RELIABILITY OF INSPECTION RATINGS OF HIGHWAY BRIDGES IN USA

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The bridge collapse in Minnesota is a wake up call for us in terms of how invest in our bridges. In the wake of tragedy, we are all trying to find bridges that may be deficient. This may be an increased loss of resources that may be used to inspect our bridges in planned way.

Current bridge inspection procedure is largely visual in nature and rely purely on judgment of bridge inspectors, not to mention their eyesight condition. In fact, a detailed 2001 Federal Highway study concluded that "From the in-depth Inspection tasks, it was observed that In depth inspections are unlikely to correctly identify many of the specific types of defects for which this type of inspection is frequently prescribed. As an example, only 3.9 percent of weld inspections correctly identified the presence of crack indications.

Furthermore, it is concluded that a significant proportion of in-depth Inspections will not reveal deficiencies beyond those that could be noted during a routine inspection. As with routine inspections, a number of factors appear to correlate with in-depth inspection results".

The study also found strong correlation between variability of inspection ratings and secondary factors related to bridge inspectors condition, such as "reported fear of traffic, near visual acuity, color vision, formal bridge inspection training, light intensity, reported structure maintenance level, reported structure accessibility level, reported structure complexity level, inspector rushed level, and wind speed".

Bridge sufficiency rating is calculated on the scale of 0 to 100 using a pre-determined formula developed by FHWA. Table 1 shows primary criteria used to classify a bridge structurally obsolete. Fig. 1 shows sufficiency rating calculations for a bridge when the bridge superstructure is rated at 6 (satisfactory condition) and substructure is rated at 7 (fair condition with sound structural members and minor deterioration). The bridge with above ratings is perfectly safe. However, other items in NBI can make it structurally deficient. Hence, a bridge may be rated structurally deficient and still be completely safe.

Given all these reliability issues, bridge inspection ratings are only considered as qualitative measures for allocation of budgets for maintenance and repair and screen bridges for a detailed study.

A 2001 study found that the Minnesota bridge had a history of problems, most notably nonredundant determinate truss. A failure of any member of the truss could lead to collapse of the bridge. This certainly warranted in-depth investigation of failure modes of the bridge. A nonredundant determinate truss carries a significant level of high risk of failure. Generally, we design bridges to have high level of redundancy so that loads can be redistributed to other members in case of failure of any load carrying member. This probably didn't happen in this case. The study concluded that this mode of failure may not be possible because of secondary effects, such as composite action of slabs, etc. There is no documented evidence that these secondary effects could prevent the collapse. To the least, further study was needed to verify the validity of their conjecture. It is also possible that the stability of the bridge was compromised because of replacement work being done on one side of the bridge, since removal bridge deck for repair may have caused lack of composite action of slabs, if slabs were contributing to the stability of the bridge at all. The conclusion is that the tragedy could be avoided if a thorough structural analysis of various failure scenarios along with in-depth inspection using non-destructive tools was carried out.

There are numerous new approaches to inspect bridge components reliably, e.g., ultrasonic scanning, infrared cameras, piezoelectric sensors, health monitoring through instrumentation, etc. Detailed structural analysis and inspection of Minnesota bridge could certainly have detected failure modes of the bridge system and critical members that could have led such failures. Let's hope that this event will force us to invest more in our infrastructures and use these technologies so that we can be safer. There is an urgent need to develop guidelines and protocols so that bridges can be inspected more reliably. We have to wake up and start inspecting bridges to really identify the state of damages and not to merely comply with Federal inspection requirements.

Table 1: Sufficiency Rating of Bridges

Element	**Description**
Deck	Overall condition, excluding wearing surface, expansion devices
Superstructure	Physical condition of structural members, excluding bearings
Substructure	Physical condition of piers, abutments, excluding bearings
Structural Evaluation	Lowest of inventory rating goal for HS load and ADT, superstructure condition and substructure condition
Waterway Adequacy	Rating of overtopping frequency and traffic delay for functional class of route on bridge
A bridge is structurally deficient if Structurally Deficient if condition rating of 4 or less for Deck or Superstructures or Substructures or Culvert and Retaining Walls or an appraisal rating of 2 or less for Structural Condition or Waterway Adequacy.	

BRIDGE SUFFICIENCY RATING CALCULATION

County /City:		Bridge ID:	FHWA No.:	152810

Structural Adequacy & Safety - S1 (max.) is 55%

Item 59. Superstructure Rating	=	6			
Item 60. Substructure Rating	=	7			
Item 62. Culvert Rating	=	N			
Item 66. Inventory Rating	=	217	(MUST START WITH "2")		
The calculated allowance for Structural Adequacy and Safety (S1)				=	31.9928596

Serviceability and Functional Obsolescence - S2 (max.) is 30%

Item 58. Deck Condition Rating	=	5		
Item 67. Structural Condition Rating	=	4		
Item 68. Deck Geometry Rating	=	8		
Item 69. Underclearance Rating	=	N		
Item 71. Waterway Adequacy Rating	=	5		
Item 72. Approach Alignment Rating	=	4		
Allowance for Serviceability -J (max.) is 13% =		6		
Item 28. Lanes on Structure	=	1		
Item 29. ADT on Structure	=	90		
Item 51. Roadway width - curb to curb	=	15.9		
Item 43. Main Structure Type	=	380		
Item 32. Approach Roadway Width	=	24		
Item 100. Is this a defense road (Y/N)	=	N		
Item 53. Vertical Clearance	=	9999		
The calculated allowance for Serviceability and Obsolescence (S2)			=	11.125

Essentiality for Public Use - S3 (max.) = 15%

Item 19. Detour Length	=	4		
The calculated allowance for Essentiality for Public Use - S3	=		=	14.9467738
Special Reduction - only used if S1+S2+S3>=50%				
Item 36. Traffic Safety	=	0000		
The allowance for Special Reductions (S4)			=	8.000013325

SUFFICIENCY RATING SUMMARY

Item				
Structural Adequacy and Safety	-	S1=	31.99286	
Servicability & Functional Obsolescence	-	S2=	11.125	
Essentiality for Public Use	-	S3=	14.94677	
Special Reductions	-	S4=	8.000013	
Sufficiency Rating (S1 + S2 + S3 - S4)			=	50

Figure 1: Sample calculation of Sufficiency Rating of Bridges