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Bridge Inspection Program: a Vital Bridge Planning Program Aid

Programme d'inspection de ponts: élément essentiel de la gestion des ponts

Inspektion von Brücken: ein wichtiges Element im Brückenmanagement

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SUMMARY
The required inspection of bridges at regular intervals not to exceed 2 years provided much information on the relative condition of bridges in each governmental entity. This information can be used in the planning, budgeting and decision-making process for all phases of a bridge program from routine maintenance to the replacement of major structures.

RESUME
L'inspection requise de ponts à des intervalles réguliers, ne dépassant pas 2 ans, fournit beaucoup d'informations sur l'état relatif des ponts à chaque niveau de l'administration. Cette information peut être utilisée pour le projet, le budget et la prise de décisions dans toutes les phases d'un programme de construction, d'exploitation et de remplacement de ponts.

ZUSAMMENFASSUNG
Wichtige Informationen über den Zustand der einzelnen Brückenverwaltungen zugeordneten Brücken können aus der in zweijährigen Intervallen nötigen Brückeninspektion gewonnen werden. Diese Informationen sind von grossem Wert bei der Planung, bei Kostenvoranschlägen und im Entscheidungsprozess von Brückenunterhalt bis zum Ersatz ganzer Konstruktionen.

1. HISTORY

Until the December 1967 collapse of the Silver Bridge over the Ohio River between West Virginia and Ohio, very little support existed for a national bridge inventory and inspection program in the United States. The collapse caused 46 deaths and the public outcry and subsequent Congressional hearings resulting from the tragedy clearly supported the need for a national program. The hearings demonstrated that many States were not sure how many bridges they owned and others had no formalized inspection or recordkeeping procedures.

As a result of these hearings, the Congress, in the 1968 Federal-aid Highway Act, directed the Secretary of Transportation "in consultation with the State highway departments and interested and knowledgeable private individuals . . . to establish national bridge inspection standards . . . for the proper safety inspection of bridges on any of the Federal-aid highway system." The law required each State to maintain a current inventory of all bridges on the Federal-aid system.

In the 1970 Federal-aid Highway Act, the Congress directed the Secretary in consultation with the States to inventory all bridges on the Federal-aid highway systems over waterways and other topographical barriers, classify them according to their serviceability, safety and essentiality for public use and assign each a priority for replacement.

On April 27, 1971, the National Bridge Inspection Standards (NBIS) were issued to satisfy the mandate of the Congress. By the end of 1973, most States had inventoried all bridges on the Federal-aid highway systems.

In the 1978 Surface Transportation Assistance Act, the Congress directed the Secretary of Transportation to extend the inventory and inspection program to include all highway bridges on public roads. The inventory was to be completed by December 31, 1980.

As a result of the legislation discussed above, the National Bridge Inventory contains data for virtually all of the 260,000 bridges on the Federal-aid highway systems and for 98 percent of the 314,000 bridges on all other public roads.

The current requirements of the NBIS stipulate that bridges on public roads be reinspected and the inventory updated at least once every 2 years.

All inventories, inspections and appraisals are done under the direction of State and local governments. The inventory data is sent to the Federal Highway Administration (FHWA) at least once a year by the State for inclusion in the National Bridge Inventory (NBI). The NBI is maintained by the FHWA and used for many purposes.

2. PURPOSE OF BRIDGE INVENTORY AND INSPECTION

Bridge inventory data has many uses for both bridge owners and the nation as well. The first step in the rational management of any extensive array of physical elements is a current inventory of the condition, age, capabilities and needs of its component parts.

The primary purpose of the inspection program is to be sure that bridges are safe for public use. In accordance with the NBIS, all bridges must be evaluated for safe load capacity. If the bridge will not safely carry the maximum State legal load, it must be load posted or, if not safe to carry at least equal to 13.35 kiloNewtons (3 tons), it should be closed to traffic.

While there is a maximum national load limit on the Interstate highway system, individual States may set lessor load limits on the Interstate system and are free to set any load restrictions they deem appropriate on other public roads within their State. As of December 31, 1981, nearly 150,000 of the Nation's bridges were reported as requiring load restrictions. About 3,400 bridges were reported as closed to all traffic.

These figures are positive indications that State and local governments are using inventory and inspection data to limit the loads on sub-standard public bridges.

While the public safety is and must be assured through application of the provisions of the NBIS, the data gathered has many additional uses in the overall management of the highway system.

When the NBIS was initiated, many individuals and management officials of State and local highway agencies did not have a reasonable knowledge of how many bridges they owned, much less what condition they were in. Most forward thinking engineers and managers rightfully saw the NBIS as a means to meet their bridge system management needs.

From a more practical viewpoint, the NBIS provided State and local government officials the opportunity, for the first in many cases, to document the fact that bridge needs had reached the critical stage on many elements of the Nation's highway system. Many experts have been voicing this opinion for some time, but it has never been fully documented to the extent that national, State and local governmental bodies had to face the hard, physical facts that more resources must be devoted to bridges.

From the inception of the NBIS in 1971, many State officials elected to gather data over and above that required for NBIS purposes. Some of these will be discussed later. However, obvious purposes for the data include:

1. Establishment of physical records for each bridge.
2. Predictions of rate of deterioration.
3. Failure predictions.
4. Cost-effective evaluation of past bridge repair and rehabilitation.
5. Truck overload routing.
6. National defense uses.
7. Maintenance scheduling.
8. Establishment and documentation of historical bridges.

3. DATA GATHERING

From the inception of the national program, rigid standards were established for the qualifications of the inspectors and the format of the data for inclusion in the NBI.

According to the requirements of the NBIS, the individual in charge of the State bridge inspection organization must:[1]

1. Be a registered professional engineer; or
2. Be qualified for registration as a professional engineer under the laws of the State; or
3. Have a minimum of 10 years of experience and completed a comprehensive training course based upon the "Bridge Inspector's Training Manual."

STRUCTURE INVENTORY & APPRAISAL SHEET

Revised 12-78

IDENTIFICATION

State ____
Hwy District ____
County ____ City/Town ____
Inventory Route ____ On ☐ Under ☐
Features Intersected ____
Facility Carried by Structure ____
Structure No. ____ 1 of ____
Location ____
Min. Vert. Clearance, Inv. Rte. ____ ' ____ "
Milepoint ____
Road Section No ____
Defense Bridge Description ____
Defense Milepoint ____
Defense Section Length ____
Latitude ____
Longitude ____
Physical Vulnerability ____
By pass, Detour Length ____
Toll ____
Custodian ____
Owner ____
FAP No ____

CLASSIFICATION

Highway System ____
Administrative ____
Functional ____

	By	Date
Transfer of Data		
Maintenance Insp.		
Condition Analysis		
Appraisal		
Cost Estimate		
General Review		

STRUCTURE DATA

Year Built ____
Lanes on Str. ____ under ____
ADT ____ Year ____
Design Load ____
Appr Rdwy Width w/Sh'ld ____
Br Median ☐None ☐Open ☐Closed
Skew ____
Structure Flared ☐Yes ☐No
Traffic Safety Features ____
____
Navigation Control ☐Yes ☐No
- Vertical ____ ft
- Horizontal ____ ft
Open, Posted, or Closed ____

Type Service ____ code
Structure Type - Main ____
- Approach ____
No of Spans - Main ____
- Approach ____
Total Horiz. Clearance ____ ft
Max Span Length ____ ft
Structure Length ____ ft
Sidewalk ____ Lt ____ ft, Rt ____ ft
Br Roadway Width (curb-curb) ____ ft
Deck Width (out-out) ____ ft
Vert Clearance over Deck ____ ' ____ "
Underclearance - Vertical ____ ' ____ "
- Lateral Right ____ ft
- Left ____ ft
Wearing Surface ____

CONDITION

	Material	Condition Analysis	Rating (9-0)
Deck			
Superstructure			
Substructure			
Channel & Channel Protection			
Culvert & Retaining Walls			

Estimated Remaining Life ____ Approach Roadway Alignment ____
Operating Rating ____ Inventory Rating ____

APPRAISAL

	Deficiencies	Rating (9-0)
Structural Condition		
Deck Geometry		
Underclearances - Vertical & Lateral		
Safe Load Capacity		
Waterway Adequacy		
Approach Roadway Alignment		

PROPOSED IMPROVEMENTS

Year Needed ____ ; Completed ____ Describe (item 75) ____
Type of Service ____
Type of Work ____
Improvement Length ____ ft
Design Loading ____
Roadway Width ____ ft
Number of Lanes ____ Prop Rdwy Improvement - Year ____
ADT ____ Year ____ - Type ____

Remarks:

Cost of Improvements ____ $ ____ ,000
Prel Engrg ____ $ ____ ,000
Demolition ____ $ ____ ,000
Substructure ____ $ ____ ,000
Superstructure ____ $ ____ ,000
Insp Date ____

Figure 1

An individual in charge of a bridge inspection team must meet the same qualifications or have a minimum of 5 years bridge inspection experience and have completed a comprehensive training course in bridge inspection.[1]

While many States collect more data than is required for NBI purposes, the standard data for the NBI is shown in Figure 1, "Structure Inventory and Appraisal Sheet." The data gathered must be in conformance with the "Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges, January 1979."[2]

In accordance with the NBIS, each bridge must be inspected a minimum of once every 2 years; oftener if the condition of the bridge warrants more frequent inspections.

The data shown on the Structure Inventory and Appraisal (SI&A) Sheet is considered minimal for national purposes. (A shorter version is permitted for use by local governmental officials on bridges on less important highways.) There has been great pressure from many diverse sources to expand the number of required data items on the SI&A Sheets. For the most part, these pressures have been resisted to minimize the economic hardship that inspection requirements impose on State and local governments.

Further, while most States and bridge experts agree that a 2-year lapse between inspections is about the maximum that can be tolerated if the general safe public use of bridges is to be assured, evaluations are underway to determine if a longer lapse between inspections is appropriate for certain categories of bridges. Tentative results indicate that for bridges in very good condition that are not over waterways, a longer time lapse between inspections may be appropriate.

For the most part, the inventory, inspection and appraisal of the Nation's bridges has taken place with remarkably good results and at a better than expected pace. The 260,000 bridges on the Federal-aid highway system have virtually all been inspected and inventoried and 98 percent of the 314,000 bridges on all other public roads not on the Federal-aid highway system have been inspected and inventoried since these were included under the NBIS in March 1979.

4. A PLANNING TOOL

The immense amount of data in the NBI now can be used for a variety of purposes. For example, using the data in Figure 2, one can determine the correlation the age of bridges versus the percent which are deficient by decade. These plots indicate the general trend of the life span of bridges, emphasize that bridges off the Federal-aid highway system become deficient faster than those on the system and that the life span of off-system bridges is shorter than those on the system.

Figure 3 depicts the number of bridges still in use by decade built. Again there is much useful data, The "boom" and "bust" years of bridge building can readily be seen to be influenced by the general national economy. One can also see that there are a substantial number of bridges built before 1940 still in everyday use. Plans must be made to accommodate heavy maintenance, rehabilitation or replacement of most of these during the next decade or two, if the highway system is to remain useable.

From a national viewpoint, the available NBI data is used by the Secretary of Transportation and the Congress in establishing national transportation policy. At the moment, it is one major factor in deliberations pertaining to whether there should be a uniform national truck size and weight law, and, if so, what should national weight limits be. For example, even though most of the Interstate highway system was designed to accommodate HS20 trucks as designated by the American Association of State Highway and Transportation Officials, more than

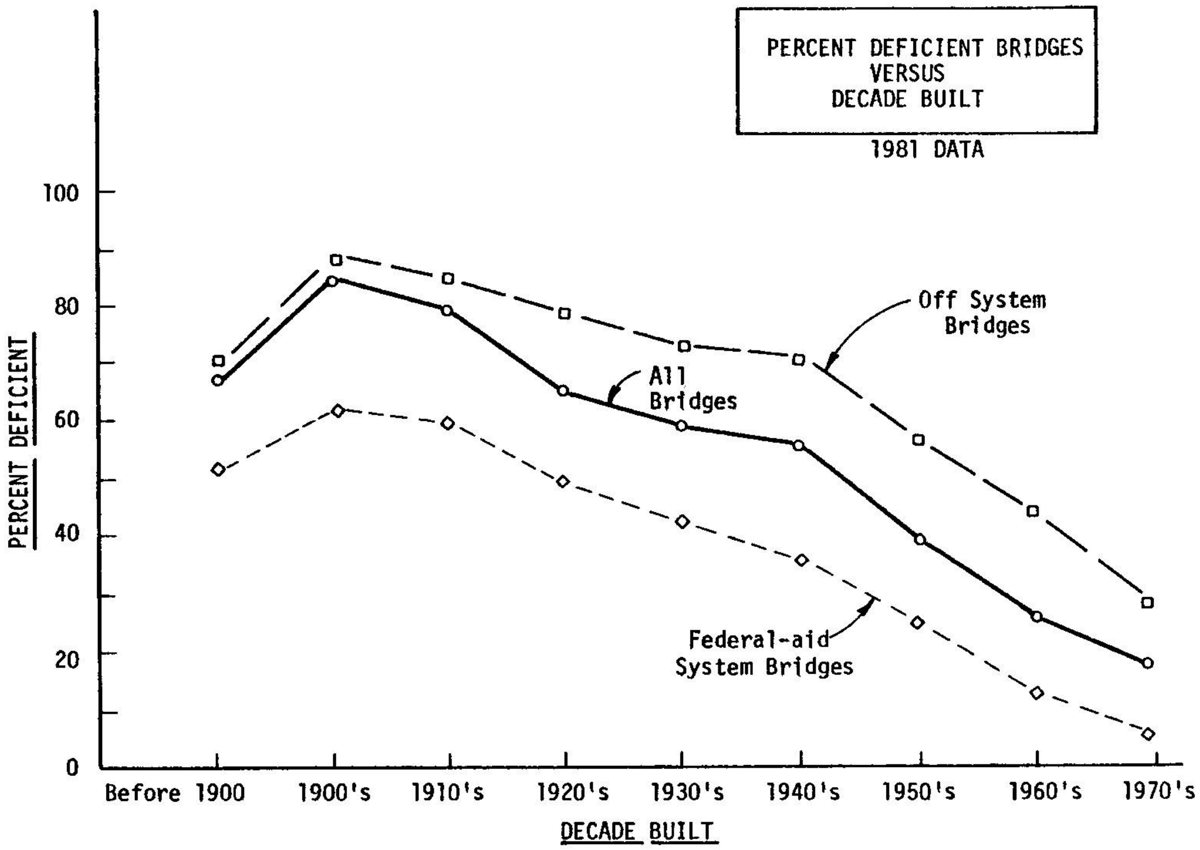

FIGURE 2

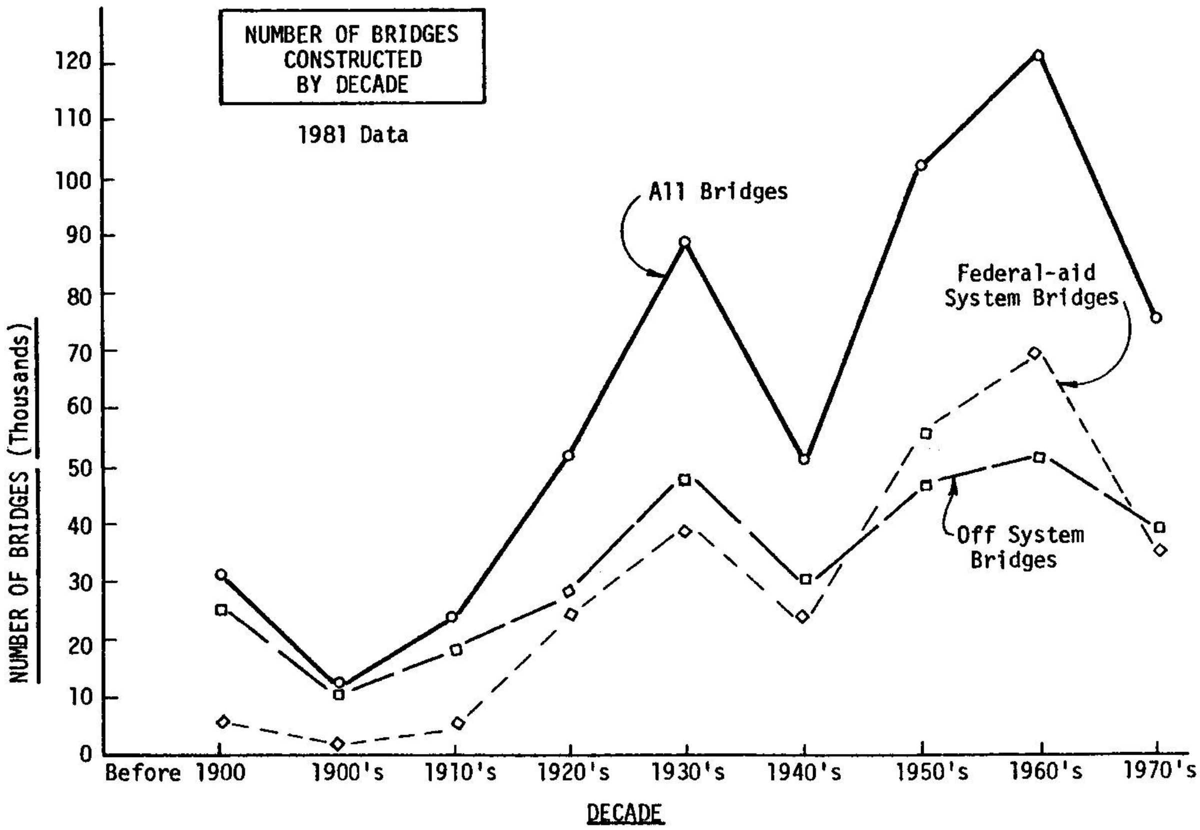

FIGURE 3

800 Interstate bridges have only H15 load capacities.[3] Fortunately, most of these are not main line structures, but they must be accounted for in any deliberations pertaining to national truck size and weight issues.

One critical element of much of the Federal-aid highway system is that of concrete bridge decks. It is well known that most States in northern and moderate climates are having problems caused by deicing chemicals applied to concrete bridge decks. But it was only by use of NBI data that the true magnitude of the bridge deck problem was identified. More than 39,000 bridges have a deck condition rating of 4 or less (marginal condition).[4] The deck data is being used to formulate a new national policy regarding cost-effective methods to prevent further deterioration.

Using NBI data, it was established this past year that bridge resurfacing, restoration, rehabilitation and reconstruction needs on the Interstate highway system are $9.6 billion.

Perhaps the most important use of the NBI data is to track bridge needs versus the national bridge program size. Figure 4 illustrates this. Caution in using the data is advised. One reason for the rapid growth in bridge needs depicted on the chart is the fact that the total bridge inventory was not essentially complete until the very last year or so shown. Earlier need estimates were based upon partial data.

This year, a new historic bridge item is being added to the required NBI data. Because special permits, project approval processes and reports must be developed and approved before historic bridges are replaced or rehabilitated, it is important to know their historicity well in advanced of any project. Otherwise, intolerable and costly delays in projects involving historic structures may result. It is, of course, beneficial to know the categories of existing historical bridges whether or not improvement projects are contemplated.

The NBI is used to supply certain data to the Department of Defense to enable adequate planning for national emergencies. These uses are obvious.

In the last several years, some experts have suggested that the NBI should contain data on bridges with fracture critical members. (A fracture critical member is one whose failure will cause failure of the bridge. Examples are the ties of tied arches, suspension bridge cables, tension chords of trusses, etc.) This knowledge is perhaps important for States to keep track of but is not at this time considered vital to the NBI.

While bridge structural safety is of critical importance, in an average year as many as 1,000 to 1,500 people are killed in the United States when errant vehicles strike bridge members. Bridge rails, guardrails, piers, end posts and abutments are the most common components hit. For this reason, a portion of the NBI is devoted to the adequency of safety appurtenances on bridges. These data are used by many experts in assessing safety, establishment of programs and setting priorities for the upgrading of bridge rail, guardrail and other safety devices on bridges. For example, the authors of NCHRP Report 239, "Multiple-Service-Level Highway Bridge Railing Selection Procedures," used NBI bridge railing data.[5]

5. A FINANCIAL TOOL

One of the most significant planning tools the NBI data can be used for is that of planning the financial requirements for development of natural resources or new manufacturing or processing centers. The existing load capacity of bridges and potential costs to increase them to desired amounts can be readily determined.

With rapidly changing sizes and characteristics of both passenger vehicles and trucks, the NBI data can be used to evaluate the need for and impact of any change in geometric standards for various elements of the existing national highway system.

Of primary importance is the capability of using the NBI data to evaluate energy impacts on the national economy stemming from current or future detours of heavy trucks. Nearly 127,000 of the Nation's bridges are currently reported as structurally deficient. Annual detour costs well in excess of $1 million per bridge have been reported for heavily traveled bridges in urban areas.[6]

The NBI has been used from the very beginning of the program as a tool for prioritizing bridge replacement and rehabilitation projects. A sufficiency index for each deficient bridge is computed using the NBI data. Generally, the lower the sufficiency rating, the higher the priority for replacement. However, other local and State factors must be considered. The sufficiency rating is described in Appendix A of reference 2.

The NBI is useful as a means of selecting research projects, determining the need for innovative rehabilitation techniques and for budgeting of future research programs.

COMPARISON BETWEEN FUNDING LEVELS AND NEEDS FOR THE HIGHWAY BRIDGE REPLACEMENT AND REHABILITATION PROGRAM

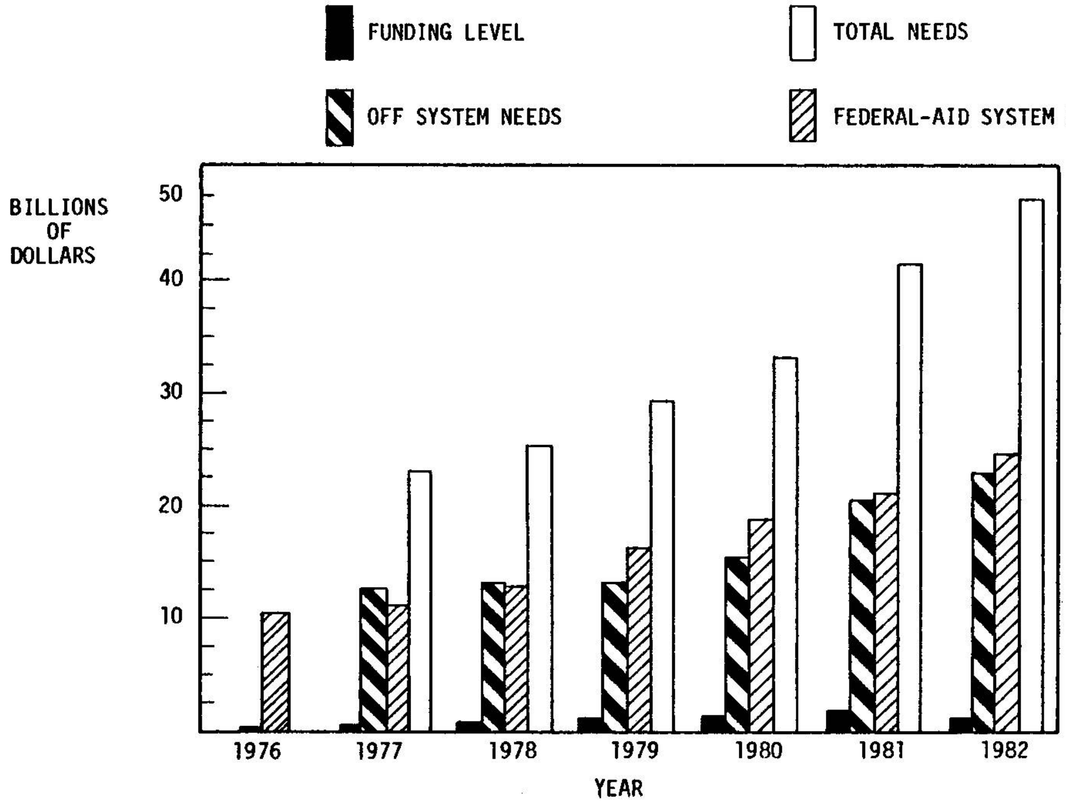

FIGURE 4

6. INSPECTION COSTS

The costs of inspection are important to evaluate the cost effectiveness of the program. Initial inventory and inspection costs have been reported as averaging from $43 to $650 per bridge. One State has reported an average cost of $0.67 per square meter ($0.06 per square foot). It is estimated that the average cost for initial inspection and inventory was about $300 per bridge. Because the initial inspection and inventory of a bridge often requires the measurement and recording of physical data, especially when construction plans are not available, subsequent inspections should be substantially less expensive.

The benefits resulting from the inspections substantially exceed the costs. These benefits accrue from prevention of loss of lives from bridge failures, prevention of detours and traffic delays imposed by closed bridges, savings of energy and general societal costs not incurred because bridges are available in time of fire, accident or related emergencies. Many times, the prompt discovery of a bridge defect may allow correction for a modest expense before major elements of a bridge fail. Computational analysis by the Federal Highway Administration staff has indicated that the benefits are in excess of $100 million per year.

7. SUMMARY

In summary, it can be demonstrated that:

1. A rational national bridge program depends upon an accurate and comprehensive bridge inventory.
2. The Federal Highway Administration holds national bridge data requirements to a minimum, but State and local officials can and often do add data items for their own management and planning purposes.
3. The benefits and savings in human life resulting from the bridge inspection program far outweigh program costs.
4. Other financial benefits are very large.
5. No State is yet taking full advantage of the bridge data available.

8. REFERENCES

1. U.S. Code of Federal Regulations, Highways, Title 23, Section 650.3.
2. Federal Highway Administration, U.S. Department of Transportation, Recording and Coding Guide for the Structure Inventory and Appraisal of Our Nation's Bridges, January 1979.
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