Project Selection Method Integrating BMS Data and Nondeterioration Based Needs

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ABSTRACT

There are about 4,900 bridges on the Oregon State Highway system. These bridges have been inspected using Pontis condition state evaluation criteria for the last 6 years. This data is now being used in the project selection process. In addition other data base priorities are being integrated to account for bridge width deficiencies, seismic vulnerability, scour susceptibility, bridge rail deficiencies, vertical height deficiencies, and painting needs. Oregon's annual budget for bridge work is about $50.0 million. Studies show that on the Interstate alone, 20-year bridge needs amount to $540 million. Needs on other routes defined as having significant statewide importance are $841 million. Needs on the remaining system are $471 million. It is clear that a system of careful prioritization is needed, which considers both predictable deterioration and functional, event-driven needs. Most of these bridges were constructed since 1950 using standard design reinforced and prestressed concrete beams. Today over 20% of the total number of bridges are deficient. Less than half of these are due to predictable deterioration. A program of rehabilitation must include not only the highest priority needs based on Pontis data, but the functional problems as well. This presentation will describe data collection, economic analysis procedures, selection of priority bridges for repair, rehabilitation and reconstruction, and collection of cost data to improve economic analysis methods. Computer data storage and manipulation will be described, as well as current projects to improve and update the Oregon Bridge Management System programs. Innovative methods of needs analysis will be presented.

INTRODUCTION

There are about 4,900 bridges on the Oregon State Highway system that are owned and managed by the Oregon Department of Transportation (ODOT). Of these, about 2,600 are National Bridge Inventory (NBI) bridges that are eligible for Highway Bridge Rehabilitation and Replacement (HBRR) funding. Selection of ODOT bridges for rehabilitation or replacement has, until 1996, been driven by modernization and preservation projects developed by the five geographic Regions. The Federal Highway Administration (FHWA) sufficiency rating and the American Association of State Highway and Transportation Officials (AASHTO) design standards were the factors determining whether a bridge project would be placed in the four year Statewide Transportation Improvement Program (STIP).

Review of bridge conditions, in particular on the Oregon Coast Highway, conducted in 1994 and 1995, revealed that the condition of bridges which were not on routes programmed for modernization was becoming seriously deteriorated. ODOT had begun using the Pontis condition state evaluation criteria for bridge inspection, but this had not replaced other condition evaluation processes in use, a number of which included "elements" not covered within Pontis. None of these had a logical statewide method for identification, ranking and selection of bridges for inclusion within the STIP. In 1995, ODOT, with the support of the FHWA Oregon Division, initiated a process which uses the Bridge Management System (BMS) data, integrated with Pontis inspection results and other data collection systems. This provided a comprehensive Bridge Program, which evaluated all possible reasons for placing a bridge project within the STIP. This has been used for development of the 1998–2001 and the 2000–2002 STIP. The same data and analysis methods are used to develop investment strategies for the 20-year Oregon Highway Plan.

BACKGROUND

The Oregon DOT is organized into five geographic Regions plus a Headquarters. Each Region functions as a geographic headquarters with several subordinate Maintenance Districts. Planning of projects has been the province of the Regions. Currently, the Regions are decentralizing this project development function to subordinate Areas, which are being structured to parallel the Maintenance Districts. Because of the specialized expertise needed to evaluate bridge needs, the Regions have decided that going in the other direction, i.e., centralizing the Bridge Program would be desirable, providing it had a truly statewide view. As part of this process Regions could offer scheduling and staffing concerns to influence the program.

A centralized Bridge Program, which split the available funds by geographic Region, raised concerns that it would not focus on the right problems at the right time. ODOT was also facing reluctance by the State Legislature to provide additional funding to deal with a new seismic vulnerability assessment and a scour assessment. These assessments pointed out significant work requirements that were not identified through BMS condition data. In 1995, ODOT's Bridge Preservation Unit, Region 2's Bridge Inspector, and the Bridge Section BMS staff jointly started a pilot project to assist Region 2 in logically selecting which bridges within the Region should be placed in the upcoming STIP. This was coordinated with the FHWA Oregon Division Bridge Engineer, who shared mutual interest in developing a system that could address both deterioration based defects and nondeterioration based defects. FHWA was also interested in a system that would rank needs by category. FHWA expressed interest in exempting some requirements on highway preservation projects, such as bridge rail upgrades, if ODOT could demonstrate that its project selection system would ensure that such problems would be resolved in order of priority.

Within six months after initiation, the remaining Regions requesting the same help and the Oregon Transportation Commission requested a presentation on this effort along with estimates of the level of funding required to meet the bridge needs. The process, the data available for evaluation, and the number of issues the program addresses continue to grow.

ODOT has also entered into an agreement with Local Agencies within the State to use a "jurisdictionally blind" method to identify which structure projects need to be pursued, without regard to ownership. Such a process is required to support developing the 2002–2005 STIP.

PROCESS SUMMARY

The project identification and selection process follows these steps:

1. Establish a comprehensive set of categories, or reasons, to program work for a structure;
2. Identify and assemble all of the diverse, issue specific, data collections that may have relevance to one or more of these categories;
3. Develop a method of linking the collections;
4. Develop a computer extraction process which reflects the established selection criteria and extracts the subset of structures meeting the criteria, along with all of the data needed to identify each structure and to enable ranking it within the subset;
5. Review of the subset of bridges in each category by inspection, maintenance and design staff, to confirm or correct information on each structure, and then rank the structures from most to least urgent;
6. Combine all categories into a single set of structure projects, ranked from most to least urgent. This final step factors in resource availability (staff and funds), time to design and practical aspects of coordination with roadway projects to develop a practical four year schedule for execution. This becomes the STIP.

CATEGORIES OF NEEDED WORK

The Sufficiency Rating provides useful ranking for modernization requirements, but fails to provide a useful basis for comparisons of condition specific problems or vulnerability. Different criteria, with a clear relationship to each observable problem and risk, were needed. ODOT and FHWA saw the need to both develop such criteria and develop a process to consistently apply the criteria to determine if and why a structure should be repaired, rehabilitated or replaced. Structures with similar needs could then easily be compared.

ODOT started with the categories used in the NBI: Substructure, Superstructure and Deck. Major categories for vulnerability, Seismic and Scour, were added. Categories for safety deficiencies, Bridge Rail and Deck Width, were added. Restrictive use categories, Load capacity and Underclearance, were included. Protection of investment categories, Paint (corrosion protection for steel structures) and Coastal Bridge (corrosion protection and correction for reinforced concrete structures) were transferred from the Maintenance Program to the STIP. Rehabilitation and upgrade of movable bridges to meet operational requirements of maritime traffic was identified as a critical, high cost, category and therefore also included as a STIP category.

Each category relates to a significant feature that is both visually and conceptually distinct. Any specific bridge may have multiple categories of work required. A selection criteria, or threshold condition, which determines how urgently the work is needed, is used to select a subset of bridges for consideration within a category. The categories used by ODOT are summarized in Table 1.

BRIDGE DATA COLLECTIONS

Oregon DOT's current implementation of BMS has an Inventory Database and an Inspection Database with Pontis element ratings. These provide FHWA with required information and allow Oregon to consistently compare bridges by sufficiency rating, by NBI ratings and by individual structural element ratings. They do not describe all conditions or risks which require funding to keep structures in fully useful service.

In addition to the BMS databases, ODOT has instituted a number of data collections to describe and prioritize specific requirements. These include a seismic vulnerability database, a scour vulnerability database, a steel bridge paint system database, a coastal bridge database, a bridge rail risk assessment database, a load rating database, a cross-stream profile database, a movable bridge database and a protective screening database. These collections were developed independently, in response to concerns about these potential problem areas.

ODOT has also set up a database with tables of accident counts per year, by highway and milepoint, that were extracted from its mainframe accident statistics database. Similarly, ODOT has extracted maintenance costs by bridge per year from its maintenance cost accounting system. Two collections are being developed, structure drawings and structure photographs, both with data and electronic images.

The organization of these data collections is described in Table 2.

ODOT has also developed databases with 20-year Highway Plan needs for structures and with projects in the current and previous STIP with structure work. Problem bridges that surface during the process are compared with the current and the previous STIP to verify that the problem has not already been addressed. The Highway Plan database contains the investment amounts recommended for each category of work,

Table 1: Oregon DOT Categories for Structure Projects

Category	Data Collections Involved	Selection Criteria
Seismic	Inventory, Seismic	Major River Crossing, Seismic Rank
Scour	Inventory, Scour	Spread Footing, Erodable Material
Substructure	Inventory, Inspection	NBI, Pontis Element Condition Rating
Superstructure	Inventory, Inspection	NBI, Pontis Element Condition Rating
Deck	Inventory, Inspection	NBI, Pontis Element Condition Rating, ADT
Railing	Inventory, Rail, Inspection	Site Risk, Element Rating
Deck Width	Inventory, Accidents	Width, Lanes, Accidents, ADT
Load Capacity	Inventory, Inspection, Load Rating	Temp Structure, Load Rating
Underclearance	Inventory, Inspection	15 Feet or less Vertical, Impact Damage
Paint	Inventory, Paint	Lead Paint, Paint Rating 3 or worse
Coastal Bridge	Inventory, Coast, Inspection	Spalling, Chlorides, Element(s) Rating
Movable Bridge	Inventory, Movable	Electrical, Mechanical Equipment Rating

Table 2: Oregon DOT Data Collections

Data Collection		
Structure Number Database	Linked by NBI Bridge Number	Bridge Inventory Database
		Bridge Log Database
		Bridge Routine Inspection Database
		Bridge Seismic Vulnerability Database
		Bridge Scour Vulnerability Database
		Bridge Rail Risk Assessment Database
		Bridge Paint System Database
		Coastal Bridge Database
		Movable Bridge Database
		Load Rating Database
		Bridge Protective Screening Database
		Bridge Cross Stream Database
		Highway Accident Database
		Bridge Maintenance Cost Database
		Bridge Drawings (being developed)
		Bridge Photographs (being developed)

based on analysis of the problem bridges over a 20-year span and without current fiscal constraints. The Highway Plan 20-year bridge needs amount to $540 million per year for Interstate structures, $841 million per year for structures on routes with statewide significance and $471 million per year for remaining routes.

Obtaining the complete picture of work needed by a bridge, developing an appropriate project to accomplish the work, and prioritizing this project against others being considered are greatly enhanced by a method to systematically assemble and relate all of these data collections.

Visualizing the complete picture, including the development of solution alternatives, the assessment of benefits and consequences, and making the final decisions on which projects will be accomplished in which years, requires professional structural judgment and knowledge of the methods and limitations in the data collections.

PRIORITIZATION WITHIN CATEGORIES

By breaking down the set of structures which need repair, rehabilitation or replacement into subsets, the problem categories, ODOT is able to focus the attention of bridge design managers, bridge inspectors and bridge maintenance supervisors on specific problems. To make the most use of these key individuals' time, this process is done in four steps.

First, the computer search engine is instructed to extract from the linked databases the subset of bridges which meet threshold criteria for selection in each category. This is placed in a standardized spreadsheet, organized by Region, Maintenance District and Highway. Each structure has standardized identification information, standardized geometric and ADT information, and has specific condition and risk information appropriate for the category.

Second, the Structural Design Team Manager responsible for a specific Region, the Bridge Inspector responsible for that Region and the Bridge Maintenance Supervisors within that Region together review the structures identified within a category. Conflicts within the data are resolved, missing data is obtained and factors, such as rate of deterioration, permit loads, maintenance problems, and criticality of the route are considered. This step in the process uncovers work which has already corrected the condition, and structures which the computer search failed to identify.

Third, a "priority band" is assigned to each structure project. A "9" is assigned if, in the judgment of this review team, the work is needed within the first two years of the upcoming STIP. An "8" is assigned if the deterioration or risk must be addressed within the second two years of the STIP. A "7" is assigned if the work would best be done within the four years of the STIP, but could be delayed two years, although at a higher maintenance cost. Priority bands "6" through "0" are used to describe work that should be accomplished within the foreseeable future. The structure projects are then organized in priority band order in each category for each Region.

Fourth, the four Structural Design Team Managers, with help from the Preservation Manager and the BMS staff, assemble a statewide list for each category. Projects are placed in the list in priority band order. This team reviews the projects in the list, and their priority band, from a statewide perspective. Projects that appear out of place in the list are discussed with the team which ranked them, and then the ranking is revised with the team's concurrence.

PRIORITIZATION AMONG CATEGORIES

The most difficult challenge in achieving a single statewide priority list for structure projects is comparing the value or urgency of projects in one category versus those in another category. There are numerous logical systems to use in dealing with this, and which is the most advantageous may never be resolved. Oregon uses the logic that the problem, which will result in the greatest expense if not addressed, has the highest need to be resolved. Oregon's citizens place a very high value on preserving historic and cultural resources, and this dramatically affects both the prioritization and available options to deal with issues such as bridge width, bridge rails and corrosion protection.

In the first use of this process, ODOT's 1998–2001 STIP, the most urgent Seismic projects were placed at the top of the list, followed by Scour Critical projects. In either case, a failure of a portion of a structure due to seismic or scour action would result in complete replacement of the structure on an accelerated schedule. This would be the most expensive course of action. The next most expensive problem area would be Substructure. Settling, shifting or overloaded substructures are so expensive to deal with that replacement of the structure is the most cost effective solution. Unique projects, such as movable bridge electrical and mechanical upgrades and historic coastal bridge restorations, had very visible value. Overdue paint projects were a significant economic issue. Delaying these projects had more than doubled the cost. Bridge rail retrofits and bridge deck repairs were clearly needed, but the economics were not as obvious. Remaining categories were difficult to rank.

In the second use of this process, the 2000–2003 STIP, currently in development, all categories were combined into a single list, ordered by priority band. This, in effect, gives equal weighting to all problem categories. On the surface, this appears to run contrary to the desired outcome. What it does accomplish is place all of the possible high priority problems in one place. No high priority problems are automatically deleted because that problem is of lower value. ODOT's Structural Design Team Managers reviewed this inclusive list to reprioritize projects that were clearly out of place in terms of the consequences for not resolving the problem. The result is the statewide list of structure problems to address in the upcoming STIP.

The statewide list will have structures that show up in multiple locations because they have multiple problems. Decisions on solutions are not made until the problems have all been identified.

MOVING FROM PROBLEMS TO SOLUTIONS

Three solution paths present themselves in this condition plus risk assessment method. The first is to repair the condition which warrants action, such as replace the structurally deficient rail. The second path is to rehabilitate the structure, repairing or replacing major components, such as structurally overlaying the deck, replacing the bridge rail and providing a seismic retrofit. The third path is to replace the structure entirely.

To determine the most economic path, costs associated with resolution of individual problems and the cost to replace the structure are needed. Having the Design Teams produce the cost estimates is proving advantageous. Those who will have to ultimately deliver the design solution have both the skills needed and the interest in producing a practical and effective solution. This solution is the project scope of work and cost which will be placed in the STIP, and which they will be expected to deliver.

A significant risk exists at this point, however. There is a natural tendency to include all possible work items, even those of too low a priority or cost to be considered initially. The resultant sum can easily be made to exceed the replacement cost. Applying this technique uniformly will result in replacement as the action to address all problems. In an environment of limited funds, this will also result in resolving the fewest number of high priority problems.

Professional judgment, knowledge of economic cost evaluation, and a consensus within Bridge Management are required to determine whether to solve the individual problem, to extend the solution to include other, lower priority, problems, or to completely replace the structure. Applying this consistently will ensure that the scope of work, project cost and priority of each structure project in this final list represent the best use of available funds.

INCORPORATING FIELD PERSPECTIVE

As the Design Team Managers are finalizing the solutions, they are again conferring with the Regions. The Region Construction Project Managers desire to provide input on whether structure projects in an area can be combined into a single project, and whether or not unrelated work, such as seismic retrofit and rail replacement, will be done together, or separately.

The District Maintenance Managers want to know if items their crews had requested are in a project, or will they need to address them separately.

The Region Project Development staffs want to know if any structure work is planned to be done in the Bridge Program for structures that lie on highway sections where they are planning to accomplish roadway preservation work. They are also interested in knowing the priority band for rail, deck, and other work to decide if it would be advantageous for them to fund that work and avoid a separate contract later which would inconvenience the public a second time. They would also like to propose that the Bridge Program consider funding lower priority work to reduce public inconvenience. This is a valid consideration, and has been incorporated where it made sense.

APPLYING FUNDING REALITIES

With a prioritized list of solution projects with scope of work and project cost identified, the crucial question, how far down the list can we go, depends on the projected availability of funds. This is a two step process.

The first step occurs very early in the process, with rough estimates based on size of structure and type of problem. The structures which are extracted initially have a cost estimate applied and are factored into a systematic funding requirement by category over a twenty year period. This analysis is integrated with other program requirements and a capitol investment scenario is presented to the Oregon Transportation Commission in the Oregon Highway Plan. Approval of the Plan results in the second step, assignment of an annual funding level for the Bridge Program. The current investment strategy for State-owned structures is to maintain them at current condition, using $52 million per year. This halts a steady decline from the mid-1980s.

The use of these linked data collections and logical evaluation by ODOT's BMS staff to produce both the Highway Plan and the STIP has made a very clear case for increased funding for structure preservation. The Bridge Program has gone from $36 million per year in fiscal year 1998, after applying expenditure limitations, to $52 million per year in fiscal year 2000. This latter figure is what we are currently using, which enables us to fund $208 million in projects for the 2000–2003 STIP.

In addition, the use of this data-driven, "geographically blind," process has resulted in the Regions passing both funding and responsibility for culverts, protective fencing and similar structure work that they had previously controlled to the Bridge Program. These are funded over and above the $52 million figure. This confidence in the process is an indication that applying this process to all publicly owned bridges could function as a "jurisdictionally blind" method to at least recommend to bridge owners which structures should be submitted for HBRR funding.

APPLYING SCHEDULING REALITIES

The Design Team Managers, as the holders of the design resources needed to deliver these STIP projects, break the list into four draft STIP year lists. Priority is no longer the issue. Instead, a practical delivery schedule is now the issue. More difficult and involved projects take longer, requiring a delivery date towards the end of the STIP. Simpler projects, on the other hand, do not require as much design lead time, and can be executed earlier in the STIP. The Design Team Managers confer with the Regions on the draft schedule of projects. This time, Region resources are the subject. Environmental, public involvement, surveying, coordination with other projects, and inspection capacity drive a different look at the schedule. In addition, other Headquarters Sections are consulted for scheduling concerns.

These scheduling requirements are applied and a revised schedule is developed. The funding picture is reviewed to ensure the project obligation rate will remain close to the $52 million per year. If necessary, additional rounds of negotiations are required to end up with a four year program that is both fundable and executable.

The entire process, from initial computer extraction to published STIP, takes 18 months.

RESULTING STATEWIDE FOUR-YEAR BRIDGE PROGRAM

The result is a set of structure preservation projects that clearly focuses available resources on the highest priority concerns within the State. The set of projects fits within the 20-year Highway Plan and contributes to programming funds for future STIPs. The projects, having been jointly developed with Region and Headquarters staff, are well understood and fully supported by all who have to deliver the projects. Because the process includes both prioritization and scheduling, it can easily adapt to changes in scheduling or available funds. The process ensures that projects in the Bridge Program closely align with the condition information provided the Federal Highway Administration and meet the goals of Oregon's Governor and Transportation Commission to preserve our existing highways and bridges.