TxDOT's Approach for Selection and Programming of Bridge Program Projects

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ABSTRACT

Part of the overall challenge of effective bridge management to a highway transportation agency is the timely identification, planning, and scheduling for construction of bridge replacement and rehabilitation projects. The Texas Department of Transportation (TxDOT) endeavors to meet this challenge as it relates to bridge replacement and rehabilitation using federal bridge funding, by selecting projects using a statewide priority scoring system.

The priority scoring system is based on the simple notion of "addressing the worst bridges first" and provides for calculation of a score from 0 to 100, with 100 representing the highest priority and 0 the lowest. The decision support tool on which statewide prioritization of the federal bridge projects is based is known as the Texas Eligible Bridge Selection System (TEBSS). TEBSS was developed at the University of Texas Center for Transportation Research (CTR).

In calculating a score for a bridge, TEBSS considers five attributes: average daily traffic, structural condition, ratio of roadway width to the current standard, the Federal Highway Administration (FHWA) sufficiency rating, and estimated construction cost per vehicle. In score calculation, weights are assigned to the five attributes, each of which in turn is multiplied times the "frequency percentile of occurrence" for the attribute, within the total eligible bridge population, to determine a number of points. The points calculated for each of the five attributes are then added up into an overall TEBSS score.

Use of statewide prioritization in the administration by TxDOT of federal bridge projects began in 1996 after a comprehensive study by a select group of senior TxDOT managers and engineers. The study group looked at the complete TxDOT project development process, including the federal bridge program. In recommending use of a statewide prioritization process in administering the federal bridge program, the group suggested use of the TEBSS system and further recommended the attribute weights to be used in calculating TEBSS scores.

The federal bridge program work is administered by TxDOT within an overall 10-year plan known as the Unified Transportation Program (UTP). The UTP is updated and reissued each year and consists of 17 categories of work, which includes a category for federal bridge projects. The federal bridge program category of the UTP is in turn subdivided into A and B portions for on and off-state system bridge replacement and rehabilitation projects, respectively.

Each yearly edition of the UTP designates 10 years worth of projects for the funding that is projected to be available during the upcoming 10-year period. For most

UTP categories, including the bridge categories, the 10-year period is divided into two multi-year portions. The first multi-year portion (four years) contains projects that are authorized for planning, development, preliminary engineering, and letting to contract construction, which is designated as the "Priority 1" level of authorization. Those projects in the second multi-year (six years) period are designated as "Priority 2" projects, which are only authorized for planning, development and preliminary engineering, but not the letting to contract construction.

Each year Priority 1 bridge program projects are let to contract construction, for which new Priority 1 projects are added to the subsequent year's UTP to be let to contract during the fourth year of the later UTP. Again, the new Priority 1 bridge program projects are selected in the order of statewide prioritization score.

BACKGROUND

The Transportation Equity Act for the 21st Century, or TEA21 as it is referred to, and its most recent predecessor, mostly apportions funds to the states by system including the National Highway System, and Surface Transportation Program, and more specific activities. The specific activities include:

- mobility
- safety
- rehabilitation
- replacement and rehabilitation of deficient bridges on the public highways, roads and streets.

UNIFIED TRANSPORTATION PROGRAM (UTP)

The Texas Department of Transportation (TxDOT) provides for utilization of the federal transportation funds as well as the state funds made available, through a 10-year plan known throughout the state as the Unified Transportation Program, or "UTP". The UTP, which is updated and reissued annually, consists of 17 categories of work which generally follow the framework of the systems and activities set forth in TEA21. The federal bridge program is represented in Category 6 of the UTP, and this category is in turn divided into A and B portions.

- Category 6A consists of projects to replace or rehabilitate deficient bridges that are located on the state highway system.
- Category 6B consists of similar bridge work on public roads and streets that are off the state highway system on county roads and city streets.

Each yearly edition of the UTP designates 10 years worth of projects for the funding that is projected to be available during the upcoming 10-year period. For most

UTP categories, including the federal bridge program categories, the 10-year period is divided into two multi-year portions.

- First Multi-Year Portion : Priority 1
- Second Multi-Year Portion: Priority 2

The first multi-year period contains projects that are authorized for planning, development, preliminary engineering and letting to contract construction, which is designated as the "Priority 1" level of authorization. Those projects in the second multi-year portion of the UTP are designated as "Priority 2" projects, which are authorized for planning, development and preliminary engineering, but not the letting to contract construction. For Priority 1 projects it is reasonably expected that funds will be available to let those projects to contract within the first multi-year period of the given edition of the UTP. However, given the nature of the funding environment no such assurance can be made for the Priority 2 projects as far out as the second multi-year period of the UTP. It is not being said that funds will not be available for those Priority 2 projects when their times come for upgrade to Priority 1; it is just being said that it is not realistic to commit construction funding that far ahead of time. There are simply too many events and factors that can occur in the interim.

Priority 2 projects are upgraded to Priority 1 under the yearly edition of the UTP to take the place of Priority 1 projects that were let to contract during the previous year. Also each year additional Priority 2 projects are authorized to take the place of those upgraded to Priority 1.

For the federal bridge program categories of the UTP (6A for on and 6B for off-state system) the two multi-year portions are four and six years, respectively. Thus, the yearly edition of the UTP authorizes four-year programs of Priority 1 authorized work for on and off-state system bridge projects, respectively. At the same time the UTP authorizes 6 years' worth of Priority 2 projects that are tentatively identified for letting to contract construction during the latter six years of the overall 10-year UTP.

The annual UTP development process typically begins in December each year and is concluded in the following March in time for compilation of the federally required Transportation Improvement Program (TIP).

STATEWIDE PRIORITIZATION OF BRIDGE PROJECTS

The Priority 1 federal bridge projects for on and off-state system respectively are mostly selected on a statewide priority basis through use of a prioritization score. The priority scoring system is based on the simple notion of "addressing the worst bridges first." The prioritization score is referred to as the "TEBSS score" with TEBSS being an acronym for "Texas Eligible Bridge Selection System." TEBSS was developed for TxDOT by the University of Texas Center for Transportation Research under the cooperative research program.

The TEBSS Scoring System

In the TEBSS system a score between 0 and 100 is calculated for each existing eligible bridge with 100 indicating the highest priority and 0 representing the lowest. The TEBSS scoring system considers a number of the most pertinent attributes of a bridge and "how frequently" the value of each attribute occurs within the total population of eligible bridges across the whole state. Another pertinent consideration is the relative weight that should be assigned to each attribute considered. The scoring process may then be roughly demonstrated as follows:

TEBSS Score = (Relative Frequency of Occurrence for Attribute A multiplied times the Assigned Relative Weight for Attribute A) + (Relative Frequency of Occurrence for Attribute B multiplied times the Assigned Relative Weight for Attribute B) + . . . , etc.

or

$$\text{TEBSS Score} = (F_A \times W_A) + (F_B \times W_B) + \ldots + (F_N \times W_N)$$

The TEBSS Score

Specifically, a TEBSS score for a bridge is calculated by using relative frequencies of occurrence and assigned weights to score each of a number of the bridge's attributes. The scores for the attributes are then totaled into an overall score for the bridge. Weights are assigned to each attribute relative to the other attributes. The attributes considered by TEBSS are five in number and include the following:

- FHWA Sufficiency Rating (SR) (0 to 100 least to highest sufficiency scale)
- Average Daily Traffic (ADT)
- Cost Per Vehicle (CPV)
- Minimum of the condition ratings (on a 0 to 9 worst to best scale) for the Deck (roadway), Superstructure and Substructure (DSS), and
- Ratio of the bridge roadway width to the standard width considering ADT (BWR)

The method used to measure the relative frequency of occurrence of an attribute is the cumulative frequency percentile. Cumulative frequency percentiles are calculated for each attribute within the entire eligible bridge population across the state.

In a previous instance there were 6,100 on-system bridges identified in the bridge inventory and inspection file statewide that were eligible under Federal Highway Administration (FHWA) criteria, for replacement or rehabilitation under the federal bridge program. To be eligible for rehabilitation under the federal bridge program, a bridge must have an FHWA Sufficiency Rating (SR) of 80 or less and be classified as structurally or functionally deficient. To be eligible for replacement, a bridge must be structurally or functionally deficient and have an SR less than 50.

An example using the minimum condition rating (DSS) attribute to demonstrate cumulative frequency percentile (TEBSS percentile) calculations is as follows:

Condition Rating	Frequency	Cum Freq	Cum Freq* (%)	TEBSS Percentile**
0	75	75	1.23	99
1	22	97	1.59	98
2	121	218	3.57	96
3	527	745	12.2	88
4	1075	1820	29.8	70
5	1443	3263	53.5	47
6	1785	5048	82.8	17
7	934	5982	98.1	2
8	118	6100	100.	0
9	0	6100	100.	0

* $\frac{\text{Cum Freq}}{6100} \times 100$

** 100 – Cum Pct (%)

In reviewing the above example, it may be seen that in a total of 6,100 eligible bridges, the minimum condition ratings (DSS) range from 0 up through 9. Initially for each DSS the number of bridges (frequency) with that respective DSS value is determined, from which in succession are further determined cumulative frequencies in terms of both numbers and percentages. The cumulative frequencies in percent are then converted to percentiles merely by subtracting each from 100. The percentiles resulting from the above example reveal that 99 percent of the bridges have a DSS greater than "0"; 98 percent have a DSS greater than "1"; 96 percent have a DSS greater than "2"; 88 percent have a DSS greater than "3"; etc.

Note that the higher the percentile the more critical the condition of the attribute. Tables of cumulative frequencies with TEBSS percentiles are calculated for each of the other four attributes of the 6,100 eligible bridge sample. In each table the same scheme is used, i.e., the more critical, the higher the TEBSS percentile.

In assigning weights to the five attributes, any combination of weights is possible, of course. However, after considerable study TxDOT senior management elected to use the following assigned weights.

SR	ADT	CPV	DSS	BWR	TOTAL
.24	.24	.04	.36	.12	1.00

The TEBSS percentiles of the five attributes of a structure together with assigned relative weights are then used to calculate a TEBSS score. The rationale is to contribute points to a score of 0 through 100 relative to the condition each attribute is in; the more

critical the condition of the attributes, the more points, and conversely the less critical, the fewer the number of points awarded. This is further explained in the following matrix.

Attribute	High	Low
SR	Less Points (the lower the percentile)	More Points (the higher the percentile)
ADT	More (the higher the percentile)	Less (the lower the percentile)
CPV	Less (the lower the percentile)	More (the higher the percentile)
DSS	Less (the lower the percentile)	More (the higher the percentile)
BWR	Less (the lower the percentile)	More (the higher the percentile)

In considering the cost per vehicle (CPV) attribute, for instance, it is being said that the lower the CPV, the more cost-effective the project is assumed to be, thus the higher the number of points awarded. For average daily traffic (ADT), the higher the ADT, the more points; the lower the Sufficiency Rating (SR), the more points; the lower the minimum condition rating, the more critical the field condition of the structure, and thus the more points. For the bridge width ratio (BWR), the lower the ratio, the more substandard the roadway width which justifies award of more points.

Example

An example structure might have the attributes of:

SR	ADT	CPV	DSS	BWR
18	360 veh/day	$149/veh	5	.529

With this data, appropriate percentiles, and the assigned weights, a TEBSS score is calculated as follows:

	SR	ADT	CPV	DSS	BWR	TOTAL
	18.	360.	149.	5.	.529	—
Weight	.24	.24	.04	.36	.12	1.0
TEBSS Pctl	94.	80.	75.	47.	82.8	—
Score	23.	19.	3.	17.	10.	72.

In the above example it may be readily seen that the subordinate attribute scores are determined and are added together to arrive at an overall TEBSS score for the bridge of 72.

SELECTION OF PROJECTS WITH CRITICAL DEFICIENCIES

As described earlier, the Priority 1 selection of projects each year is mostly in the order of higher to lower TEBSS score. However, as much confidence as we do have in the scoring process being a good indicator of the need for when a bridge should be scheduled for remedy, it is recognized that some bridges have deficiencies so critical they need to be Priority 1 selected regardless of TEBSS score; i.e., the need for a default option. Therefore, the following "critical deficiency" rules are used for Priority 1 selection regardless of TEBSS score.

- a minimum condition rating for the deck, superstructure or substructure (MinDSS) of "2 or less"
- a cumulative total of the deck, superstructure and substructure condition ratings (CumDSS) of "10 or less"
- a bridge classified culvert condition rating (CC) of "3 or less"
- an FHWA sufficiency rating (SR) of "30 or less"

Currently, these "critical deficiency" rules are having to be used very heavily for our off-system bridge project selection, with relatively light use for on-system projects.

SUMMARY

With the current fiscal year (FY 1999) TxDOT has used the TEBSS statewide priority scoring system for federal bridge projects for four years. It appears the process is mostly successful in targeting the remedy of "the worst bridges first" and more effective use of the state's federal bridge program apportionments. It replaced a process where allotments of the federal bridge funds were made to the districts, and it was then left up to the districts to select the projects using only the basic eligibility criteria prescribed by FHWA.

It is acknowledged that this TEBSS scoring system being used by TxDOT for selection of bridge replacement and rehabilitation projects may lack the preciseness, quantitativeness and perhaps overall sophistication that systems like Pontis might offer. But, our needs in Texas for bridge replacement and rehabilitation of a staggering number of deficient bridges are great, and in most cases, at least for the foreseeable future, the need for such work is obvious without having to use the more sophisticated tools.

At the same time we do also acknowledge, however, that the TEBSS scoring system probably does have shortcomings when it comes to using it for managing bridge preventive maintenance, repair and minor rehabilitation work. So we are looking at using Pontis for managing that more maintenance related bridge work. If we then have good success with using Pontis in that area and we are able to economically collect and keep up to date the additional data required, consideration may be given in the future to using the Pontis system in the statewide prioritization of the bridge replacement and rehabilitation projects.