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Systems Approach in the Inspection of Suspension Bridges

Approche globale de l'inspection des ponts suspendus

Gesamtplanung bei der Inspektion von Hängebrücken

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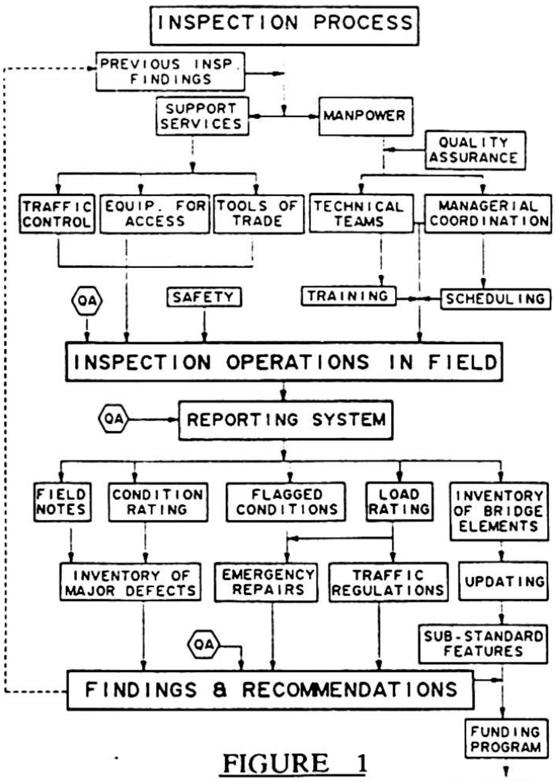

FIGURE 1

1.0 INTRODUCTION

In the early part of this century, a number of suspension bridges were built in the metropolitan areas of the USA. These heavily traveled bridges are aging rapidly due to fatigue, corrosion and wear. While it is not practical to replace these bridges, especially in a megalopolis, these bridges can be salvaged by maintenance and rehabilitation through regular inspection that will keep them functioning for the demanding traffic needs of the next millennium. Hence methodical inspection and reporting has assumed paramount importance.

2.0 INSPECTION AS A PROCESS

A scientific and systematic approach for bridge inspection is outlined in figure 1. It is critical to recognize inspection as a process and not as an isolated event that takes place on a periodic basis. By doing so, the need based attitude, which normally has short term applications only, can be transformed to a wider spectrum that encompasses several short and long term applications. For example, the quantitative condition rating of elements allows tracking of their conditions over a period of time so as to monitor the overall condition of the bridge; inventory of bridge elements complements the rehabilitation expenditure planning, etc.

A case study of the recently completed biennial inspection of the Manhattan Bridge, New York, USA is presented below wherein the above principles were implemented.

3.0 CASE STUDY

Manhattan Bridge is a 90 year old bi-level suspension bridge carrying 7 lanes of vehicular traffic and 4 tracks of New York City transit trains. The AADT (1988) was over 75,500 along with 960 trains a day. This bridge, being one of the major crossings serving the City of New York, requires uncompromising traffic restrictions on the allotment of time for inspection and rehabilitation.

The 1990 biennial inspection was performed over a period of 4 months. The authors were in the team of 11 Registered Professional Engineers and 10 Structural Engineers. The inspection was conducted for the New York State and New York City Departments of Transportation.

As the train tracks are located on the outer portions of the bridge, the eccentric train loads penalize the stiffening trusses and floor systems with torsional effects. During the inspection more than 1200 defects were recorded and 615 of them were flagged demanding immediate attention. Prompt corrective actions were taken by the New York City Department of Transportation in terms of performing emergency repairs, reviewing the load rating and temporarily closing of one lower roadway lane and two tracks of NYC transit, pending repairs. Some of the major defects are highlighted in the bridge cross-section in Figure 2

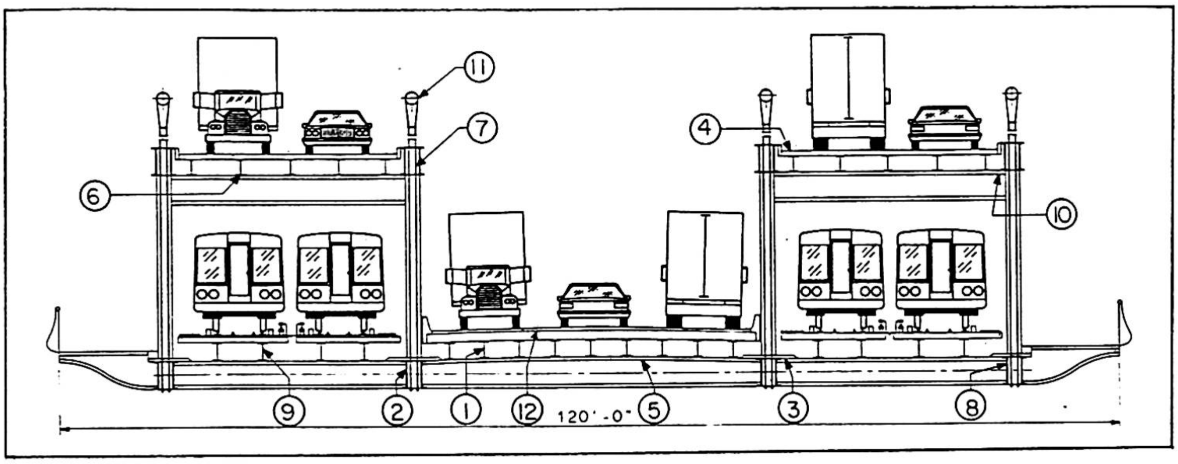

FIGURE 2: CROSS SECTION OF MANHATTAN BRIDGE, NEW YORK - *Major Defects Reported*

1. *Cracks in stringers*
2. *Corrosion*
3. *Cracked continuity angle*
4. *Deck defects*
5. *Corrosion of top flange*
6. *Uplifted Stringer brg.*
7. *Suspender wear/ Striking top chord*
8. *Cracked chord splice*
9. *Track Stringer Brg.- Displaced/cracked*
10. *Cracked floorbeam end*
11. *Corroded Cable Wrapping at lower saddle*
12. *Leaky deck joints*

4.0 INSPECTION INFORMATION SYSTEM (IIS)

A system of collecting, preparing and representing a comprehensive database from the data collected in the field became a powerful tool for decision making on issues like traffic limiting, planning for rehabilitation, etc. This database included past and present condition ratings of various elements, classified listings of hazardous conditions demanding immediate action, respective actions taken, etc. New York State Department of Transportation has developed a system of quantitative rating of elements based on the residual capacity and functionality of the element instead of using terms like "Sound", "Fair", "Satisfactory", etc. On a scale of 7 (new condition) to 1 (hazardous condition), a rating of 3 denotes "serious deterioration and not functioning as originally designed." Usage of this system led to drastic reduction in the subjectivity of the rating between inspectors.

For the Manhattan Bridge, a database of defects and flagged defect conditions was prepared. It also included the condition ratings of over 30,000 elements of the bridge. Defects observed during the previous inspection were also reviewed and checked whether repaired or not.

With all the above information when organized and mapped, the contour of even rated elements revealed a pattern of deficiencies on the bridge. Individually, this information could not have revealed the complete picture. For example, the flagged condition would identify a serious defect, but would not present any information about adjoining members, without which the overall condition of the bridge could not be visualized. In one particular instance, the owners of the Manhattan Bridge decided to close one lane of vehicular traffic after observing a concentration of low ratings on the floor system of the lower roadway. It was this systematic and logical approach that eased the process of decision making.

5.0 CONCLUSION

The potential of IIS is multifarious. It can act not only as a management tool to attend to immediate needs, but also can improve forecasting and the process of selective rehabilitation to match the available funding. IIS will become more and more valuable, particularly in metro areas, as the existing older bridges will gain more prominence due to the impracticality of replacing them.