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Bridge Inventory and Inspection Programs in New York State

Inventaire des ponts et programme d'inspection dans l'Etat de New York

Zustandsaufnahme und Überwachungsprogramm der Brücken im Staat New York

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SUMMARY

Bridge inspection is an accepted and necessary part of the activities required to assure bridge safety. Records produced as a part of a bridge inspection program may be supplemented with other data and be used for a variety of bridge program management purposes. Because of the competition for construction funds, it is important that transportation system managers have the means to identify problems and costeffective solutions, and have the ability to allocate funds in such a way as to produce the best possible transportation system at the least cost. This paper reviews the type of records which are of value for this purpose and the way in which the information is obtained and used to produce the desired result.

RESUME

L'inspection des ponts fait partie des activités nécessaires à la sécurité de ces ouvrages. Des protocoles de mesures effectuées dans le cadre d'un programme d'inspection peuvent être complétés par d'autres données utiles et être utilisés pour des programmes de gestion de ponts. Eu égard aux fonds limités, il est important que les responsables puissent identifier les problèmes et leurs solutions afin d'attribuer les fonds de façon à produire le meilleur système de transport pour les frais minima. Ce rapport présente le genre de mesures à effectuer et la façon de les réaliser.

ZUSAMMENFASSUNG

Die Brückenüberwachung ist eine allgemeine akzeptierte und notwendige Tätigkeit, um die Sicherheit von Brücken zu garantieren. Protokolle, die als Teil eines Brückenüberwachungsprogrammes erstellt werden, können mit zusätzlichen Daten ergänzt und für den Ablauf verschiedener Brückenbauprogramme benützt werden. Wegen der Nachfrage für Baukapitalien ist es wichtig, dass die Verantwortlichen die Mittel haben, Probleme und kosteneffektive Lösungen zu erkennen, und dass sie die Fähigkeit besitzen, Kapital so zuzuteilen, dass ein bestmögliches Transportsystem zu geringsten Kosten geschaffen wird. Dieser Beitrag behandelt die Art von Protokollen, die zu diesem Zweck von Wert sind und zeigt, wie diese Information zustande kam und verwendet wird, um die gewünschten Resultate zu erzielen.

This symposium is devoted to the maintenance, repair and rehabilitation of bridges. Just as any properly engineered bridge must have an adequate foundation, planning for bridge maintenance, repair, rehabilitation and replacement must also have an adequate foundation. That foundation is provided by the development of a bridge data file, the gathering of bridge information for the data file and the use of the data to identify what should be done to the bridges in the inventory, and when.

Because the funds required for the correction of bridge problems have never been sufficient to meet all needs, and probably never will be, it is important for a bridge owner to identify problems and cost-effective solutions, and to have the ability to allocate funds in such a way that the transportation system containing the bridges is allowed to operate at the greatest possible efficiency. This can be done with accurate and current bridge inventory and inspection records, and the means to analyze the records.

This paper will discuss what should be included in a bridge data file, how the information should be obtained, how the information should be managed and how the information can be used. The experience of the New York State Department of Transportation will be used to illustrate the accomplishment of these activities.

First, some definitions will be useful. A bridge data file is made up of two elements, information about the bridge which does not change with time, defined as inventory data, and information about the bridge which does change with time, defined as inspection data. Inventory data is constant; inspection data varies with the bridge condition.

THE CONTENTS OF THE FILE

The first and most important consideration when developing a bridge data file is the contents of the file. The number and type of items which go into making up an inventory file and an inspection file can vary widely depending on the purposes for which the file is to be used. Those creating the file must first decide what these uses will be.

The minimum content for files maintained in the United States is found in the "Recording and Coding Guide for the Structures Inventory and Appraisal of the Nation's Bridges". This is a 40 page manual published by the Federal Highway Administration (FHWA) and endorsed by the Subcommittee for Bridges and Structures of the American Association of State Highway and Transportation Officials (AASHTO). It identifies and describes 57 inventory items, 16 inspection and appraisal items and, if the bridge is to be rehabilitated or replaced, 16 items relating to the proposed improvement.

The inventory items include 16 items relating to bridge identification, location and jurisdictional information and 31 items relating to bridge type, dimension and geometric information.

The inspection or condition related items include an evaluation of the deck, superstructure, substructure, stream channel and bridge protection and retaining walls, if any. These items are rated on a scale of 0 to 9, with zero being the poorest condition and nine the best. Three other items are found in the inspection group, two providing the load capacity of the bridge and the third an estimate of the remaining life of the bridge.

The appraisal items are intended to evaluate a bridge with relation to the highway system it serves, and include numerical rating values for the general condition of the bridge, the relationship of the bridge to the approach highway width, the adequacy of the vertical and horizontal underclearances, the safe load capacity, the waterway adequacy and the adequacy of the alignment of the approach roadway.

The items related to future improvements provide the basic information required for establishing the criteria for a bridge replacement, should one be judged necessary. These include the proposed bridge length, width and loading requirements; the date when the new bridge should be completed and the estimated cost of the bridge.

These inventory, inspection and appraisal items make up the minimum data which must be reported to the FHWA for each public bridge in the country, each year. The requirement for this is found in Federal statutes and the data collected is used to provide a continuing national perspective on bridge conditions and a means to allocate Federal aid for bridge rehabilitation and replacement among the states.

Many states have established inventory and inspection programs which only gather this data. Others, including New York, have gone beyond these requirements in order to build a file which has far greater use. The incremental extra cost of gathering the additional information was small, so the additional benefits derived from the larger file were obtained with little extra expence.

In New York the content of the file was developed in 1970 with a series of discussions involving all potential file users, aimed at identifying all information which might possibly have any value for any purpose. The uses of the file identified at that time included the ability to assure bridge safety, to prepare bridge maintenance work programs and bridge construction programs, including prioritizing of projects; to assist with short and long-range capital budget planning; to evaluate load capacities of bridges; to assist with the routing of overloads; and to evaluate new structure types and details.

This effort resulted in the establishment, by 1972, of a bridge data file consisting of 194 inventory items and 60 inspection items. In 1978 a number of additional items were added which were required for the Department's bridge load rating program. These items are kept in a separate file, called the bridge load rating file, but the type of data is either inventory (fixed) or inspection (condition variable).

The New York State inventory, inspection and load rating data files are computerized and the data is stored in the Department's computer center in Albany. A new inventory and inspection data management system went into use on July 1, 1982 and all file data was converted to the new system at that time. Because the development of the new system incorporated data base management concepts, in which inquiry is made directly to the data source rather than through a sort process, inquiry response time has been greatly reduced from that required for the old data management system. This permits on-line inquiry, and allows the use of remote cathode ray tube terminals in the Regional Offices of the Department. This development also allows the scrapping of vast amounts of paper; the hard copy output from the data file.

The New York State inventory file includes 55 items of bridge identification, location and jurisdictional information; 68 items of bridge type, dimension and geometric information; 27 items of bridge detail and hardware information, such as railing types, curb types, drainage and lighting; 9 appraisal items; 12 items required for planning future improvements and 21 items relating to the underpassing roadway, if any. The significant differences between the minimum inventory described earlier and the New York State inventory are that the New York inventory records each span of a bridge rather than the bridge as whole, providing important detail; records ramps which meet or leave bridges as separate bridges, a useful feature in complex interchanges; includes bridge detail and hardware information and uses more questions to gather certain information so that the information can be more specific and thus more useful.

The inspection portion of the New York State bridge data file includes condition information on abutments, wingwalls, stream channel, bridge approaches, deck elements, superstructure, piers and utilities, with the condition of 50 items spread across these eight categories and recorded on a per span basis at the time of each inspection. In addition, each of the eight bridge elements noted above are given a condition rating, and the bridge itself is given a condition rating. New York State rates bridge conditions using a scale of 1 through 7, with 1 the worst and 7 the best. Finally, the inspection includes nine items related to repairs which are found to be necessary as a result of the inspection, and the quantities of material or work required to make the repairs.

The bridge rating portion of the file, created six years after the inventory and inspection portion, contains additional, more detailed inventory information about the structural system and deck of the bridge and additional information about the level of deterioration of the critical parts of the bridge.

In New York State bridges are also documented in a manual file, called the bridge history file. This is done to provide a means of capturing and retaining, in one place, important information which is not readily kept in a computer file, in addition to copies of the input data for the computer file. The bridge history file is intended to complement the computerized data file so that an immediate response can be provided to most questions relating to a specific bridge by reviewing both information sources. The contents of the bridge history file include:

Photographs showing
- both approaches to the bridge
- the bridge roadway
- the bridge in elevation (from both sides for a stream bridge)
- the configuration of abutments, wingwalls and piers
- a general view of the underside of the bridge
- problem areas, if any
- the bridge identification number

A statement indicating where the bridge plans are located, or preferably a set of plans, if the plans are not preserved on microfilm.

Foundation construction information, including pile driving records and foundation design loads.

Other construction information which might have future value.

Hydraulic design information, if a stream bridge.

Bridge inventory, inspection and load rating input forms.

Other information may be included, if it is needed to provide the quick response capability. The bridge history file is maintained by the Department's staff in the Regional Office having jurisdiction over the bridge.

The forgoing discussion related to the content of the bridge data file, and the considerations which must go into developing that content. Following the establishment of the content the major work effort of a bridge data program must take place - the gathering of the information for the file.

THE GATHERING OF THE INFORMATION

Here, as with all engineering activities, the most important concern must be control of quality. The best-conceived data file will be of little or no value unless the material in it is creditable. The data must be gathered by personnel who understand what a bridge is and how it functions, and who are well trained in the use of the data storage system and the forms used for inputing that system.

The personnel should be engineering professionals, or technicians with many years of bridge related experience. They must be well-motivated and conscientious, since they will be working without direct supervision. Their training must include strong emphasis on the interpretation of condition data, which makes up a significant part of the file and is subjective. The work must be monitored on a continuous basis so that problems are solved early and not allowed to continue or grow. And the work should be subjected to extensive editing and proof checks, not because of lack of confidence in the workers, but simply to assure that the best information possible goes into the file. Edit checks may be used to normalize the information which, despite training, might vary because many people are likely to be involved in the data gathering.

For efficiency in data gathering, inventory information should be obtained from existing paper records whenever possible. Doing so reduces the field time required for the work, and allows work to continue during periods of bad weather. Data taken from paper records should be verified during field visits to the bridge since there can be changes during construction which do not show up on record plans, and work done by maintenance forces during the life of the bridge which has not been documented.

New York State Bridge data has been gathered in a variety of ways. A pre-1970 data file, with a small amount of information about the more than 6000 bridges owned by the state, was converted to the present system using a computer to make the transfer. The result was printed with blanks shown where data required for the new file was missing. This output was sent to the Department's Regional Offices with instructions to verify the information in the file, and gather the missing data. This work continued for several years. In addition, the file was subjected to an intensive edit prior to the recent changeover to the new data-base management system mentioned earlier.

Inspection data for state bridges is gathered on a regular basis by state personnel assigned to the maintenance program of the Department. The inspectors receive training annually in order to sharpen their skills, inform them of new

types of bridge problems, make them aware of inspection deficiencies noted in the previous year and generally make them understand what is needed to make quality inspections. Rating data for state bridges has been and continues to be gathered by the Regional Office staff. This work has not progressed as rapidly as desirable, but will be completed in the next year or two.

Data relating to the remaining publicly owned bridges in New York State are documented in the bridge data file as well. This includes more than 11,000 County, Town, Village and City bridges, as well as those owned by authorities. The information for virtually all of these bridges was obtained by consulting engineers working under the direction of the Department, as a result of an action by the New York State Legislature of 1977. The continuing inspection of these bridges is also being done by consulting engineers, but at a slower pace than desirable because of competition for limited funds.

THE MANAGEMENT OF THE INFORMATION

After the content of the data file is established, and the information for the file obtained, the file must be maintained. The management of the file includes three important elements. The first is to assure that the file contains all the data required for bridge decisions, the second is to have the data accessible, and the third is to have the data creditable. Fundamental to all aspects of managing the data file is the need for a responsive computer system designed to serve the system user. The requirements for the computer system should include security for the data and the ability to readily recover and manipulate the data. The data itself has no value; its only value is its availability for use.

In New York these requirements have been met. The first was accomplished by devoting a great amount of time in determining the specific items to be included in the file, as discussed earlier. The test of success for this requirement is that practically no change has had to be made in the file in the 10 years it has been in use. The second requirement, accessibility, was met with the recent conversion of the file to a data base system. This system will allow on-line access to the file for individual bridge inquiries. The third requirement, credibility, was met by controlling the information going into the file. Data can only be added to or deleted from the file by the Inventory and Inspection Unit of the Department. Thus, all data is screened by the same two or three people, providing a high level of consistency. In addition, edit checks are constantly being run to seek out problems with the data. Finally, a continuing program of file updating is required to reflect changes in bridges brought about by replacement, rehabilitation and maintenance programs.

THE USE OF THE INFORMATION

The development and management of a bridge data file will take much time and effort. The benefits of an expanded, well maintained file to New York State were cited earlier, and are as follows: the ability to assure bridge safety; to prepare bridge maintenance work programs and bridge capital construction programs, including prioritizing of projects; to assist with short and long range capital budget planning; to evaluate load capacities of bridges; to assist with the routing of overloads; and to evaluate new structure types and details. These benefits are discussed in detail below.

Assurance of Bridge Safety - A key element of any bridge inventory and inspection system is the regular inspection of bridges. AASHTO and FHWA have established an inspection cycle of two years or less. The inspection made for this purpose is a survey of bridge condition and is not done in the detail required for a refined structural analysis or the preparation of plans for a rehabilitation project. In New York State the general inspection of a 100 foot bridge will take a two person team about two hours, under average conditions.

General inspections must be made in order to monitor the condition of a bridge as it changes with time, and to find deterioration which may make the bridge unsafe. Without inspections unsafe conditions are likely to go undetected and cause serious damage to the bridge, or collapse with resultant danger to the user.

Preparation of a Bridge Maintenance Work Program - The New York State bridge inspection form includes nine items, with quantity estimates, which are used by the Department's Maintenance Division to plan remedial work on bridges needing such work. This information is taken from the inspection forms for those bridges which are to be included in the bridge maintenance work program. The quantities are summarized and labor and equipment factors added, providing the Division with the information needed to budget for bridge maintenance activities. The budgeting data, coupled with a review of rate of deterioration of the part of the bridge requiring attention in order to provide a time frame for the work, provides the information needed for planning a bridge maintenance work program.

Preparation of a Bridge Capital Construction Program - As a part of the inspection of New York bridges each component of the bridge is given a numeric rating value based on condition. The condition rating for the bridge as a whole is developed by weighting bridge components in proportion to their importance for the proper structural functioning of the bridge. For example, primary members are given a weight of 10, secondary members 5 and sidewalks 2. The component and the component weight are multiplied, all weighted components are summed, and a weighted average value computed providing the condition rating for the bridge. In a variation more commonly used, a traffic factor is applied to the condition rating to produce a combined value. The traffic factor provides an indication of the relative importance of the bridge, with higher traffic volumes indicating greater importance. The result is a priority rating for the bridge which is typically used for programming in New York State

It is likely that other states use similar methods to develop priorities. There is a national method which was developed by AASHTO and is shown in the "Recording and Coding Guide" mentioned earlier. It uses bridge condition for 55% of the final value, geometric conditions and traffic for 30% of the final value and detour length and traffic for the last 15% of the final value. These items are combined to calculate the "Bridge Sufficiency Rating," which is used by the FHWA to show nationwide bridge priorities and as a basis for allocation of federal funds to the states for bridge rehabilitation and replacement. The data used to calculate this rating are provided by the States annually, and are that data discussed earlier as being the minimum which a State must obtain for the inventory and inspection file. New York State continues to use the state priority method for decision making, primarily because it has been in use longer than the Federal and the longer data base is valuable for progress reporting and projections. The two systems correlate generally, and no program management problems have been experienced because of the use of the dual system.

Short and Long Range Capital Budget Planning - With the development of a reliable computerized bridge data file and the addition to it of a continuous flow of inspection data showing changes in bridge condition, it is possible to develop computer-based analyses showing condition trends. With the use of defined condition levels indicating the need for rehabilitation or replacement of bridges, it is possible to develop projections of the numbers of bridges requiring attention at any given time. Adding cost-to-correct values, estimates can be made of the expenditure per year, or other interval, required to keep the average condition of all bridges constant or to improve such condition. Optimization studies can be made leading to the determination of the most cost-effective time to repair or replace specific bridges. In New York a computer model has been developed which will do this. The early results from this study are found in a report titled FHWA. N.Y./S.R. 80-70 "The Deterioration of New York State Highway Structures", and have been reported at the Transportation Research Board annual meetings and AASHTO meetings.

Evaluation of Load Capacities of Bridges - The load-carrying ability of a bridge can be readily determined if the data file information is complete enough. In New York State, the load rating portion of the inventory and inspection data was established to provide the raw material for this purpose. The computation is done using a computerized bridge load rating program. The output, while not sufficiently refined to be the basis for bridge load posting, does provide a variety of benefits. For example, the load rating value can be used as a second prioritizing method, in addition to the condition value. If used in this way, bridges with lesser load carrying ability would have a higher priority for repair, strengthening or replacement than those with greater load carrying ability. Bridges can be identified which represent the limiting load on a portion of a highway, and those identified upgraded so that the portion of the highway is made reasonably uniform in terms of the load-carrying ability of the bridges. Perhaps most important, a review of bridge ratings can be used to identify bridges which, while in good condition, were not designed for current loadings. Such bridges would never show up in condition-related deficient bridge lists, but are as great a problem to the highway user as those bridges which do.

Overload Routing - The routing of overload vehicles is facilitated by having data file information available for bridges along the proposed route. The ability of each bridge on a route to carry the anticipated load can be determined quickly using the bridge load rating computer program and, generally, without the need for a field reconnaissance. In some cases bridges may be found which are marginal in ability to carry the load. A field investigation will then be required to assure that their condition is no worse than that shown on the latest inspection report. In addition, such bridges may require a more thorough analysis than provided by the rating program. If a bridge on the proposed route is clearly unable to carry the anticipated load, an alternate route can be sought and evaluated quickly. These procedures allow responsive review of overload movement requests with minimal expenditure of money; and result in greater assurance of the safety of the bridges on the overload route.

Evaluation of New Structure Types and Details - With inventory and inspection data in sufficient detail, the performance of various structure types and details can be monitored on a continuing basis. Differences in performance can be determined between similar items, and performance related to time can be developed to show rates of deterioration of details, materials or construc-

tion methods. Generally, the level of detail needed to do this is not found in most inventory files, but if the file is developed in such a way as to allow the addition of items as new evaluation needs are identified, data bases can be started for these items.

Summary and Conclusion - Many states have an extensive bridge data file, while others have files designed to provide only the data required for FHWA. There is no best answer; each state must decide for itself how it will approach this matter. The New York Department of Transportation believes the decision to create a large file was the correct one because of the many benefits which have already been experienced and the continued and expanded usefulness of such a file in the future.

Bridge inventories need to be kept current, reflecting changes in bridges and the replacement of existing bridges with new. The data on file must be constantly checked for reliability. Inventories may have to be expanded to meet changing bridge technology or the demand for new kinds of bridge data.

Bridge inspections must be made as cost effective as possible. Inspection frequencies may be lengthened for certain types of bridges and shortened for other types. Inspection effort must be constantly monitored to assure that the result is consistant with needs.

Finally, the inventory and inspection records must be stored in such a way as to be readily recoverable and usable. Bridge inventory and inspection is not an end, but instead a means to provide safe, serviceable and economical bridges for the user.

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