AASHTO Commonly-Recognized Bridge Elements

Successful Applications and Lessons Learned

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Paul D. Thompson
Consultant
2425 Hawken Drive
Castle Rock, CO 80104
303-681-2425; fax 303-681-9439
pdt@pdth.com

Richard W. Shepard
Supervising Bridge Engineer
Office of Structures Maintenance
California Department of Transportation
PO Box 942874
Sacramento, CA 94274
916-227-8266; fax 916-227-8357
richard.shepard@dot.ca.gov

1. Introduction

Today's manager is faced with many competing priorities and must rely on computerized data processing when managing large inventories of infrastructure assets. This "management by data" is only possible when there is an understanding of what the data represents and a trust in the quality of the data. To develop this trust and understanding in the data, standards must be created. For bridge data, California and most other states have successfully used the "Commonly Recognized (CoRe) Elements for Bridge Inspection" as a basis for data collection, performance measurement, resource allocation, and management decision support. The CoRe element standard has been adopted by FHWA and AASHTO as the preferred standard to collect bridge condition information. The widespread use of common standards encourages innovation in the use of data, enables uniform training of inspectors and engineers, increases the marketability of products developed by the private sector, and allows for sharing of data and research results.

Prior to the CoRe Elements, bridge managers used data based on the National Bridge Inspection Standards (NBIS) to help make decisions. Though the NBIS did provide a consistent standard for the collection of bridge data, it was not comprehensive enough to provide performance-based decision support that included economic considerations. Among the problems with the NBIS were:

- Each bridge was divided into only four major parts for condition assessment: superstructure, substructure, deck, and culverts. This level of detail was not sufficient to identify appropriate repair strategies, or to estimate costs.
- Each of the four major parts was rated on a 0-9 scale by severity of deterioration, without identifying the deterioration process at work or the extent of deterioration.
- NBIS condition ratings are vulnerable to the subjective interpretation of the bridge inspection staff. Because the ratings include multiple distress symptoms and are expected to describe the "general" condition of the bridge, inspection staff must decide which distress is more representative of the general condition. It is often difficult to decide what the "general" condition is when a bridge has mainly localized problems.
- An overall sufficiency rating based on NBIS data was used as a performance measure at the Federal level for funding allocation, but this measure emphasized large-scale functional and geometric characteristics of bridges, making it irrelevant for maintenance decision-making.

During the 1990-91 development of the Pontis Bridge Management System by FHWA and Caltrans, the deficiencies of the NBIS were addressed by the development of a standardized description of bridge elements at a greater level of detail. There would be a menu of as many as 160 elements, from which each bridge would contain an average of about 10. This would provide a common nucleus for implementation of the system in a large number of states, provide for the sharing of bridge management data and research, and would be a significant step forward in the state-of-the-practice of bridge inspection. Examples of elements include:

12– Bare concrete deck
14– Concrete deck protected with an asphalt concrete overlay
101– Unpainted steel closed web/box girder
121– Painted steel thru-truss, bottom chord
205– Reinforced concrete column or pile extension
216– Timber abutment
300– Strip seal expansion joint

314– Pot bearing
330– Uncoated metal bridge railing

Immediately on completion of Pontis at the end of 1991, several early-adopter states began applying the first version of standardized elements to bridge inspection. They wrote their own inspection manuals and provided their own inspector training. In 1993 under FHWA guidance, a task force was created to revise the standards based on the early experience. The new standard, called the Commonly Recognized (CoRe) Elements, would be somewhat more generic than the first version, less tied to Pontis, with a smaller set (108) of standardized elements. The CoRe element manual specified the definition of each element, the unit of measurement, definitions of a set of 3-5 standardized condition states, and lists of typical feasible actions for each condition state.

During the AASHTO Bridge Subcommittee meeting in May 1995, the CoRe Element Manual was accepted as an official AASHTO Manual. With this acceptance came the need to provide a mechanism to make changes and updates to the manual as needed. This mechanism was placed under the jurisdiction of the AASHTO Bridge Technical Committee on Bridge Replacement Surveys and Inspection Standards (T-18) with technical input from the AASHTOWare® Pontis® Task Force.

Although there was discussion in the early 1990s of making the CoRe Element Manual a national standard as part of the NBIS, the new Federalism environment of the period made it impractical to attempt to modify the existing national standard. Instead, FHWA developed a translator algorithm to convert the new, more detailed CoRe element condition data into NBIS condition ratings consistent with the old standard. This would allow states to perform inspections under the new standard while still reporting the results to FHWA under the old standard. This algorithm was completed and accepted by FHWA in 1997.

The CoRe Element Manual has not been revised since 1995, though most of the states using it have written their own field guides with agency-specific variations. As described below, the CoRe Element Manual anticipated and encouraged states to modify it, and provided standardized ways of doing so that would not interfere with the benefits of a common standard. Currently more than 40 states have made the transition to an element-level inspection standard based on the CoRe elements.

As an increasing number of states develop completely populated bridge management system databases using the CoRe elements, they are starting to use this information for management decision support. The experience of one of the leading states, California, in developing and using performance measures is described later in this paper.

2. Basic requirements of CoRe elements

In bridges, as in most types of maintenance, transportation agencies differ widely in maintenance practices, funding mechanisms, policy concerns, and even terminology. However, the physical components of bridges, and the chemical and physical processes that attack them, are quite the same worldwide. In the development of the AASHTO CoRe Elements for bridges, it was evident from the start that one of the most important factors in widespread implementation would be the degree to which the specification describes characteristics that apply to all agencies. The specification must be truly generic.

The concept of "generic" also includes stability over time. It is important for element definitions to accommodate foreseeable technological change, and to remain acceptable and useful to each new generation of management and staff. If the product is successful, agencies will start collecting enormous volumes of data tied to these definitions, data that must retain their value over long periods of time.

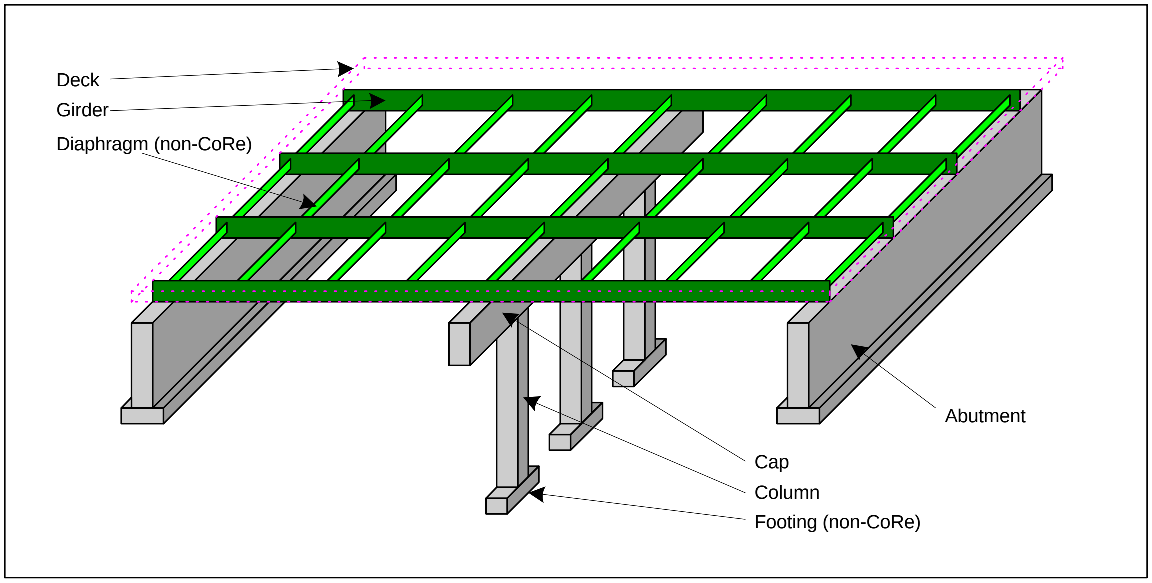
Change is inevitable, but it is important to think through the means of adapting to change. Similarly, agencies must be able to customize the CoRe elements to satisfy their own purposes without sacrificing the benefits of a common standard. After a CoRe element definition is finalized and implemented, subsequent modifications could entail the need to modify or dispose of historical data, or could introduce incompatibilities among agencies or time periods. This is to be avoided if at all possible.

The CoRe element specification anticipates change by providing the ability for an agency to add its own sub-elements (to enable a more detailed classification), or non-CoRe elements (to accommodate types of elements that are not covered by the CoRe definitions). It is also possible for a future CoRe Element Task Force to add new elements or sub-elements. Extensibility of the specification is maximized if the distinctions among elements are as clear and permanent as possible, while each definition internally is as simple and brief as possible. The following are useful guidelines for accomplishing this goal.

- Each element should have a unique functional role in the facility of which it is a part. For example, a deck is a surface that carries traffic; a girder is a beam that provides the horizontal span between substructure units; a floor beam is a beam that provides the horizontal span between girders; and a stringer is a beam that provides the horizontal span between floor beams.
- Distinguish elements that have significantly different maintenance requirements. For example, unpainted steel elements are separate from painted steel, concrete, and timber.
- Distinguish elements that are measured in different ways for costing or inspection. For example, bearing maintenance costs are related to the number of bearings, but not related to the size of girders or substructure units.
- Distinguish elements whose conditions are described in different ways. For example, the deterioration noted on the top of a bridge deck (e.g. potholes) is of a different nature, with different consequences, from the deterioration observed on the bottom of a deck (e.g. rust staining).
- Each element should be significant from the standpoint of maintenance cost or functionality. For each element, ask whether the cost of collecting inventory, condition, and serviceability data about the element is justified. In the development of bridge CoRe elements, it was decided to omit truss lateral bracing, diaphragms, and other secondary members because the level of detail in data collection would be too large relative to the effect of these elements on decision-making.
- Also ask whether the deterioration behavior and maintenance alternatives for the element are sufficiently understood. In the development of bridge elements, it was decided to omit tunnels and slope protection because of the complexity of describing them.
- If an element is much more significant than other elements, or if its behavior or condition description are complex, consider subdividing it into smaller elements. Deck joints, for example, are separated from decks.
- Try to develop a formal “Webster’s Dictionary” definition of each element, to clarify thinking. The CoRe bridge element developers decided to omit rigid frames because it proved too difficult to write a definition that was sufficiently distinct from girders and substructure units, for maintenance purposes.

In addition, it is important to think about the various ways in which the CoRe elements will be used. One primary use of the definitions is to provide structure to an inventory of facilities. Such an inventory may be exhaustive, as it is for bridges, or it may be based on a sampling plan or a collection of representative examples. To establish a useful inventory, it is necessary to clearly identify each element in the field, to measure and count the elements economically, and to describe important element attributes (size, material, condition, serviceability) quantitatively. It must be practical to enter the data into a computerized database. All personnel collecting and using the data must be readily able to develop a common, objective understanding of the definitions.

The commonality aspect of CoRe elements depends on having definitions that are widely understood by transportation agencies and are stable over time. Since a common element specification has not previously existed, it is natural to find that each agency has its own terminology and its own way of organizing maintenance issues. It is necessary that each agency be readily able to translate the common definitions into concepts and terms used locally. It is also highly desirable that each agency be able to develop a migration plan to gradually transition from the older local terms to the new commonly understood terms.



If this transition is to happen, it must be driven by economic factors, by economies of scale that are made possible by the common standard. For bridges, a major factor is the National Highway Institute’s Bridge Inspector Training Course. Most of the states rely on this course for training and certification of bridge inspectors, because it is not economical for most states to develop their own training course in-house. Another factor is AASHTO’s Pontis bridge management system (BMS), which is licensed by over 40 transportation agencies. Development of a BMS is far too costly and complex for most individual organizations to undertake by themselves, yet joint development of a common system would have been impossible without a standardized basis for describing a bridge inventory. Since the completion of Pontis, the CoRe element standard has continued to provide economies of scale as a platform for widely applicable bridge management research in the areas of inspection technology, cost estimation, and bridge deterioration.

Ultimately, CoRe elements must be usable to support management decision-making. Element-level bridge data is far too detailed for most management purposes, and by itself it leaves too many unanswered questions, relative to higher-level decisions. The missing link must eventually be filled by decision-support tools, of which a BMS is just one example.

The main purpose of a decision support tool is to reduce a large volume of raw data into essential nuggets of useful information. Responsible transportation agency managers typically are concerned with accomplishing as much of the agency's mission as possible within a very limited budget, so decision support tools typically focus on the calculation of cost and performance estimates, using predictive models and, sometimes, optimization models.

In fact, the original development of bridge CoRe elements was heavily influenced by the parallel development of the Pontis software. The CoRe elements provided structure for the Pontis database and models, helping to keep the development team focused and ensuring that a large number of agencies would be able to implement the product. The CoRe element team, in turn, benefited from the rigorous discipline that was imposed upon them by the need to produce a working software product.

While many other decision support tools have been developed, and some have considered and even required alternative approaches to the CoRe Element standard, their success has been limited partly because the large data collection investment of many agencies in the current CoRe standard has created a resistance in the states to change the standards. This inertia, rather than computer technology, can limit the capabilities of decision support tools that must comply with the CoRe standard, such as Pontis. An important lesson that has been learned from the evolution of bridge management systems over the past 10 years is that the lifespan of decision support tools is much shorter than the lifespan of databases. Although the needs of decision support tools are important in the definition of CoRe elements, it is important to ask whether the decision support requirements might later change, to ensure that the element definitions will continue to serve management needs over a long period of time.

3. Condition states

One of the most immediate applications of CoRe elements is the collection and analysis of performance data. In the development of bridge elements, it was considered essential that the original data collection be as objective and repeatable as possible. The data collected through the biennial bridge inspection process would be stored in a database, with subsequent users, generally in the office and sometimes many years later, unable to apply any sort of subjective interpretation to the data. Although some degree of analysis or interpretation may be applied by an inspector or engineer at the time of inspection, it is essential that the raw, objective data be stored so that the analysis may be updated or improved at a later time. It is likely that the same considerations would apply to any type of transportation asset.

As a result of this thought process, certain types of performance data are not suitable for the CoRe element definitions. In general, economic performance is not suitable because it is not directly measurable with objective measurement tools, and because the methodology for estimating it is likely to evolve over time. A prescribed methodology for calculating economic performance might not be uniformly accepted across the industry because of differing policy concerns in each agency. For bridge elements, it was decided to develop economic performance measures using an analytical process in the bridge management system, subsequent to the inspection.

Similarly, a general scale of good-fair-poor would not be acceptable unless these terms have precise definitions that can be observed unambiguously in the field or by measuring equipment that can be deployed economically.

Serviceability also proved a tricky concept for data collection. For bridges, most types of deterioration do not directly affect serviceability in the short run. Frequently the justification for maintenance is an economic one, to intervene in a bridge's life at the most cost-effective time to prevent the structure from ever having a serviceability problem. When condition becomes bad enough, serviceability might become a concern, but even then it would require significant additional data collection and analysis to determine whether serviceability is in fact impaired.

It was decided for bridges to measure condition on a single scale that reflects the most common processes of deterioration and the effect of deterioration on serviceability. The general pattern goes as follows:

1. Protected. The element's protective materials or systems (e.g. paint or cathodic protection) are sound and functioning as intended to prevent deterioration of the element.
2. Exposed. The element's protective materials or systems have partially or completely failed (e.g. peeling paint or spalled concrete), leaving the element vulnerable to deterioration.
3. Attacked. The element is experiencing active attack by physical or chemical processes (e.g. corrosion, wood rot, traffic wear-and-tear), but is not yet damaged.
4. Damaged. The element has lost important amounts of material (e.g. steel section loss), such that its serviceability is suspect.
5. Failed. The element no longer serves its intended function (e.g. the bridge must be load-posted).

Each of these levels of deterioration is called a condition state. When a bridge is inspected, the total quantity of each element is allocated among the condition states based on the visual observations of the inspector. For example, if 10% of the total length of a bridge's girders has peeling paint, the inspector would note 10% in state 2 and 90% in state 1.

As the examples indicate, the bridge condition states travel along just one dimension, normally describing only one deterioration process. At the time the bridge elements were developed, this was a limitation of both the Pontis analytical framework and of the state-of-the-art understanding of bridge deterioration processes. Other deterioration processes, such as scour, fatigue, and settlement, are described as separate elements, called "smart flags." This limitation, however, does not have to apply to other types of assets. There can be more than one dimension of condition states for an element, and one or more of those dimensions can address serviceability separately from condition if it is useful to do so. In fact, for clarity of presentation, it is important that separate deterioration processes be recorded on separate condition state scales, so a later user of the data can tell which process was at work. As the technology of inspection and maintenance improves, new dimensions of condition states can be added.

It is useful to recognize that a condition state methodology for describing an element provides two types of information on each dimension:

- Severity, which is characterized in the precise language of each condition state definition, and
- Extent, which is characterized as an allocation of the element among condition states.

In general, severity is important for the selection of a feasible and cost-effective maintenance treatment, while extent is important for cost estimation. Condition states represent an efficient way to collect both types of data at the same time.

Since a typical bridge inspection is predominantly visual, it is important to keep the number of states as small as possible, to maximize the reliability of visual distinctions. This is also important for efficient application and reporting of the data, regardless of the type of measurement used. For bridges, condition state distinctions were made only if one or more of the following factors applied:

- The transition from one state to the next changes the list of feasible maintenance treatments.
- The transition significantly changes the cost.
- The transition significantly changes the rate of further deterioration.

Since bridge element quantities are merely allocated among states, it is not necessary in an inspection to list each instance of damage or deterioration individually. This is suitable for bridge inspection, where the entire quantity of each bridge is examined, but it is also very appropriate for assets whose condition is sampled. For example, if suitable statistical methods are followed, a sign reflectivity survey on a sample of signs can provide an accurate and useful picture of the sign inventory as a whole. In cases where data collection is more detailed than the CoRe elements, it is also possible to "roll up" the data into CoRe element form.

4. Application to decision-making

Condition state data provide a direct indication of physical performance, relevant to detailed treatment selection and costing decisions. Also, the effects of treatment actions can be tracked over time because of the stability of the condition measures. However, element-level condition data need further processing in order to be suitable for other types of agency decisions. Examples of these potential applications include:

- Development and testing of new maintenance techniques
- Treatment selection policies
- Project priority setting and programming
- Budgeting
- Funding allocation
- Long-range planning

For these more aggregate types of decisions, it is necessary to digest the detailed condition data into higher-level cost and performance measures. Usually, it is necessary to be able to use these measures across dissimilar types of facilities. There are many ways to do this, for example:

Weighted average condition state. Overall condition of one or more elements can be summarized by computing a weighted average condition state number. The California Health Index, described in the next section, is an example of this. Alternatively, a weighted average distribution among states can be computed. This type of measure is most easily understood if the condition state definitions for all types of facilities follow the same rationale, such as the five levels described in the preceding section of this paper. For example, it is useful to report to the public that only 2% of all facilities are in a damaged or failed state, down from 2.5% the preceding year. This type of measure requires a consistent means of weighting dissimilar elements. Economic measures, such as construction cost, current value, or economic benefits, are quite suitable for this. California's health index uses a measure of the economic consequences of element failure as the weight.

Asset value. In principle, the depreciated economic value of a transportation asset should be related in some way to its condition. Unfortunately, since these assets are seldom traded on an open market, and since the tax concept of depreciation is usually not applicable, there has been little progress so far to develop a method for this. Managers with an accounting background sometimes find this perspective to be useful, so a handful of efforts are underway worldwide to try to make some progress in this area. These efforts have recently been spurred by Government Accounting Standards Board (GASB) Statement 34, which promulgates accounting rules for infrastructure assets.

Benefit/cost analysis. A more common framework for economic performance measures involves comparing the cost of an initiative against the economic benefit, usually expressed as the present value of future costs that would be avoided if the initiative is undertaken. Economic benefits might include user and/or social costs, which in principle could encompass any or all serviceability benefits to be experienced by road users or society as a whole. Nearly all asset management systems today employ this perspective for priority-setting and resource allocation, by identifying the cost and benefit of each need, and allocating funding to the initiatives having the highest increment of benefit per unit of money expended. When there is not enough funding to meet all needs, the unrealized benefits of these unfunded initiatives is considered to be an indication of the economic health (or lack thereof) of the facility inventory. The Pontis bridge management system uses deterioration and cost models to convert element-level condition data to economic benefits and costs for this type of analysis.

Transportation values/serviceability. Another common approach is to develop measures of transportation system performance based on the core values that the agency is tasked to maintain and enhance. Such values include safety, mobility, origin-destination speed, reliability, comfort, convenience, and air quality. Since bridge maintenance tends to have only an indirect effect on these values, this aspect was not addressed in detail in the bridge CoRe Elements. However, these values could be much more important for other types of maintenance, and could form the basis for condition states for certain elements.

In general, core elements and condition states that focus on physical condition and serviceability would be expected to be easiest to develop and to standardize across agencies, because they are valued in the same way everywhere. Standardization of any higher-level performance measures, especially economic measures, would be more difficult because of differing management styles and policy concerns across jurisdictions.

5. Case Study – California

After determining the feasibility of using the new element level inspection procedure, the California Department of Transportation (Caltrans) in 1991 decided to fully implement it. The first and most time-consuming step, development of an inventory of bridge elements on California's nearly 23,000 bridges, took approximately 3,500 person-hours.

The first cycle of routine bridge inspections utilizing element level data were found to be more time consuming (by 5-20 percent) than the routine inspections prior to element level procedures. However, most inspection staff interviewed thought this additional effort was due to the need to verify the element inventory in the field, as well as their unfamiliarity with the new system. On the other hand, it was found that training in the more objective condition state language was easier than the previous, more subjective NBIS scale. It has been found that subsequent cycles of inspections are less time consuming than the first.

Acceptance of the new system by the data collection staff was a key success factor. Inspectors felt that the new system vastly improved the quality and usefulness of their work product.

Even though bridge data collection processes have been in place in California since the 1960s, the complexity of a large facility inventory has presented an insurmountable barrier to the application of this valuable data resource to assist management decision-making. What was needed — and was finally provided by the CoRe Element Standard — was a comprehensive organizing framework for decision support applications, a framework that would balance the competing goals of realistic cost and performance modeling for decision support on the one hand, with an affordable data collection process on the other hand. With the CoRe Elements in place, California was able to implement the Pontis bridge management system to turn the valuable output of bridge inspectors into useful management information.

Bridge Health Index

Even with data and analytical software in place, a major remaining task is to establish a format for clear, dependable communication of bridge performance information to management, elected officials, and the public. California, like every state with a new management system, struggled to find the right way to bridge this communication gap. Often it is necessary to try out several types of performance measures until one finally "clicks," engaging decision-makers in useful dialog. For California, this turned out to be the Health Index.

With a relatively new inventory, California's bridges are in relatively good health. The management challenge is to maintain this level of wellness, by detecting and addressing early any health problems that emerge.

The Bridge Health Index is a 0-100 ranking system for bridge maintenance. Although element condition states are categorical, it is useful to think of the condition of an element at a given time as a point along a continuous timeline from 100% in the best state to 100% in the worst state. The 0-100 health index merely indicates where the element is along this continuum. To aggregate the element-level result to the bridge level, weights are assigned to the elements according to the economic consequences of element failure. Thus, elements whose failure has relatively little economic effect, such as railings, receive less weight than elements whose failure could close the bridge, such as girders.

The Health Index number can be developed for a single bridge or a group of bridges, thus providing an excellent performance measure and management tool for bridge maintenance. Caltrans has developed reports that will combine the forecast deterioration of the bridge inventory and the Health Index, to allow it to predict the health of the inventory in future years based on various funding levels. The Health Index is also being incorporated into the staff allocation process and the annual maintenance performance evaluation report.

The health index is calculated as follows:

$$\text{Health Index (HI)} = (\sum \text{CEV} \div \sum \text{TEV}) \times 100$$

where:

$$\text{Total Element Value (TEV)} = \text{Total element quantity} \times \text{Failure cost of element (FC)}$$
$$\text{Current Element Value (CEV)} = (\sum [\text{Quantity in condition state } i \times WF(i)]) \times FC$$

The condition state weighting factor (WF) is given by the following table.

Number of Condition States	State 1 (WF)	State 2 (WF)	State 3 (WF)	State 4 (WF)	State 5 (WF)
3 Condition States	1.00	0.50	0.00		
4 Condition States	1.00	0.67	0.33	0.00	
5 Condition States	1.00	0.75	0.50	0.25	0.00

Or mathematically: $(WF) = 1 - [(\text{State\#} - 1) \div (\text{State Count} - 1)]$

An example will help to demonstrate the application of the Health Index formulas for a sample bridge. First, consider a bridge with the following data.

Element Description	Total Quantity	Units	State 1	State 2	State 3	State 4	State 5	Unit Failure Cost (FC)
Conc. Deck	300	sq.m			300			$600
Steel Girder	100	m	61	34	5			$3,500
RC Abutment	24	m	24					$7,700
RC Column	4	each	4					$9,000
Joint Seal	24	m			24			$556

The list of elements and total quantities is a part of the basic bridge inventory. The quantities in each condition state come from the most recent inspection. Failure cost is determined by Caltrans for each type of element by performing a sensitivity analysis of the Pontis optimization model, to determine the failure penalty needed to prevent element failure. However, any meaningful economic or non-economic weighting scheme could be used. The weight is expressed in the same units as the inspection quantities. With these data, total element value (TEV) is calculated as follows:

Element Description	Calculation	Resulting Element Value
Conc. Deck	300 × $600	$180,000
Steel Girder	100 × $3,500	$350,000
RC Abutment	24 × $7,700	$184,800
RC Column	4 × $9,000	$36,000
Joint Seal	24 × $556	$13,344
	Total	$764,144

Current element value (CEV) and element health are calculated as follows:

Element Description	Calculation	CEV	Element Health
Conc. Deck	300 × 0.5 × 600	$90,000	50.00
Steel Girder	((61 × 1.0) + (34 × 0.75) + (5 × 0.5)) × 3500	$311,500	89.00
RC Abutment	24 × 1.0 × 7700	$184,800	100.00
RC Column	4 × 1.0 × 9000	$36,000	100.00
Joint Seal	24 × 0.0 × 556	$0.00	00.00
	Total	$622,300	

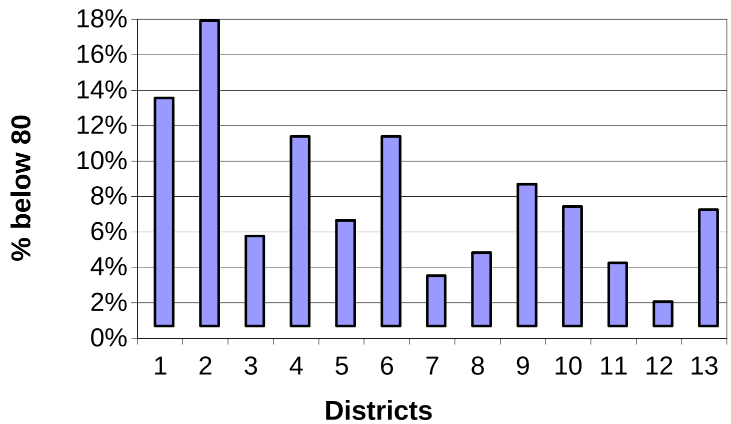
Finally, the bridge Health Index (HI) is determined by: HI = ($622,300 ÷ $764,144) × 100 = 81.4

Uses of the Health Index in California

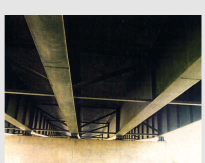
The use of the Bridge Health Index has impacted the business processes of managing bridges in California. Currently California is using the Health Index to help allocate resources, to help judge District bridge maintenance and rehabilitation performance, and to provide Level of Service indicators. California is also developing uses of the Health Index to aid in the evaluation of annual budget strategies and life cycle performance of maintenance and rehabilitation actions.

In California, each District manages its own bridge maintenance activities. The condition of bridges is a function of the resources available and the management strategies used. To help judge the performance of the management strategies used by each District, the bridge health index is used. The statewide goal is to have no more than 5% of the bridges below a health of 80. The effectiveness of the District's bridge management activities is judged by its ability to move positively towards this goal.

When allocating resources to each district, Caltrans uses an allocation formula that is a function of the size, make-up, and congestion of the bridge inventory within each district. If the bridges were all of the same size and subjected to the same traffic congestion, we would expect this baseline to be consistent across District boundaries. However, due to resource shortfalls, operating practices and environmental issues, each District's network condition as represented by the Health Index is different. The District's Network Health Index is used to adjust the allocation formula so that the base allocations are proportionately increased for bridge inventories with a poor network health index.



Using the Health Index as a performance measure and using it in the allocation of resources are accepted practices internal to Caltrans. However, to convey the physical condition of a bridge to a layperson, a visual representation of the health index was developed. This visual representation utilizes the distinct condition state definitions available from the element level inspection process. The visual representation created in California is used to define the levels of service for the maintenance and rehabilitation of bridges. The photos below show a sample of the visual level of service ranges.

				
Health 100	Health 99-99.5	Health 80-89	Health 70-79	Health below 70

Bridge managers often have the need to evaluate the impact of several budget scenarios on the future condition of a bridge network. Evaluating the impact of multiple budgets on the value and condition of a bridge network is possible by applying the Health Index concepts to simulated future conditions. Most bridge management software programs have the ability to predict future actions based on some modeling logic. The actions that are selected by the management system software are a function of the available budget for preservation actions. If the available budget is minimal, the number of actions that can be selected by the management system software is limited and the corresponding Health Index will be reduced for the network. By evaluating the change in the network Health Index, it is possible to represent the future condition and the change in the value of the network as a whole based on any budget. The link that the Health Index provides between condition and asset value is a tool that now allows bridge managers to quickly convert condition to dollars.

6. Conclusions

A standardized definition of CoRe elements has enabled California and many other states to develop complete, logically consistent frameworks for management decision support and communication of bridge inventory performance. The principles behind the AASHTO Bridge CoRe Elements can be applied to any other kind of transportation asset, providing a solid foundation to advance the state of the art in maintenance management.