between FHWA and the states for the critical tasks of identifying candidate items of labor, equipment, and materials for the market basket; actually defining and building the market basket; redesigning Form 1521 and developing instructions to state DOTs for completing the unit cost form annually; creating the weighting functions to translate state unit cost input into regional and national composite; and defining the regions that are to be encompassed by the maintenance index. Furthermore, periodic reviews of both the market basket and the index's weighting functions are needed.

A potential mechanism to accomplish these items is a joint panel of state technical experts working in concert with FHWA technical experts. The structure and authority of this task force remain to be defined by both FHWA and the states. Having as wide a representation as possible would be useful, because this group would establish the broadest possible base for defining the market basket and the weighting functions. If this panel is untenable or unwieldy, then a sample of states or a hierarchical structure that grouped states by regions might be feasible.

The FHWA has taken these recommendations under advisement, and will consider the future of the index from three major perspectives:

1. Any redevelopment undertaken must be geared to producing an index that can be implemented and used by both the states and the FHWA.

2. The index inputs should reflect today's maintenance practices, and should not place an undue burden of data collection and analysis on state agencies.

3. As the index would still require information to be gathered from nonfederal sources, it must be defensible from both the technical and the administrative viewpoint.

ACKNOWLEDGMENTS

This study has been sponsored by FHWA. The authors wish to acknowledge the contributions of George Romack, of FHWA, who prepared some of the background material on the index that is cited herein.

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Publication of this paper sponsored by Committee on Maintenance and Operations Management.