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Bridge Integrated Analysis and Decision Support: Case Histories

Final Report

By

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16. Abstract

This report presents a database of case histories of incidents due to impact, fire and scour for sixteen bridges in Wisconsin. It is intended to expand and use such case history and other relevant data in a future study to develop a decision support system. Such decision support system can aid bridge engineers take appropriate actions when rapid response is required in emergency cases such as major bridge damage or failure. The case history information presented here was assembled using available archived data from various DOT offices and through interviews with various active and retired staff of the WisDOT Districts and the City of Milwaukee. Each case history document includes information regarding any associated event, remediation, and past repair and maintenance. Essential structural and geometric data is also included with each case history document. As a part of this study, incident response procedures for WisDOT and the City of Milwaukee were developed through consultation with appropriate staff of those offices. The database is searchable with keywords and can be accessed through the web. User's manuals for both users and system administrators are included in the report.

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EXECUTIVE SUMMARY

Project Summary

This research provides an easy-to-use but comprehensive document that includes sixteen case histories of bridge problems in Wisconsin when emergency responses were required to mitigate them. The selected cases include the most common damage and failure types within the state. The document has been prepared in an electronic reference format and an internet web site has been designed and implemented for use with the case history database. The website allows users to add to the database, edit current entries, and search for suitable case histories by means of keywords.

Also, this report provides a detailed literature review of decision support and expert systems relevant to the solution of bridge maintenance and repair issues.

Background

According to the state bridge inventory, Wisconsin has 18,413 bridges. Based on a recent survey approximately 156 bridges were listed as having a damage inspection performed between July of 2000 to May of 2007. These damage inspection reports relate problems requiring simple maintenance of minor elements to the repair or replacement of major superstructure components. Each WisDOT regional office filed damage inspection reports in this time period.

In responding to such damages, regional and county engineers have few tools to assist in the decision support making process, especially in the case of an emergency incident. The purpose of this research has been to develop an easy-to-use, widely accessible, database of bridge case histories that would assist bridge engineers and inspectors in evaluating a structural incident and then formulating an effective response.

The Department of Civil Engineering and Mechanics at the University of Wisconsin – Milwaukee, through the Wisconsin Highway Research Program, conducted the project. The research team included Al Ghorbanpoor (Professor and Principal Investigator), John Dudek (Senior Lecturer and Research Associate), Rita Srivastava (Graduate Student), and Chris Wells (Graduate Student). The Project Oversight Committee, chaired by Mr. Scot Becker, included Mr. Edward Fitzgerald, Mr. Bruce Karow, and Mr. Thomas Strock.

Process

The case history tool presents the accumulated experiences of active and retired Wisconsin engineers and inspectors while responding to a range of structural issues. The sixteen bridges included in this study were chosen in such a manner so as to have at least one structure from each of the five WisDOT regions. The structures consisted of both concrete and steel bridges. The failures involved sudden impacts, fire, scour, fatigue cracking, and material deterioration. The bridges chosen for this study were located over waterways as well as highways.

The project was completed in 24 months. Initial research activities involved the identification and gathering of specific types of information needed for an effective decision support system that were to be developed based on the recorded case history database. This was accomplished through a literature review and a set of interview questions. To facilitate the accumulation of accurate and complete data, contacts were established with bridge maintenance authorities in each WisDOT regional office, the cities of Milwaukee and Madison, as well as the Wisconsin DOT Traffic Operations Center located in Milwaukee, Wisconsin.

Extensive interviews were performed with bridge maintenance engineers, inspectors, and/or supervisory personnel at each location. In addition, a significant amount of information was obtained for each bridge from the State of Wisconsin Highway Structures Information System (HSI). The information from each interview was used to compile three documents. The first is a complete case history background for each bridge. The second is a bridge physical description and location summary. The third is a detailed process flow diagram for evaluating and correcting issues as implemented by the authority responsible for the maintenance of the structure.

All of the case history documents are made accessible by means of an internet web site. The structure of this site allows for both the insertion of data (documents and graphics) and retrieval. Incorporated into this database is a keyword search feature for locating structures with specific parameters of interest to the user.

Findings and Conclusions

This study has accomplished the following tasks.

1. A literature review examining the current state-of-the-art in decision support system development and use has been completed.
2. The formats for case history documents, bridge information files, and process descriptions have been developed and utilized for sixteen Wisconsin bridges.
3. The case history documents have been accumulated into a computerized Bridge-Incident-Response-Database (BIRD) that is accessible by means of standard internet methods.
4. The database has been enhanced with a simple keyword driven search routine and a set of administrative activity routines.
5. A computer server has been dedicated to provide a temporary database site and manuals concerning installation and use of the database have been written.

Recommendations for Further Action

The research team offers the following recommendations:

- Based on the original intent of this study, initiate a new study to expand the current case history database and incorporate other required elements of a decision support system for emergency responses

- Develop essential elements of an appropriate decision support system that is based on the case histories and other relevant elements
- Implement training of WisDOT personnel in all Regions for the use of the database and the decision support system
- Maintain a permanent server and site for the database and the decision support system
- Require appropriate WisDOT personnel to populate and update the database with new case histories or incidents as they occur in the future

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Chapter 1: Introduction

Highway bridge structures constitute the lifelines of our nation's economy. They are a critical component in the transportation system that allows for the flow of commerce and the every day needs of the traveling public. With the aging of these structures, bridge owners and engineers are experiencing serious problems of deterioration, safety, and levels of utilization. Although it is a work in progress, for the last several years, bridge engineers have made significant advances in assessing the physical condition of in-service bridge structures and in providing remedial services for guaranteeing the continuing safe operation of these structures. The problems associated with aging and deterioration are often magnified by unforeseen events, such as natural disasters and accidents caused by human error or intentional acts of terror. Examples of unforeseen events include impacts by highway, waterborne, or railway vehicles, unauthorized overloads, explosions or fires, acts of terror, and natural disasters such as earthquakes, tornados, extreme cold or heat, scour, and flooding. These types of incidents could compromise the structural integrity of the bridge and lead to loss-of-life, economic losses to the community, and inconvenient disruption of traffic patterns.

Bridge owners, engineers, and transportation officials have a critical role in making timely and appropriate decisions to address such issues and to minimize the resulting adverse effects. To achieve success in responding to emergency situations, the responsible authorities must have appropriate training and be prepared well in advance. Appropriate tools must be developed to use the most modern engineering principles as well as the knowledge accumulated from previous experiences.

The most appropriate tool to utilize is a Decision Support System (DSS) that is tailored to the types of problems associated with the need to respond to transportation emergencies as well as the associated management and maintenance issues. An effective DSS contains different components and incorporates all relevant information such as previous history, current condition of the structure, local police, fire, and medical personnel, traffic type and level, and available service groups such as contractors and consultants. Further, a DSS should be able to enhance the decision making process by having access to the relevant information, utilize modern engineering analysis and design techniques, probabilistic modeling and other decision support methodologies. One important part of a transportation decision support system is the knowledge from previous experiences where emergency responses were required. This knowledge will become the foundation for future decisions and actions under similar conditions.

As a first step in developing a functional DSS the State of Wisconsin Department of Transportation (WisDOT) initiated research project 0092-04-15 titled "Bridge Integrated Analysis and Decision Support: Case Histories" through the Wisconsin Highway Research Program. The long-term goal of the WisDOT is to develop a cyber-based decision support system that will be used to aid DOT personnel to make informed decisions in cases of bridge accidents, damage, and other emergencies. One of the main sources of information for the DSS is case histories for prior bridge incidents. The case history portion of this project has focused on developing an easy-to-use, widely accessible, database that would assist bridge engineers and inspectors in evaluating a structural incident and then formulating an effective response. The primary emphasis for this study has been on situations of an emergency nature requiring efforts at damage evaluation, impacts on normal traffic patterns, repair or replacement of the structure, and costs related to design, repair and labor. The structures included in this study consisted of both concrete and steel bridges. The failures involved sudden impacts, fire, fatigue cracking, and material deterioration. The bridges chosen for this study were located over waterways as well as highways.

The sixteen bridges to be included in this study were chosen in such a manner so as to have at least one structure from each of the five WisDOT regions. To facilitate the accumulation of accurate and complete information, contacts were established with bridge maintenance authorities in each WisDOT regional office, the cities of Milwaukee and Madison, as well as the Wisconsin DOT Traffic Operations Center located in Milwaukee, Wisconsin.

Extensive interviews were performed with bridge maintenance engineers, inspectors, and/or supervisory personnel at each location. In addition, a significant amount of information was obtained from the State of Wisconsin Highway Structures Information System (HSI). The information from each interview was used to compile three documents. The first is a complete case history background for each bridge. The second is a bridge physical description and location summary. The third is a detailed process flow diagram that describes the current procedures for evaluating and correcting issues as implemented by the authority responsible for the maintenance of the structure.

All of the case history documents are made accessible by means of an Internet Web site. The structure of this site allows for both the insertion of data (documents and graphics) and retrieval. Incorporated into this database is a keyword search feature for locating structures with specific parameters of interest to the user. The long-term goal is to continue adding further case histories of incidents and to eventually develop a decision support system using the case histories as a "library of expertise" or “knowledge base” for bridge repair and maintenance efforts.

Chapter 2: Literature Review

2.1 INTRODUCTION

A great deal of research has been done in the field of bridge management, monitoring, analysis and rehabilitation. Several expert systems and decision support systems have been developed for analyzing highway structures. This literature review summarizes various research efforts related to condition assessment techniques for highway structures, analysis methods, bridge management, monitoring, and inspection of bridges.

2.2 BRIDGE MANAGEMENT SYSTEMS (BMSS)

Recently, appropriate maintenance of bridges has become a major concern, and thus the development of a practical bridge management system that incorporates maintenance is required [2]. The increasing age of bridge structures, reduced maintenance budgets and lack of proper preventative maintenance often result in structural failures [1]. Also, since the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 mandates that all state Departments of Transportation and metropolitan planning organizations use bridge management systems (BMSs), there is a need to develop more effective BMSs.

The objective of bridge management is to allocate and use limited available resources to balance lifetime reliability and life-cycle cost in an optimal manner [8]. BMSs assist decision makers in forecasting the effect of actions on the performance of a bridge. For a BMS to be effective there should be timely and accurate gathering of data related to bridge conditions, costs and effectiveness. It should also include an analysis of a bridge's vulnerability to an unexpected event such as an earthquake or a vehicular impact. A great deal of research has been done in this area and several BMSs have been developed. Three examples of a BMS are listed and discussed below

- **PONTIS** is a bridge management system developed by the Federal Highway Administration (FHWA) in conjunction with six state DOTs, including Wisconsin, and the joint consulting venture of Optima, Inc. and Cambridge Systematic [1]. The system stores bridge inventories and records inspection data. Once inspection data have been entered, it can be used for maintenance tracking and reporting. This software integrates the objectives of public safety and risk reduction, user convenience, and preservation of investment to produce budgetary, maintenance, and program policies. It also provides a systematic procedure for the allocation of resources to the preservation and improvement of all bridges in a network.

  In this bridge management system, a bridge is divided into individual elements or sections of the bridge, which are of the same material and can be expected to deteriorate in the same manner. The condition of each element is reported by means of a quantitative measure of deterioration called a condition state.

- **BRIDGIT** was developed jointly by the National Cooperative Highway Research Program (NCHRP) and the National Engineering Corporation. This system is very similar to PONTIS in that it also gathers data at an element level and reports the condition of an element as a condition state. The primary difference between PONTIS and BRIDGIT lies in the optimization model. BRIDGIT has adopted the bottom-up approach to optimization whereas PONTIS uses top-down approach. In a bottom-up approach individual parts of the system are specified in detail. The parts are then linked together to form larger components, which are in turn linked until a complete system is formed. In the top-down model an overview of the system is formulated, without going into detail for any part of it. Each part of the system is then refined by designing it in more detail. Bottom-up programming provides better results for smaller bridge populations than top-down programming. The disadvantage is that the system is slower than PONTIS for larger bridge populations. In 1995, BRIDGIT was being beta tested at 8-10 sites in the United States.

- **North Carolina BMS** North Carolina was the first state to pursue research in BMS technology. This BMS uses data related to deck, superstructure and substructure elements. The data is rated based on a scale used in the National Bridge Inventory (NBI). It consists of a cost model (determines user cost, detour cost, length of accident unit cost, etc.) and an optimization model (OPBRIDGE).

  Further BMSs have been developed for Alabama, Indiana, and other state DOTs. These are project level systems.

2.3 EXPERT SYSTEMS

Expert systems are knowledge based computer systems combined with an inference engine that processes knowledge stored in the knowledge base in order to respond to a user's request for advice. It emulates the decision making ability of a human expert [4]. The knowledge can be gathered from books, journals, reports, other available records, or knowledgeable individuals. There have been many expert systems developed for use in various technical fields. In Civil Engineering, efforts have been made in the areas of bridge analysis and design, damage assessment of structures, highway bridge rating, maintenance of bridges, etc. Several examples of expert systems are presented in this review.

2.3.1 Expert Systems for Bridge Design

Expert system technology has been successfully applied to bridge design by several groups of researchers [7]. The design of any structure usually consists of three stages: conceptual design, preliminary design, and detailed design. The design process involves many decisions that are based on past experience, analysis, rules of thumb and other factors. Also, since a design can be done in many alternative ways, expert systems developed for bridge design may provide the most appropriate method that can be used for these structures. Four expert systems developed for use in bridge design are discussed below.

- **KYBAS** (Kentucky Bridge Analysis System) is an interactive expert system developed for structural analysis and design of highway bridges [3]. This system eliminates the time required in developing a separate finite element model. It ties together a collection of engineering algorithms (using FORTRAN) with an expert system and an interfacing module (using C). In the preliminary design, knowledge is required of the bridge type, structural components, support conditions, basic design loads and requirements etc. This portion makes a recommendation for the conceptual bridge designs that satisfy the bridge requirements with an estimate of cost for each design. In the detailed design part, an analysis model is developed followed by a load and cost analysis. In this part, one of the recommended bridge designs is selected. Different rules in this system are used for recommending structural components, doing the structural analysis, and estimating cost. The structural analysis is performed by means of finite element methods.

- **BDES** (Bridge Design Expert System) is an expert system developed to design superstructures for small to medium span highway bridges. The principles of artificial intelligence have been used to develop this system [5]. This system designs superstructures using structural steel and prestressed concrete girders.

- **BTEXPERT** [6] is a knowledge-based expert system developed for the optimum design of truss bridge and is limited to only four types of truss bridge: Pratt, Parker, Parallel-chord K truss and curved chord K-truss for span ranging from 100 ft to 500 ft. This system was the first to integrate an expert system with mathematical optimization. Knowledge contained in this system is obtained both from past experience and also from experiment. The knowledge base consists of rules and controls. A user interface is provided by means of a visual edit screen. This system recommends a type of bridge truss based on previous experience. Then, an initial estimate of the cross sectional area of the member is determined through experimentation for various spans, AASHTO live loads and grades of steel. In the next step an analysis of dead and live loads is performed. The final step provides an optimum detailed design for the bridge.

- **ES-PDLB** [7] is an expert system for the preliminary design of long span bridges. The system draws the most reasonable design projection of a bridge to be built after the topography, geology and hydrology conditions at the bridge site and traffic requirements under and on the bridge are provided. This design projection will include bridge type, span layout, dimensions of each cross section, and the construction method. The bridge type portion has been divided into 7 categories: simply-supported concrete beam, simply-supported steel truss, continuous concrete beams, continuous steel truss, arch, cable stayed bridge, and suspension bridge. Different construction methods are suggested based on the bridge type, construction speed and equipment, etc.

2.3.2 Expert Systems for Bridge Rating

A bridge rating evaluation carried out in the late 1970s revealed that nearly 105,000 bridges out of a half million bridges in the 50 states were rated as critically deficient [11]. A FHWA survey showed that one out of every five highway bridges in United States is considered deficient [11]. This extent of US bridge condition deterioration increases in severity every year. Many older bridges will survive only if properly maintained. Several expert systems have been developed which provide a method for determining the bridge rating and an estimate of remaining service life. Five of these expert systems are discussed below.

- A microcomputer-based expert system was developed for rating a simple span highway bridge with a reinforced concrete deck and prestressed concrete I-beams [12]. This expert system provides an interface between a database and two finite element programs. The rating process for bridges in this system is slightly different from the routine AASHTO approach often utilized elsewhere. This system doesn't indicate that the bridge is rated for some percentage of HS20 – 44 per AASHTO. This system indicates whether or not the bridge can carry the specified load entered by the user. If not, it will specify which rating criteria (strength or serviceability criteria) are violated. This system also shows the results from two other approaches: AASHTO approach and the overload directories. For the finite element analysis the standard programs SAPIV and BOVAC are used. SAPIV is used for linear elastic finite element analysis and BOVAC is used for nonlinear analysis.

- The next expert system is the Concrete Bridge Rating Prototype Expert System with Machine Learning [9]. This system shows how the introduction of machine learning can facilitate the knowledge-based refinement of bridge ratings. The objective of this expert system is to evaluate the structural serviceability of concrete bridges based on several conditions: traffic volume, environmental conditions and several other factors. This is an inference system, where a neural network and bidirectional associative memories (BAM) concepts are combined. The system uses fuzzy logic theory and acquires knowledge by defining a parameter known as a membership function based on the results of a survey questionnaire given to bridge rating experts. The system asks a series of basic questions such as relevant bridge structural data, traffic volume, and condition of defects. Then the system searches all relevant fact clauses based on rules. The system asks additional questions based on the found fact clause. The system then combines all the findings and provides a result in the form of a probability of five conditions: safe, relatively safe, moderate, slightly dangerous, and dangerous.

- Another expert system is developed for highway bridge rating and fatigue life analysis [11]. This is the only expert system which determines bridge rating and also gives information about the remaining service life of the bridge. The authors provide various models for both vehicles and bridges. The vehicle model consist of H 15-44, H 20-44, HS 15-44, and HS 20-44 trucks and the available bridge models are simple and continuous span steel structures. The operating rating and inventory rating are those recommended by the AASHTO specifications. The fatigue life is determined by using the method suggested by Schilling and Klippstein [11]. According to the method, N, the number of cycles to fatigue failure is related to the equivalent stress range, Se (ksi), by the following equation:

  $N = A / (Se)^m$ where m (=3 used here) is the slope of the SN curve.

  $L_f = N / (365.T.P)$ where T is the ADTT (average daily truck traffic), P is the number of loading cycles per truck passage, and L_f is the bridge life in years.

- **BRES** (Bridge Rating Expert System) uses a knowledge-based computer artificial intelligent expert system for the analysis and rating of existing short span prestressed concrete highway bridges [10]. Different rating methods are considered such as inventory rating, operating rating, factor rating and sufficiency rating. The strength ratings are based on AASHTO specifications and inventory ratings are formulated according to the FHWA guide "Structural Inventory and Appraisal of the Nation's Bridges" [10]. The different parameters considered are: bridge type, dead loads, type of vehicle loading, bridge dimensions and cross-section, material properties, reinforcement details, and the existing physical condition of the bridge.

- The fifth system was developed for rating concrete bridges. This expert system evaluates the bridge rating for deteriorated concrete bridges using multi-layer neural networks with fuzzy logic in order to carry out fuzzy inference and machine learning [13]. The system evaluates the performance criteria of concrete bridges such as durability and load-carrying capability on the basis of a simple visual inspection and a listing of technical specifications. The application of the neural network facilitates refinement of the knowledge base by use of the Back-Propagation method and prevents the knowledge base from becoming a black box.

2.3.3 Expert Systems for Damage Assessment

As mentioned above, many bridge management systems are developed to assist decision makers in repairing and maintaining bridges. A typical BMS (bridge management system) consists of several modules; one of the most important is the one for damage assessment. Damage assessment is a process for evaluating the damaged state of the bridge based on visual inspection and empirical tests [14]. Expert systems have been widely used for damage assessment when human experts are not available. The following examples review a portion of the progress made in this area.

- **FPNES** (Fuzzy Petri Net Based Expert System) is the framework for an integrated expert system based on proposed fuzzy petri nets [14]. In one instance, this framework has been used to develop an application for damage assessment. FPNES has been implemented in Java with client-server architecture. It consists of FPNES, a user interface, a knowledge base and a transformation engine. The inputs to the system are the defects observed by inspectors. The outputs of the system are level of damage, severity of defects and intensity of confidence. The level of damage and severity of defects are expressed linguistically and are considered as linguistic variables. The severity of damage is classified into seven levels: very severe, severe, fairly severe, fair, fairly slight, slight and very slight. The intensity of confidence is also classified into seven types: very true, true, fairly true, fairly false, false, very false, and unknown.

- **DAPS** (Damage Assessment of Protective Structure) was developed for Air Force applications [15]. The database was created from experimental tests on buried reinforced concrete boxes subjected to explosive pressures. It uses fuzzy logic theory and a back chaining procedure. This system is rule-based in that observed damage attributes (entered by the user) are matched with consequent portions of the rule base to establish which rule should be triggered. This system also shows all the rules which were triggered, if the user wants to know why the system comes to a certain conclusion. A commercially available shell, known as EXSYS, was used to develop DAPS.

- The next expert system was developed to diagnose cracks in damaged bridge slabs using the knowledge refinement function of an existing expert system [16]. In this program an algorithm is developed for a rule-base inference system. This algorithm interacts with damage-cause-estimation expert system for bridges that have a reinforced concrete floor system (Mikami's system) [17]. The cause of damage is found based on the type of damage from visual inspection, the number of the lanes of traffic, design load and the location of the damage. With this data the probability of cause of damage is inferred using a modified rule base.

- Another expert system was developed for the assessment of deteriorating concrete bridges. It incorporates on-site inspection data, an evaluation of inspection results and a condition assessment for the concrete bridge. General information and detailed inspection can be done by visual inspection, NDT, a real time monitoring of the structure [18]. This data is required as input for the expert system and are the basis for damage assessment. The inspection results can be either single values, sets of data or linguistic expressions. Fuzzy logic is used to assign a membership function to each linguistic expression and convert it into numerical values. Probable damage mechanisms are determined, which are necessary for realistic damage evaluations. The output of the expert system indicates the current and future damage state of the structure and provides a prediction of service life.

2.3.4 Other Expert Systems Related to Highway Bridges

Besides the three types of systems discussed above, there are many other areas, related to highway structures, in which expert systems have been developed.

- One such system has been developed to study the performance of long span bridges which were built between 1801 and 1993 in New York State [32]. It is basically a database consisting of general and performance data in a tabular format. General data includes location, type of bridge, span lengths, clearance width, deck framing, etc. Data on rehabilitation and testing of the bridges is also included. Performance is being evaluated during the construction and service stages. Lessons learned from poor performance are highlighted for future use and the performance of the bridge both as a "whole" and in terms of the "components" is recorded.

- This expert system is developed to assist bridge inspectors with the identification of scour damage and it lists various recommendations. Scour is a term for the erosion of bed and bank material by flowing water and it poses a threat to bridge performance and integrity by undermining piers and abutments [19]. Regular inspection and maintenance can reduce the risk of such damage but it is difficult to identify the conditions indicative of scour. The system consists of two parts: an interface and an inference engine. The interface was developed in Microsoft Visual Basic and the inference engine was developed in EXSYS, an expert system programming platform. A survey of scour inspection practices at 21 state transportation departments provided information regarding data collection and inspection procedures. After completing an inspection, data is recorded to provide a history of the site and is then analyzed to screen the bridge information for severe scour problems.

- **BRITE/EURAM** is a reliability based expert system for inspection and maintenance of corroded reinforced concrete bridges [20]. This expert system's objective is to optimize strategies for inspection and maintenance of reinforced concrete bridges. This system indicates the cause of observed defects, utilize appropriate diagnosis methods and indicate other related defects. After a detailed inspection of the bridge, the investigator must decide whether a structural assessment is needed. After a structural assessment, it must be decided whether the bridge should be repaired and, if yes, how the repair is to be performed. This expert system helps in making all of these decisions.

- Another expert system was developed for selecting methods for retrofitting fatigue cracked members in a steel bridge [21]. This system consists of a knowledge base and an inference engine. The knowledge base consists of 90 cases of fatigue cracking in steel bridges and is represented by a set of relations between the external and internal causes of cracking, applied forces at joints, cracking modes and retrofitting methods. The inference engine is developed by using a knowledge-based network model with learning ability. The input to the system is observed facts such as external cause of cracking. Based on knowledge-based relations, retrofitting methods are selected.

- **BFX** (Bridge Fabrication Error Solution Expert System) has been developed to help designers and inspectors determine the extent of damage due to a fabrication error. The system was developed for the Kansas Department of Transportation and focuses on the errors which do not have codified repair methods. Development methodology consists of panel information and feasibility analysis, conceptual design, knowledge acquisition and engineering, integration and development of pilot delivery applications [22]. Furthermore, validation, verification, project evaluation, documentation, delivery and maintenance issues are addressed. The information for the knowledge base is gathered from experts by interviews, reviews of historical records such as case studies, maintenance data and inspection reports. The case history format developed for the study discussed in this thesis is based on the process utilized in this expert system.

As seen above, there are several expert systems available for bridge design, rating, and damage assessment. The expert system developed in this study gives basic recommendations for several bridge emergency situations. This system can be used in conjunction with any of the expert systems we have studied in this literature review to make it more efficient.

2.4 DECISION SUPPORT SYSTEM (DSS)

Decision Support Systems evolved early in the era of distributed computing. The history of such systems began around 1965. By the late 1970's, a number of researchers and companies had developed interactive information systems, called Decision Support Systems, which used data and models to help managers analyze semi-structured problems. A DSS is an interactive computer-based system which assists decision makers by using communications technologies, data, documents, knowledge and/or models. There are five specific types of Decision Support Systems: communications-driven, data-driven, document-driven, knowledge-driven and model-driven systems. Based on these DSS type, focus will be on the principal features of knowledge-based DSS for this study. This type of system can suggest actions to be pursued by managers or engineers. Decision support systems have been developed for use in engineering, in several organizational structures, in the health field, in defense and other areas. In Civil Engineering several efforts have been made in the field of DSS development. Here, several Decision Support Systems for highway bridges have been summarized.

- The first decision-support system was developed for selecting the best set of strategies (projects) for bridge rehabilitation and replacement on a highway network. Specifically, the system is used during long-range planning of the bridge funding needs for budgeting and legislative information purposes [23]. This system includes different aspects of the decision problem faced by bridge engineers such as the multiple attribute nature of bridge deficiencies, risk impact of predicted deterioration of the bridge and uncertainty. This system uses concepts such as multiple criteria decision making (MCDM), utility theory, fuzzy logic and decision making under risk.

- Finding good models of behavior is important for explaining the performance of structures in service [24]. However this is often a difficult engineering task. For example, the repair plans for structures with serviceability deficiencies often require accurate knowledge of the real behavior of the structure. A lack of such knowledge may significantly influence the cost and the efficiency of the repair plan. Such knowledge can be gathered from answers to questions that arise during the life of a structure. Questions, such as the following may be relevant:
  - Is something wrong with the structure? (Damage detection)
  - What might be the most critical problem in a particular situation? (Damage prediction)
  - What is the state of the structure (cracks, excessive deflections, corrosion, creep, support displacement, etc.)? (Serviceability problem)
  - What might be the state of the structure after several years? (Prediction)
  - Is the structure capable of performing well in a new situation? (Adaptation)
  - Which solutions are more appropriate for a particular deficiency? (Repair)

  The next system focuses on the use of measurement data for identifying feasible models for explaining the behavior of a structure. This system has three modules: model library, model retrieval, qualitative evaluation. Users either define models manually or models are generated automatically through the technique of model composition by selecting a set of assumptions. Results obtained from the models are used to help define the most appropriate measurement that is required. Users provide visual information about the structure such as cracks, deformations, general aspects, and others. Users define rules for retrieval and for comparing measurement data with model results.

The concept involved in this type of analysis was used in the case of the Lutrive Bridge in Switzerland and their results are reported. The Lutrive Bridge was constructed in 1972 using the cantilever method with central hinges. It was found that the bridge continued to creep significantly even after twenty-seven years from the construction date. However, load tests indicated that the bridge possessed unusually high rigidity and earlier theoretical models (constructed manually) gave results that were different from displacement measurements by as much as 100%. It was necessary to evaluate different modeling possibilities in order to obtain reasonable correlation with measured data. Use of this DDS improved the effectiveness of engineers by allowing the use of models, data, and appropriate measurement systems.

- Previous approaches to decision support for project planning using rule-based expert system techniques have failed to make an impact in practice because of the complexity and large-scale nature of structural issues. The problems associated with expert systems include: knowledge acquisition, rule-based knowledge representation, information storage (or memory), learning techniques, and robustness [25]. Case-based reasoning is one solution for overcoming a number of these problems. In another system, previous case-based reasoning work is examined. Further a conceptual framework is developed which captures previous planning experience on a construction project and uses this to provide decision support in construction planning and control. A prototype system, CBRidge, was developed to test and demonstrate the concepts within the framework as presented.

- **MDSS** (Maintenance Decision Support System) is a decision support system developed for maintenance of road during winter with the support of the Federal Highway Administration (FHWA) Office of Transportation. MDSS is a unique data fusion system designed to provide real-time treatment guidance for winter maintenance decision makers and is specific to winter road maintenance routes. The system integrates weather and road data, weather and road condition model outputs, chemical concentration algorithms, as well as anti-icing and deicing rules of practice [26]. This system was designed as a modular system so that individual components could be extracted, replaced, improved and implemented. The MDSS provides decision makers with information on current and predicted weather and road conditions for user defined locations along winter road maintenance routes.

- The expert system discussed here is used to evaluate a number of highway alignments in the planning phase of a highway development process [27]. Here a criteria-based decision support system is developed for selecting cost effective highway alignments using a generic algorithm and GIS. This system can assist highway planners and designers in evaluating a number of alignment alternatives when considering the construction of a new highway. A criteria flowchart is developed to select highway alignment based on several factors such as environmental impacts and notable differences.

- This system introduces a Civil Engineering decision support system developed in Lithuania [28]. The DSS consists of three parts: data (database and its management system), a model (model base and its management system) and a user interface. The data in the database can be conceptual or quantitative. The database was developed using a multiple criteria analysis of alternatives from economical, infrastructure, technical, technological, social and other perspectives. There are several web DSS's developed at the Vilnius Gediminas Technical University such as a multiple criteria decision support online system for construction products, multiple criteria DSS for facilities management and others.

- Another paper discusses a multicriterion DSS developed for the management of field data for vehicular impacts with crash attenuators [29]. This system has been developed for an intranet platform with a JAVA based interface. This application supports the design and selection of attenuators for a new structure. To assess the effectiveness of attenuators it is necessary to know the effect of a driver's action, road conditions, maintenance history, etc. It is also necessary to know the relative in-service performance of the new structure. This expert system includes an in-service performance database for various crash attenuators that relates to traffic, driver, roadway and environmental conditions. Also this system provides a user interface to support data collection. The user interface is capable of identifying historical data sources and gathering critical information. This DSS uses historical data to rank the performance of attenuators based on a set of site characteristics.

- Another system includes a prototype of an interactive support system for visual inspection of bridges [30]. This system complements the technical knowledge and experience of skilled inspectors and suggests several alternatives for on-site decision making. A rule-based expert system has been developed as somewhat of a substitute for a human expert who has acquired large amount of knowledge and insight in a certain field. This system assists bridge inspectors in optimizing the inspection routine, listing checkup items when defects are found and recording the results of an inspection.

As seen above, there are several decision support systems developed for bridge maintenance and management. In the future the concept of GIS can also be used to develop alternate routing options for bridges.

2.5 KNOWLEDGE ACQUISITION, DATABASE AND KNOWLEDGE REPRESENTATION

For any bridge management system, data collection and representation is one of the most important features. Data used in these expert systems may differ for each system and data collection is often expensive and time consuming. There have been several investigations that focused on data collection, storage and representation. Also a great deal of research has been done in the areas of usability of collected data and its applicability to the issue being investigated. There are several tools which are helpful in improving the data collection process, one example being the structuring of the data collection process; using data flow models [31].

Puri has investigated the development of a relational database for long span bridges [32]. A database of this type assists with expert system development and also can be linked with the National Bridge Inventory. There are six tables in this database; general data, substructure data, superstructure data, bid, construction, and cost data, performance data, and rehabilitation or reconstruction data. General data contains the bridge number, name, year completed, location, name of crossing, main and side spans, width of the bridge, height of the towers, clearance, number of lanes and shoulders, number of deck levels, roadway configuration, number of sidewalks, the owner, the designer and the general contractor. The other tables were organized in a similar manner. The data is gathered from engineering contract documents, reports, engineering journals, conference proceedings, and textbooks on bridge design and construction. This database is limited to the analysis of long-span bridges with certain restrictions on support conditions and span lengths. Furthermore photographs and sketches cannot be included in the database.

In closing, this literature review has emphasized the basic features of bridge management systems, expert systems, and decision support systems. Many of the citations presented here stress the reliance on carefully documented previous experiences. Hence, this project has initially focused on the development of a case history database that would be compatible with the type of computer based decision systems discussed above.

Chapter 3: Decision Support Systems

Over the last several decades, the concepts of computational decision theory have been used to develop decision support systems for many different applications. A bridge integrated analysis and decision support system for managing and maintaining bridge structures can be developed to assist engineers in making appropriate and timely decisions in the field when unexpected or emergency situations arise. Any such decision support system (DSS) must incorporate all relevant information, including past experiences, into appropriate probabilistic modeling and decision support methodologies. For such a system to be effective, it must include information from a number of separate but integrated components. Information from these various sources would form a comprehensive database in support of the probabilistic modeling and decision support approaches that are used in the DSS. These database components would include:

- Bridge inventory
- Bridge maintenance records
- Bridge monitoring records
- Bridge security records and considerations
- Case histories
- NDE capabilities (with probabilistic approaches) and vendors
- Required support, staff, and equipment
- Analysis and design capabilities for sub- and super-structures
- Alternate routing options
- Warning systems for various possible damages
- Bridge vulnerability assessment methods
- Coordination needs with other authorities and agencies
- List of outside expert consultants including costs and qualifications
- List of contractors and engineers qualified to provide emergency services
- An expert system

The current project primarily addresses the creation of a case history database. Included in the case histories is information related to bridge incidents, extent of damage, remedial work, bridge inventory, bridge maintenance records, and support staff and equipment. This information has been collected into a database format that is readily accessible via a standard Internet connection. The specific aspects of the database are discussed in Chapter 4 (Case History Database) and a discussion of the Bridge-Incident-Response-Database (BIRD) website is given in Chapter 5 (Bridge-Incident-Response-Database).

Chapter 4: Case History Database

Bridge management and maintenance programs, including repair and rehabilitation efforts and responding to emergency situations can be effective only when they are based on accurate and reliable information regarding the condition of the structure and other relevant data. Currently, such information either does not exist in an accessible form or is difficult to access. Responding to an emergency bridge incident is often difficult since the required response time is generally very short and the situation is inherently of great urgency, such as when there is a likelihood of a catastrophic structural failure. A well-known example of such a case with an urgent need for bridge condition assessment and quick decision-making is the cracking of steel girders at the Daniel Webster Hoan Bridge in Milwaukee during the winter of 2000. (See the case history for bridge # B-40-0400 in Appendix 7.1) In this case, although the involved WisDOT engineers were trained and skilled in various aspects of bridge structural analysis, design, construction, and general structural behavior, the character of the problem and its urgency created a significant challenge that required special attention. Numerous other emergency cases have been experienced in Wisconsin and other states where bridge owners and engineers are faced with equally difficult challenges. The November 2002 impact of a truck with the center pier of a local bridge carrying traffic over Interstate Highway I-94 in Menomonie, Wisconsin is another example of a significant transportation crisis. (See the case history for bridge # B-17-0040 in Appendix 7.1) In this case, because of the extensive damage and failure of the piers, both sides of the interstate, normally carrying approximately 25,000 vehicles per day, had to be closed with traffic diverted through the City of Menomonie, causing major delays and disrupting city residents and the traveling public. An emergency case had to be declared by the local Regional Director and WisDOT personnel had to make critical decisions in order to rapidly return the Interstate Highway to its normal service condition.

The primary objective of this study is to develop an easy-to-use but comprehensive document that includes case histories of previous emergency incidents. These case histories illustrate the types of responses required in various kinds of emergency situations. Each case history includes a background narrative, a summary listing of the structure's physical attributes, and a process flow diagram showing the principal activities needed to respond to an emergency and provide corrective action.

In collaboration with WisDOT officials and members of the Advisory Committee for this study, bridge engineers, inspectors, and maintenance personnel from each WisDOT region were visited and interviewed to obtain information on specific structures with an emphasis on incidents that required immediate emergency response. During each interview the individuals related personal experiences and provided, when available, documentation describing an incident that provided insight into the solution of emergency situations. These personal experiences were further supported with documentation available in the Wisconsin HSI (Highway Structures Information System) database. In each case history the background document summarizes information related to condition assessment techniques, analysis methods, failure investigation, emergency and long-term repair or replacement methods, traffic control issues, and budgetary requirements. The background document is presented in a narrative format which includes photographs (when available) and a list of keywords for the purpose of implementing a basic database search feature. The following table lists the sixteen bridges included in the database (Regional Designations: NE – North East, NC – North Central, NW – North West, SW – South West, SE – South East).

Bridge ID #	WisDOT Region	Community	Structure Type	Incident Type
B-05-0086	NE	Green Bay	Concrete	Vehicle Impact on Girder
B-05-0131	NE	Suamico	Steel	Vehicle Impact on Girder
B-37-0082	NC	Weston	Concrete	Vehicle Impact on Girder
B-17-0040	NW	Menomonie	Concrete	Vehicle Impact on Pier
B-18-0026	NW	Eau Claire	Concrete	Vehicle Impact on Girder
B-13-0264	SW	Madison	Concrete	Vehicle Impact on Girder
B-14-0028	SW	Lomira	Concrete	Vehicle Impact on Girder
B-14-0044	SW	Watertown	Steel	Vehicle Impact on Girder
B-12-0027	SW	Prairie du Chein	Steel	Fatigue Cracking in Girder
B-32-0036	SW	La Crosse	Steel	Vehicle Impact on Girder
B-32-0037	SW	La Crosse	Steel	Vehicle Impact on Girder
B-52-0111	SW	Muscoda	Concrete	Scour Under Piers
B-40-0400	SE	Milwaukee	Steel	Fatigue Cracking in Girder
B-40-0285	SE	Milwaukee	Concrete	Fire
B-40-0377	SE	Milwaukee	Concrete	Vehicle Impact on Girder
P-40-0654	SE	Milwaukee	Steel	Watercraft Impact on Girder

The initial phase of this project stressed the development of the formats for the various documents and the preliminary methods of data acquisition. In the second phase a design of a web-based tool for inputting information into the database, for retrieval and editing of existing files, and providing a search capability was developed. The web site was designed to allow access at several utilization and administration levels (see Appendix 7.2 for a detailed User Manual). Details of the web site server installation and maintenance are provided in Appendix 7.3.

At present, the Web tool allows a user to log in and then either input information or view currently available files. With the "view" feature the user has access to a detailed description of the bridge and its operational characteristics, copies of the case history background document, and all supplemental documents that have been attached to the case history file. All of these files are created and stored in the standard Microsoft WORD format. The user may view the documents, save them to his/her computer, or print them for immediate use.

The "input" feature allows any authorized user to add documentation for new bridges or to edit the data located in files already residing in the database. The database includes the capability for archiving all versions of the documents in order to repair errors or return the document to a previous version. The details of various user functions are presented in the User Manual (Appendix 7.2).

Chapter 5: Bridge – Incident – Response – Database (BIRD)

With the Bridge – Incident – Response –Database (BIRD) a user can access the case history documents that have already been generated and add updates or new case histories to the database. With the appropriate access level a user may also edit or delete previously generated case histories. The database can be expanded to include new structures or previously generated case histories can be updated with new information as it becomes available. Included within BIRD are all functions necessary for access and login, database administration, management of case history background and bridge information files, and viewing, printing, or storing of file elements.

All of the file structures in BIRD, except for process flow diagrams, have been created using Microsoft WORD. Access to the database is restricted to users who have received a logon user name and password from the system administrator. Requests for database access should be sent to John A. Dudek at the University of Wisconsin – Milwaukee (jadudek@uwm.edu, 414-229-4638).

The BIRD system currently resides on a server computer located in the College of Engineering and Applied Science at the University of Wisconsin – Milwaukee. Access is obtained via the BIRD website: http://www.uwm.edu/CEAS/bird with a User Name and Password provided by the system administrator.

The accessibility to the database is limited to three levels called USER, MANAGER, and ADMINISTRATOR. The appropriate level is assigned to each user by the system administrator at the time when the user name and password are generated. The basic access level (USER) allows the individual to view and retrieve files on any structure that is currently listed in the database. At the second level (MANAGER) the individual may, in addition to viewing current elements and adding new elements, also edit previously created file structures. At the highest level (ADMINISTRATOR) the individual has increased capabilities for editing, deleting, and other database administration activities such as adding or deleting users from the access list.

There are two classes of documents that are stored in BIRD. The first is the Bridge Structure Information document and the second in the Bridge Case History document. Both documents are stored in the database using the Microsoft WORD format. Each document is labeled with the standard bridge designator B-XX-XXXX or P-XX-XXXX.

The data for the Bridge Structure Information document is obtained from the WisDOT Highway Structures Information System (HSI) database using the Bridge Inventory and inspection records. The user creates this document by inserting the relevant information into several screens with a tabular format. A BIRD file for a bridge is initiated by preparing a Bridge Structure Information document. A sample of a completed Bridge Structure Information document is shown at the end of this section.

Once the Bridge Structure Information document has been initiated the user can then insert a Bridge Case History document into BIRD. A Bridge Case History document is less formally structured but is created using the following guidelines. The document is written in the form of a narrative that summarizes the features of the bridge and various incidents that affected the physical integrity of the structure. In general, the first paragraph indicates the location, construction date, general features, and average vehicular traffic level. The next paragraph provides further structural details as to the number and type of spans, the abutments and piers, and the load ratings.

The next portion of the document gives a brief history of incidents for which repairs were required. For the incident requiring an emergency response the cause of the damage, a description of immediate responses, details of repair or replacement efforts, and final status are presented. It is possible to update the case history background by including subsequent events as desired by the database owners. Further, a string of keywords for the search function are added either at the start or the end of the narrative. Photographs and drawings may be inserted using standard Microsoft WORD features. Lastly, a process flow diagram summarizing the procedures followed by the responsible authority is appended. In this report, two process flow diagrams are presented. These include one for the City of Milwaukee and one general process flow diagram for the State of Wisconsin. A complete set of case history documents, bridge information files, and process flow diagrams are provided in Appendix 7.1.

The search feature of BIRD allows a user to scan the entire database for any case history documents that are labeled with a specific keyword or combination of keywords. If the search is successful the user can then access the indicated documents and either view, store, or print them as is desired.

In Appendix 7.2 an Installation Manual has been provided for assisting any WisDOT group intending to develop and maintain a BIRD site. Also, a complete User’s Manual is available in Appendix 7.3

Chapter 6: Summary, Conclusions and Recommendations

6.1 Summary and Conclusions

The primary objective of this study was to develop a case history database for approximately ten Wisconsin bridges that were subject to past incidents such as vehicular impacts and other unexpected damages that required emergency responses from bridge owners and engineers. This study was initiated to address the concerns of the state DOT officials about the loss of such important information due to a lack of adequate existing and systematic documentations as well as retirement of key staff who had responded to past bridge incidents in Wisconsin. The intent of the study was to eventually expand the size of the case history database and utilize the information to develop a decision support system (DSS). The DSS will then be used to aid Wisconsin bridge engineers and maintenance personnel in making appropriate decisions regarding appropriate actions in cases of emergency bridge incidents.

To achieve the goals of the study, the following tasks have been accomplished:

1. A literature review examining the current state-of-the-art in bridge management and decision support system development and use has been completed.

2. The format for case history documents, bridge information files, and process descriptions has been developed.

3. Sixteen case histories have been produced based on information available in the Wisconsin Highway Structures Information System site (HSI) and personal interviews conducted with maintenance engineers and other responsible individuals.

4. The case histories have been accumulated into a computerized Bridge – Incident – Response – Database (BIRD) that is accessible by means of standard internet methods.

5. A keyword driven search routine has been incorporated into the database to enhance the effectiveness of database use.

6. A set of administrative activities have been developed that allow for maintenance of the database elements and the user listing.

7. A computer server has been dedicated to provide a temporary site for the database. Also, an installation and maintenance manual has been prepared for guidance when the database site must be relocated.

8. A complete user’s manual has been prepared for training BIRD users at all access levels.

In conclusion, we note that the Bridge – Incident – Response – Database provides a means for accumulating, documenting, and distributing the expertise obtained in responding to emergency situations involving bridges in Wisconsin and other locations. It incorporates data from the Wisconsin Highway Structures Information site as well as personal information from bridge maintenance engineers, inspectors, and other informed individuals. The BIRD system is readily accessed by interested individuals and can be easily expanded or enhanced with further information on previous or future emergency incidents. We also note that this type of resource will enable the future development of a Decision-Support-System for effective action plans in those situations where a timely emergency response is required.

6.2 Recommendations

Based on the original intent of the Wisconsin State DOT officials and the accomplishments of this study, the following recommendations for future studies are presented here:

- Initiate a new study to expand the current case history database and incorporate other required elements of a decision support system for emergency responses
- Develop essential elements of an appropriate decision support system that is based on the case histories and other relevant elements
- Implement training of WisDOT personnel in all Regions for the use of the database and the decision support system
- Maintain a permanent server and site for the database and the decision support system
- Require appropriate WisDOT personnel to populate and update the database with new case histories or incidents as they occur in future

Chapter 7: Appendices

Appendix 7.1: Current Case Histories

Appendix 7.1.1: Background and Bridge Information Documents

1. B-05-0086
2. B-05-0131
3. B-37-0082
4. B-17-0040
5. B-18-0026
6. B-13-0264
7. B-14-0028
8. B-14-0044
9. B-12-0027
10. B-32-0036
11. B-32-0037
12. B-52-0111
13. B-40-0400
14. B-40-0285
15. B-40-0377
16. P-40-0654

Case History Background
Mason Street Bridge (State Highway 54) over U.S. Highway 41
Bridge Number B – 05 – 0086
Revision Date: 6/14/2007

The Mason Street (State Highway 54) Bridge is located on the southwestern boundary of the City of Green Bay, Wisconsin. The bridge was constructed in 1966 and carries six lanes of traffic over four lanes of U.S. Highway 41 (USH 41). The average daily vehicular traffic level (ADT) was recorded as 20,890 vehicles per day in 1992 on the bridge and 69,490 vehicles per day in 2003 under the bridge. (See Figure 1.)

Figure 1: General View of Bridge B-05-0086.

The bridge has two prestressed concrete girder spans with twenty girders in each span. Span 1 has a length of 92.0 ft. and span 2 has a length of 90.0 ft. The total structure length is 185.7 ft. The deck width is 100.0 ft. and the deck area is 18,570 sq. ft. It has retaining type abutments with 12 in. treated timber pilings and a round column bent type pier with 12 in. treated timber pilings. Load ratings are specified as H20 for the design, HS41 for an operating load rating, and HS20 for the inventory load rating. The bridge was designed for over 2,000,000 stress cycles and the prestressed concrete girders were manufactured to have a compressive strength of 5,000 psi.

Since the date of construction the Mason Street Bridge has suffered numerous impacts requiring significant repairs. These are summarized in the following listing.

Number	Year	Description
1	1974	Patch girders 1 and 4 over northbound USH 41.
2	1975	Patch girders over northbound USH 41.
3	1976	Patch several girders over southbound USH 41.
4	1979	Replace the south exterior girder over northbound USH 41.
5	1980	Patch the south exterior girder over southbound USH 41.
6	1980	Patch the south exterior girder over northbound USH 41.
7	1984	Replace a damaged girder.
8	1984	Patch several girders over southbound USH 41.
9	1989	Replace three girders.
10	1996	Patch the south exterior girder over northbound USH 41.
11	1998	Replace girders 1 and 2 over northbound USH 41.

The latest incident occurred in October of 2005. On Wednesday, October 26, 2005, the Mason Street Bridge was struck by a backhoe/excavator that was too high for sufficient clearance. The vehicle pulling the trailer containing the backhoe was traveling in the northbound lanes of USH 41. The impact resulted in extensive damage to several concrete girders with debris scattered over the roadway and striking another vehicle immediately behind the truck. There were no injuries but the driver of the truck/trailer did not stop or report the incident and was cited for a hit-and-run.

The incident occurred at approximately 3:20 p.m. and was reported to the City of Green Bay Police Department at 3:22 p.m. An officer was immediately dispatched to the site and arrived at 3:25 p.m. Because of the extent of heavy damage, the incident was reported to the Brown County Highway Department who then contacted the Northeast Region offices of the Wisconsin Department of Transportation (WisDOT) located in Green Bay, Wisconsin. The call was forwarded to the region’s Structure Maintenance Engineer, Dale S. Weber. Mr. Weber immediately visited the site and prepared a preliminary evaluation of the damage. It was decided not to restrict the use of the structure after debris from the impact was removed from the roadway.

Mr. Weber noted severe damage to girder 1 with six exposed reinforcing steel strands and one severed strand. (See Figure 2.) The bottom flange of girder 1 has severe cracking that extended into the web. It was recommended that because of the extensive cracking the girder be replaced. Furthermore, the impact caused patches placed over previously damaged areas on girders 6 and 7 to fall off. (See Figure 3.) It was recommended that both of these girders be repaired. Although the damage, especially to girder 1, was extensive it was decided that the bridge was still structurally sound and no restrictions were placed on its use. In an effort to repair these damages before another impact occurred it was decided to use an outside contractor to complete the repairs as quickly as possible.

Figure 2: Detailed View of Severely Damaged Girder #1.

Figure 3: Detailed View of Damaged Area with Lost Patch in Girder #7.

After receiving plans and specifications from the WisDOT Central Office in Madison, Wisconsin, a request for bid was issued on November 15, 2005 to three local contractors. The work was awarded to Pheiffer Brothers Construction Company for their low bid of $77,565.74 on December 5, 2005. The contract was approved by the Governor of Wisconsin on December 21, 2005.

The repair operations began on Monday, February 6, 2006 and were completed by February 23, 2006. During repairs the right lane on eastbound State Highway 54 (STH 54 – Mason Street) was closed. When the replacement girder was installed all lanes on STH54 were closed for approximately one-half hour. The USH 41 northbound lane restrictions were in place during repair and the northbound lanes were closed while setting the girder. All repairs were successfully completed. No restrictions remain on the use of the bridge and it retains its original load ratings.

KEYWORDS: impact, girder, concrete, cracking, exposed strands, severed strands, replacement, patching.

Bridge Incident Response Data (BIRD)
Bridge Information Report
Bridge Number B-05-0086
Generated 6/13/2007

Basic Bridge Information

Structure Name	Mason Street Bridge
Year Built	1966
Municipality	City of Green Bay
Section	28
Town	24N
State	WI
Range	20E
Maintenance Agency	State Highway Dept.
Owner	State Highway Dept.
Replaced Structure Number	
Historical Significance	5
Latitude	443126.53
Longitude	880456.37
County	Brown
District	3

Bridge Geometric Data

Structure Length (ft)	185.7
Number Lanes On	6
Left Sidewalk Width (ft)	6.0
Right Sidewalk Width (ft)	6.0
Median Type	Concrete > 6”
Median Width (ft)	8.0
Skew Angle (Deg)	3
Direction Skew Angle	Left
Horizontal Curve Radius (ft)	0.0
Direction Horizontal Curve	
Girder Spacing (ft)	4.7
Height (ft)	45.0
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Semi Retaining
Pile Type	Treated Timber
Pile Size (in)	12
Slope Protection Type	Solid Conc.
Roadway width (ft)	80.0
Deck Width (ft)	100.0
Wing Type	

Abutment Data (Non Cardinal)

Abutment Type	Semi Retaining
Pile Type	Treated Timber
Pile Size (in)	12
Slope Protection Type	Solid Conc.
Roadway width (ft)	80.0
Deck Width (ft)	100.0
Wing Type	

Bridge Capacity

Design MS	HS20
Inventory MS	HS20
Operating MS	HS41
Maximum Vehicle Weight (kips)	190
Load Governing Member	Deck Girder
Deck Composition	NONE
Deck Membrane	NONE
Deck Surface	Integral Concrete

Bridge Construction

Beam/Girder Material	Continuous Prestressed Concrete
Beam/Girder Type	Precast
Span Type	Continuous
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Treated Timber

Planning Data

Functional Classification	OTH Prin Art-Urban
ADT	20890
ADT Year	1992
Truck ADT (%)	10
Future ADT	32500
Future ADT Year	2018

Hydraulic Data

Design Flood Frequency (yrs)	
Design Discharge (cu-ft/s)	
Maximum Velocity (ft/s)	
Drainage Area (sq. ft)	
High Water Elevation (ft)	
Scour Critical Code	
Scour Calculated	

Service Data

Type Service On	Hwy. Pedestrian
Type Service Under	Highway

Clearance Data

Vertical Clearance (Cardinal) (ft)	15.0
Vertical Clearance (Non-Cardinal) (ft)	15.1

Condition Data

Deck Condition	8
Super-Structure Condition	6
Sub-Structure Condition	6

Case History Background
Harbor Lights Road Bridge over U.S. Highway 41/141
Bridge Number B – 05 – 0131
Revision Date: 6/20/2007

The Harbor Lights Road Bridge is located on the southern boundary of the Town of Suamico, Wisconsin. The bridge was constructed in 1971 and carries two lanes of traffic over four lanes of U.S. Highway 41/141 (USH 41/141). The average vehicular traffic level was recorded as 200 vehicles per day in 1980 on the bridge and 37,490 vehicles per day in 2003 under the bridge. (See Figure 1.)

Figure 1: General View of Bridge B-05-0131.

The bridge has two steel girder spans with four girders in each span. Span 1 has a length of 115.5 ft. and span 2 has a length of 111.0 ft. The total structure length is 230.7 ft. The deck width is 37.0 ft. and the deck area is 8,535 sq. ft. It has semi-retaining abutments with 12 in. treated timber pilings and a round column bent type pier with 12 in. treated timber pilings. Load ratings are specified as H20 for the design, HS51 for an operating load rating, and HS24 for the inventory load rating. The bridge was designed for over 2,000,000 stress cycles and the girders were manufactured with ASTM A-36 (AASHTO Grade 36) structural carbon steel.

Previous records indicate that this structure required deck joint repair in 1988 and again in 1994. Also, the bridge was painted during the summer of 2004. The current incident occurred on Thursday, December 16, 2004, when the Harbor Lights Road Bridge was struck by a waste removal truck equipped with a boom lift for handling large containers. The truck was traveling in the southbound lanes of USH 41/141 and the impact resulted in heavy damage to the northernmost exterior girder on the bridge. The boom and its supports were torn from the body of the truck and the driver was ejected from the vehicle. The truck moved off to the right, crashed through a wire mesh fence, eventually coming to rest in a ditch on the side of the road.

The incident occurred at approximately 12:15 p.m. and was reported to the Brown County Sheriff's office. An officer was immediately dispatched to the site and arrived at 12:18 p.m. Because of the extent of damage, the incident was reported to the Northeast Region offices of the Wisconsin Department of Transportation (WisDOT) located in Green Bay, Wisconsin. The call was forwarded to the region's Structure Maintenance Engineer, Dale S. Weber. Mr. Weber immediately visited the site and prepared a preliminary evaluation of the damage. Traffic on the westbound lane of Harbor Lights Road (located over the damaged girder) was restricted. This restriction remained in place until the structural repairs were completed. All four lanes of USH 41/141 remained open to traffic after the loft boom fixture was removed from the roadway.

Although the steel girder was significantly bent by the impact (See Figure 2) it was decided that the structural integrity of the bridge had not been significantly compromised. Thus, it was recommended that the girder be heat straightened and repainted. The heat straightening was performed by County and State employees on August 27, 2005. (See Figure 3.) An outside contractor repainted the girder from August 29, 2005 till September 1, 2005. The total cost of all operations was $96,647.73. No restrictions remain on the use of the bridge and it retains its original load ratings.

Figure 2: Detailed View of Severely Bent Northernmost Exterior Girder.

Figure 3: Heat Straightening of Bent Girder.

KEYWORDS: impact, girder, steel, bent, heat straightening.

Bridge Incident Response Data (BIRD)
Bridge Information Report
Bridge Number B-05-0131 Generated 6/13/2007

Basic Bridge Information

Structure Name	Harbor Lights Road Bridge
Year Built	1971
Municipality	Town of Suamico
Section	23
Town	25N
State	WI
Range	20E
Maintenance Agency	State Highway Dept.
Owner	State Highway Dept.
Replaced Structure Number	
Historical Significance	5
Latitude	443712.93
Longitude	880301.49
County	Brown
District	3

Bridge Geometric Data

Structure Length (ft)	230.7
Number Lanes On	2
Left Sidewalk Width (ft)	0.0
Right Sidewalk Width (ft)	0.0
Median Type	
Median Width (ft)	0.0
Skew Angle (Deg)	0
Direction Skew Angle	
Horizontal Curve Radius (ft)	0.0
Direction Horizontal Curve	
Girder Spacing (ft)	10.2
Height (ft)	
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Semi Retaining
Pile Type	Treated Timber
Pile Size (in)	12
Slope Protection Type	Stab CR Stone
Roadway width (ft)	34.0
Deck Width (ft)	37.0
Wing Type	

Abutment Data (Non Cardinal)

Abutment Type	Semi Retaining
Pile Type	Treated Timber
Pile Size (in)	12
Slope Protection Type	Stab CR Stone
Roadway width (ft)	34.0
Deck Width (ft)	37.0
Wing Type	

Bridge Capacity

Design MS	H20
Inventory MS	HS24
Operating MS	HS51
Maximum Vehicle Weight (kips)	230
Load Governing Member	Deck Girder
Deck Composition	NONE
Deck Membrane	
Deck Surface	Concrete

Bridge Construction

Beam/Girder Material	Steel
Beam/Girder Type	Plate Girder
Span Type	Continuous
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Treated Timber

Planning Data

Functional Classification	Local - Rural
ADT	200
ADT Year	1980
Truck ADT (%)	0
Future ADT	220
Future ADT Year	2000

Hydraulic Data

Design Flood Frequency (yrs)	
Design Discharge (cu-ft/s)	
Maximum Velocity (ft/s)	
Drainage Area (sq. ft)	
High Water Elevation (ft)	
Scour Critical Code	
Scour Calculated	

Service Data

Type Service On	Highway
Type Service Under	Highway

Clearance Data

Vertical Clearance (Cardinal) (ft)	16.47
Vertical Clearance (Non-Cardinal) (ft)	16.47

Condition Data

Deck Condition	6
Super-Structure Condition	6
Sub-Structure Condition	7

Case History Background
Alderson Street Bridge over State Highway 29
Bridge Number B – 37 – 0082
Revision Date: 6/21/2007

The Alderson Street Bridge is located on the southwestern boundary of the Town of Weston, Wisconsin. The bridge was constructed in 1989 and carries four lanes of traffic over four lanes of State Highway 29 (STH 29). The average vehicular traffic level was recorded as 5,300 vehicles per day in 1991 on the bridge and 13,940 vehicles per day in 2003 under the bridge.

The bridge has two prestressed concrete spans (seven girders in each span). Span 1 has a length of 108.0 ft. and span 2 has a length of 118.0 ft. The total structure length is 229.5 ft. The deck width is 59.5 ft. and the deck area is 13,655 sq. ft. It has sill/semi-exposed abutments with 10 in. or 10 ¾ in. steel pilings and round column bent type piers with no pilings. Load ratings are specified as HS20 for the design, HS40 for an operating load rating, and HS24 for the inventory load rating. The bridge was designed for over 2,000,000 stress cycles and the prestressed concrete girders were manufactured to have a compressive strength of 6,000 psi.

No major repairs to the structure were documented until the incident which occurred in September of 2004. On Wednesday, September 8, 2004, the Alderson Street Bridge was struck by a logging truck boom. The truck was traveling in the eastbound lanes of STH 29 and the impact resulted in heavy damage to the exterior 70-inch concrete girder. There were multiple cracks, smaller spalls, exposed and sheared prestressing strands, and other delaminations. (See Figures 1, 2, and 3.) There were no reported injuries.

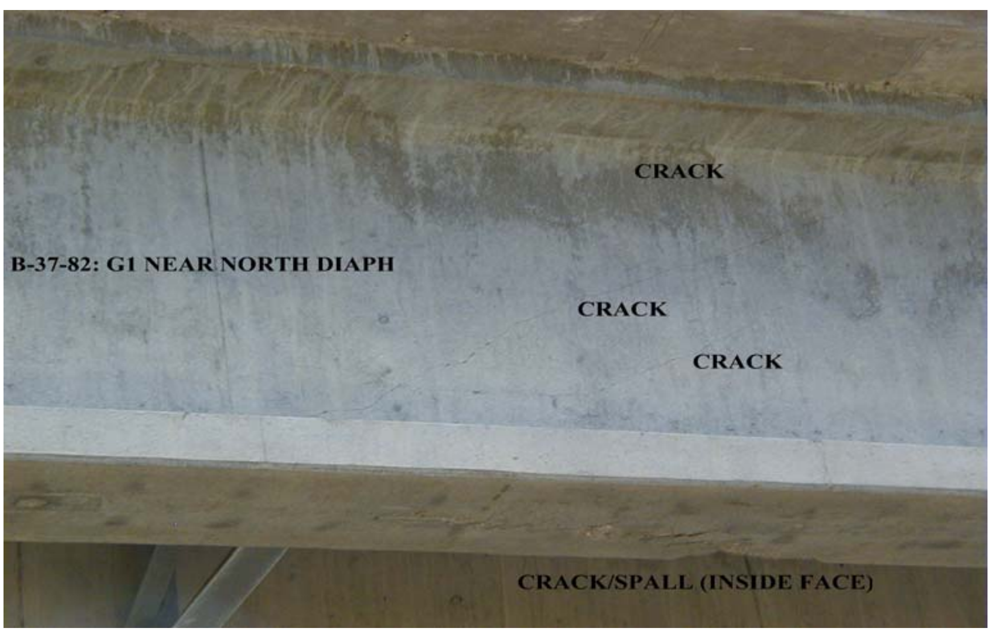


Figure 1: Detailed View of Severely Cracked Girder #1.

Figure 2: Detailed View of Severely Cracked Girder #1 (Looking North).

Figure 3: Detailed View of Severely Spalled Web in Girder #3.

The incident occurred at approximately 4:45 p.m. and was reported to the Wisconsin State Highway Patrol. An officer was dispatched to the site and prepared an accident report. The local fire department was also informed and sent a vehicle to the site to assess any possible fire hazards. Because of the extent of heavy damage, the incident was reported to the North Central Region offices of the Wisconsin Department of Transportation (WisDOT) located in Wisconsin Rapids, Wisconsin. The call was forwarded to the region's Structure Maintenance and Inspection Engineer, Thomas J. Hardinger. Mr. Hardinger immediately visited the site, arriving at 6:30 p.m., and prepared a preliminary evaluation of the damage. The two southbound lanes (over the damaged girder) on the Alderson Street Bridge were temporarily closed restricting all traffic to the two northbound lanes. All four lanes of STH 29 remained open to traffic after the logging truck and debris were removed from the roadway.

Based on the extent of damage suffered by the bridge it was recommended that girder #1 in span #1 be replaced. Further recommendations included the replacement of one abutment and pier diaphragm, patching of girder #3 in span #1, and some miscellaneous repairs. The work could have been performed by WisDOT crews (at an estimated cost of $126,500) but the need to complete other repair and maintenance projects required a delay till the Spring of 2005. The bridge was open to traffic with the furthest southbound lane closed off by means of a temporary barrier. Also, the sidewalk was redirected to maintain pedestrian/bicycle accommodations for a nearby high school. Because of the resulting inconvenience to the public it was decided to use an outside contractor to complete the repairs as quickly as possible. A request for bid was issued on September 29, 2004 and bids were received from three local contractors. The work was awarded to Zenith Tech. Inc. for their low bid of $124,031. The contract was approved by the Governor of Wisconsin on November 1, 2004.

The repair operations began on November 3, 2004 and were successfully completed on December 4, 2004. The southbound lane closure on the Alderson Street Bridge remained in force until the repairs were completed. It was necessary to close STH 29 for half an hour at the time when the replacement girder was set in place. No restrictions remain on the use of the bridge and it retains its original load ratings.

KEYWORDS: impact, girder, concrete, cracking, exposed strands, spalls, replacement, patching.

Bridge Incident Response Data (BIRD)
Bridge Information Report: Bridge Number B-37-0082
Generated 6/13/2007

Basic Bridge Information

Structure Name	Alderson St. Bridge
Year Built	1989
Municipality	Town of Weston
Section	19
Town	28N
State	WI
Range	08E
Maintenance Agency	State Highway Dept.
Owner	State Highway Dept.
Replaced Structure Number	
Historical Significance	5
Latitude	445338.21
Longitude	893533.87
County	Marathon
District	4

Bridge Geometric Data

Structure Length (ft)	229.5
Number Lanes On	4
Left Sidewalk Width (ft)	5.0
Right Sidewalk Width (ft)	0.0
Median Type	
Median Width (ft)	0.0
Skew Angle (Deg)	0
Direction Skew Angle	
Horizontal Curve Radius (ft)	0.0
Direction Horizontal Curve	
Girder Spacing (ft)	8.7
Height (ft)	70.0
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Other
Pile Type	Steel
Pile Size (in)	10 OR 10 3/4 in.
Slope Protection Type	Stable CR Stone
Roadway width (ft)	52.0
Deck Width (ft)	59.5
Wing Type	Parallel to Roadway

Abutment Data (Non Cardinal)

Abutment Type	Other
Pile Type	Steel
Pile Size (in)	10 OR 10 3/4 in.
Slope Protection Type	Stab CR Stone
Roadway width (ft)	52.0
Deck Width (ft)	59.5
Wing Type	Parallel to Roadway

Bridge Capacity

Design MS	HS20
Inventory MS	HS24
Operating MS	HS40
Maximum Vehicle Weight (kips)	190
Load Governing Member	Deck Girder
Deck Composition	Epoxy Coated Reinforcing
Deck Membrane	NONE
Deck Surface	Concrete

Bridge Construction

Beam/Girder Material	Continuous Prestressed Concrete
Beam/Girder Type	Precast
Span Type	Continuous
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Cast In Place

Planning Data

Functional Classification	Minor Art-Urban
ADT	5300
ADT Year	1991
Truck ADT (%)	0
Future ADT	0
Future ADT Year	0

Hydraulic Data

Design Flood Frequency (yrs)	
Design Discharge (cu-ft/s)	
Maximum Velocity (ft/s)	
Drainage Area (sq. ft)	
High Water Elevation (ft)	
Scour Critical Code	
Scour Calculated	

Service Data

Type Service On	Hwy. Pedestrian
Type Service Under	Highway

Clearance Data

Vertical Clearance (Cardinal) (ft)	16.34
Vertical Clearance (Non-Cardinal) (ft)	18.17

Condition Data

Deck Condition	7
Super-Structure Condition	8
Sub-Structure Condition	8

Case History Background
Wilson Street Bridge over U.S. Interstate Highway I-94
Bridge Number B – 17 – 0040
Revision Date: 6/21/2007

The Wilson Street Bridge is located on the northern boundary of the City of Menomonie, Wisconsin. The bridge was constructed in 1958 and carries two lanes of traffic over four lanes of U.S. Interstate Highway 94 (I-94). The average vehicular traffic level was recorded as 2,600 vehicles per day in 1989 on the bridge and 25,000 vehicles per day in 1993 under the bridge.

The bridge has four prestressed concrete spans (six girders in each span). Span 1 has a length of 45.0 ft., spans 2 and 3 are 61.2 ft. long, and span 4 has a length of 39.0 ft. The total structure length is 210.5 ft. The deck width is 36.3 ft. and the deck area is 7,641 sq. ft. It has sill with bearings abutments with 12 in. diameter treated timber pilings and round column bent type piers with no pilings. Load ratings are specified as HS20 for the design, HS25 for an operating load rating, and HS15 for the inventory load rating. The bridge was designed for over 2,000,000 stress cycles and the prestressed concrete girders were manufactured to have a compressive strength of 5,000 psi.

No major repairs to the structure were documented until the incident which occurred in November of 2001. On Thursday, November 15, 2001, the Wilson Street Bridge was struck by a semi-trailer truck carrying a load of lumber. The truck was traveling in the westbound lanes of I-94 and struck the center pier separating the eastbound and westbound lanes. The east pier column was completely demolished and the pier cap was severely cracked at the center column. (See Figure 1.) The truck cab was also demolished and the driver was found dead at the scene.

Figure 1: General View of Severely Damaged Central Pier.

The incident occurred at approximately 12:00 NOON and was reported to the Wisconsin State Highway Patrol by local residents. Because of the extent of heavy damage, the incident was reported to the Northwest District offices of the Wisconsin Department of Transportation (WisDOT) located in Eau Claire, Wisconsin. The call was forwarded to the district's Highway Operations Structures Engineer, Patrick Kern. Mr. Kern immediately visited the site, arriving at 12:20 p.m., and prepared a preliminary evaluation of the damage. Both lanes on the Wilson Street Bridge and all four lanes of I-94 were closed because of the possible collapse of the unsupported structure. Mr. Kern requested that the Director of the WisDOT Northwest region declare the situation as an "emergency" requiring immediate attention.

The severe damage to the bridge and closure of all lanes on I-94 prompted the use of an outside contractor (Lunda Construction Company) to begin immediate site cleanup and repairs. A contractor's representative arrived at the site at 3:45 p.m. and equipment began arriving at 5:00 p.m. Sawing operations on the bridge began at 6:00 p.m. The damaged portion of span #2 was dropped at 10:00 p.m. and the damaged portion of span #3 at 10:45 p.m. Pulverizing of damaged concrete started at 11:30 p.m. and continued through the night. On Friday, November 16, all debris was removed from I-94 by 7:00 a.m. The westbound lanes of I-94 were opened at 8:00 a.m. and the eastbound lanes were opened at 9:00 a.m. (See Figure 2.)

Figure 2: Wilson Street Bridge after Completion of Sawing and Pulverizing.

On Tuesday, November 20, substructure plans from the WisDOT Central Office were received at the Eau Claire district office and alternative repair options were discussed on Wednesday, November 21. Traffic control was initiated by the contractor and a barrier wall was placed so as to protect the contractor's employees The footing for the replacement column was poured on Thursday, November 29, and the column was poured on Friday, November 30. Starting on December 4 the pier cap was formed and poured and the bearing pads were installed.

On December 6, 2001, the Wisconsin State Highway Patrol closed I-94 (beginning with the westbound lanes at 10:30 p.m.) in order to place the new girders. The westbound lanes were reopened at 12:38 a.m. on December 7. The last girders were set at 2:00 a.m. and the eastbound lanes were opened at 2:45 a.m.

The pouring of the deck surface began on December 10, 2001 and work continued until December 19. After checking the compressive strength of test cylinders Wilson Street was reopened to traffic. All repairs to the Wilson Street bridge were completed on December 27, 2001.

Payment for the contracted work ($216,518) was approved by the Governor of Wisconsin on January 29, 2002. No restrictions have been implemented and the bridge retains its original load ratings.

KEYWORDS: impact, column, pier, girder, concrete, cracking, replacement.

Bridge Incident Response Data (BIRD)
Bridge Information Report
Bridge Number B-17-0040
Generated 4/24/2007

Basic Bridge Information

Structure Name	Wilson St. Bridge
Year Built	1958
Municipality	City - Menomonie
Section	S14
Town	T28N
State	WI
Range	R13W
Maintenance Agency	State Highway Dept.
Owner	State Highway Dept.
Replaced Structure Number	
Historical Significance	5
Latitude	445425.2
Longitude	915528.8
County	Dunn
District	6

Bridge Geometric Data

Structure Length (ft)	210.5
Number Lanes On	2
Left Sidewalk Width (ft)	3.2
Right Sidewalk Width (ft)	3.2
Median Type	
Median Width (ft)	0.0
Skew Angle (Deg)	0.0
Direction Skew Angle	
Horizontal Curve Radius (ft)	0.0
Direction Horizontal Curve	
Girder Spacing (ft)	6.2
Height (ft)	36.0
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Sill With Bearings
Pile Type	Treated Timber
Pile Size (in)	12
Slope Protection Type	Stab or Stone
Roadway width (ft)	30.0
Deck Width (ft)	36.3
Wing Type	

Abutment Data (Non Cardinal)

Abutment Type	Sill With Bearings
Pile Type	Treated Timber
Pile Size (in)	12
Slope Protection Type	Stab or Stone
Roadway width (ft)	30.0
Deck Width (ft)	36.3
Wing Type	

Bridge Capacity

Design MS	H20
Inventory MS	HS15
Operating MS	HS25
Maximum Vehicle Weight (kips)	90
Load Governing Member	Deck Girder
Deck Composition	NONE
Deck Membrane	NONE
Deck Surface	Integral Concrete

Bridge Construction

Beam/Girder Material	Continuous Prestressed Concrete
Beam/Girder Type	Precast
Span Type	Continuous
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Other

Planning Data

Functional Classification	Minor Art - Urban
ADT	2600
ADT Year	1989
Truck ADT (%)	0.0
Future ADT	0.0
Future ADT Year	0

Hydraulic Data

Design Flood Frequency (yrs)	
Design Discharge (cu-ft/s)	
Maximum Velocity (ft/s)	
Drainage Area (sq. ft)	
High Water Elevation (ft)	
Scour Critical Code	
Scour Calculated	

Service Data

Type Service On	Hwy. Pedestrian
Type Service Under	Highway

Clearance Data

Vertical Clearance (Cardinal) (ft)	18.59
Vertical Clearance (Non-Cardinal) (ft)	17.59

Condition Data

Deck Condition	6
Super-Structure Condition	6
Sub-Structure Condition	6

Case History Background
U.S. Interstate Highway I-94 Westbound Over State Highway 37/85
Bridge Number B – 18 – 0026
Revision Date: 6/21/2007

The U.S. Interstate Highway I-94 westbound bridge is located on the southwestern boundary of the City of Eau Claire near the Town of Brunswick. The bridge was constructed in 1966 and carries two lanes of traffic over four lanes of State Highway 37/85 (STH 37/85). The average vehicular traffic level was recorded as 14,250 vehicles per day in 2003.

The bridge has four prestressed concrete spans (seven girders in spans 1 & 4, ten girders in spans 2 & 3). Span 1 has a length of 32.5 ft., spans 2 and 3 are 57.5 ft. long, and span 4 has a length of 39.5 ft. The total structure length is 191.0 ft. The deck width varies from 52.5 to 56.2 ft. and the deck area is 10,380 sq. ft. It has sill with bearings abutments with no pilings and round column bent type piers with no pilings. Load ratings are specified as HS20M for the design, HS33 for an operating load rating, and HS21 for the inventory load rating. The bridge was designed for over 2,000,000 stress cycles and the prestressed concrete girders were manufactured to have a compressive strength of 5,000 psi.

The bridge superstructure was repaired in 1980 and no further records of damages are available till October of 2001. On Tuesday, October 2, 2001, the westbound I-94 bridge was struck by the boom of an excavating shovel loaded on a flatbed truck trailer. The truck was traveling in the northbound lanes of STH 37/85. In this incident four concrete girders were struck with girders #18 and 19 in span 3 being severely damaged. (See Figure 1.)

Figure 1: General View of Severely Damaged Concrete Girders.

The incident occurred at approximately 2:30 p.m. and was first investigated by a Wisconsin State Police officer at 2:40 p.m. Because of the extent of heavy damage, the officer reported the incident to the Northwest District offices of the Wisconsin Department of Transportation (WisDOT) located in Eau Claire, Wisconsin. The call was forwarded to the district's Highway Operations Structures Engineer, Patrick Kern. Mr. Kern immediately visited the site, arriving at 3:15 p.m., and prepared a preliminary evaluation of the damage. At this time, closures of both northbound lanes of STH 37/85, (see Figure 2), the entrance ramp to westbound I-94, the exit ramp from eastbound I-94 to northbound STH 37/85, and the ramp at the STH 93 exit were put into effect. All closures were coordinated with the State Highway Patrol. A review of the length of time required for the lane and ramp closure was initiated on the morning of October 3, 2001. The Director of the WisDOT Northwest region declared the situation as an "emergency" requiring immediate attention.

Figure 2: Closure of Northbound Lanes on State Highway 37/85.

The emergency status of the westbound I-94 bridge allowed for immediate repairs to be performed by an outside contractor (Lunda Construction Company). The extent of the damage required removal and replacement of the severely damaged girders. To accomplish this, barriers were erected on westbound I-94 at 11:00 a.m. on Thursday, October 4. Sawing began on the afternoon of October 5 and was completed on the morning of October 5. (See Figure 3.) On October 5 debris from the sawing operation was removed and the northbound lanes of STH 37/85 were reopened to traffic at 4:00 p.m. Only the westbound I-94 entrance ramp remained closed. On Monday, October 8, traffic on one lane of northbound STH 37/85 was restricted to allow working space for the contractor to perform the demolition operation. (See Figure 4.)

Figure 3: Sawing Operations Initiated.

Figure 4: Demolition of Severely Damaged Girders.

This restriction remained in place until the end of the project. The replacement girders were received and erected on Wednesday, October 7. (See Figure 5.) Forming of the deck was initiated on October 11 and setting of the iron began on October 12. The diaghrams were poured on October 16, the deck pour began on October 17 (see Figure 6), and curing of the deck continued until October 19. All remaining repair work was completed by October 25 and traffic was restored to normal conditions on October 26 at 4:00 p.m.

Figure 5: Installation of Replacement Girders.

Figure 6: Pouring Deck Concrete.

Payment for the contracted work ($91,152) was approved by the Governor of Wisconsin on November 7, 2001. No restrictions have been implemented and the bridge retains its original load ratings.

KEYWORDS: impact, girder, concrete, exposed rebar, replacement.

Bridge Incident Response Data (BIRD)
Bridge Information Report: Bridge Number B-18-0026
Generated 5/2/2007

Basic Bridge Information

Structure Name	I-94 WB over STH 37/85
Year Built	1966
Municipality	Town - Brunswick
Section	36
Town	27N
State	WI
Range	10W
Maintenance Agency	State Highway Dept
Owner	State Highway Dept
Replaced Structure Number	
Historical Significance	5
Latitude	444643.63
Longitude	913155.57
County	Eau Claire
District	6

Bridge Geometric Data

Structure Length (ft)	191.0
Number Lanes On	2
Left Sidewalk Width (ft)	0.0
Right Sidewalk Width (ft)	0.0
Median Type	
Median Width (ft)	0.0
Skew Angle (Deg)	4
Direction Skew Angle	RIGHT
Horizontal Curve Radius (ft)	0.0
Direction Horizontal Curve	
Girder Spacing (ft)	8.7
Height (ft)	36.0
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Sill With Bearings
Pile Type	Other
Pile Size (in)	
Slope Protection Type	Solid Concrete
Roadway width (ft)	52.2
Deck Width (ft)	56.2
Wing Type	

Abutment Data (Non Cardinal)

Abutment Type	Sill With Bearings
Pile Type	Other
Pile Size (in)	
Slope Protection Type	Solid Concrete
Roadway width (ft)	48.5
Deck Width (ft)	52.5
Wing Type	

Bridge Capacity

Design MS	HS20M
Inventory MS	HS21
Operating MS	HS33
Maximum Vehicle Weight (kips)	250
Load Governing Member	Deck Girder
Deck Composition	NONE
Deck Membrane	
Deck Surface	BITUMINOUS

Bridge Construction

Beam/Girder Material	Concrete
Beam/Girder Type	Precast
Span Type	Other
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Other

Planning Data

Functional Classification	Interstate Rural (01)
ADT	11300
ADT Year	2003
Truck ADT (%)	15
Future ADT	21753
Future ADT Year	2023

Hydraulic Data

Design Flood Frequency (yrs)	
Design Discharge (cu-ft/s)	
Maximum Velocity (ft/s)	
Drainage Area (sq. ft)	
High Water Elevation (ft)	
Scour Critical Code	
Scour Calculated	

Service Data

Type Service On	Highway
Type Service Under	Highway

Clearance Data

Vertical Clearance (Cardinal) (ft)	14.84
Vertical Clearance (Non-Cardinal) (ft)	15.67

Condition Data

Deck Condition	7
Super-Structure Condition	5
Sub-Structure Condition	5

Case History Background
Seminole Highway over Madison, WI Beltline
Bridge Number B – 13 – 0264
Revision Date: 6/24/2007

The Seminole Highway Bridge is located on the southern boundary of the Town of Madison where it spans U.S. Highways 12/14/18/151 (Madison, WI, Beltline). The bridge was constructed in 1971 and its height was raised in 2003. It carries four lanes of traffic over six lanes of U.S. Highways 12/14/18/151. In 1994 the average vehicular traffic level (ADT) was recorded as 11,350 vehicles per day on Seminole Highway. The ADT for U.S. Highways 12/14/18/151 was recorded as 105,406 vehicles per day in 2003.

The bridge has two continuous prestressed concrete spans (seven girders in each span) each with a length of 81.0 ft. and a total structure length of 166.2 ft. The deck width is 60.0 ft and the deck area is 9,972 sq. ft. It has semi retaining abutments with treated timber piling of size 12 inches and a round column bent type pier with 12 inch diameter treated timber piling. Load ratings are specified as HS20 for the design, HS36 for an operating load rating, and HS19 for the inventory load rating. The bridge was designed for over 2,000,000 stress cycles and the prestressed concrete girders were manufactured to have a compressive strength of 6,000 psi.

This structure has suffered several vehicular impacts. Records indicate that repairs to the bridge superstructure were implemented in 1996 and 1997. On 7/21/2001 girders 1, 2, and 3 of span 2 were damaged and girders 1 and 2 were replaced. On 12/13/2002 and 7/10/2003 damage reports indicated significant damage to various girders and diaphragms, especially in span 2. The evidence of repeated impacts resulted in the closing and raising of the bridge beginning on 8/12/2003.

On Friday, January 13, 2006 the Seminole Highway Bridge was struck by an oversize load mounted on a flatbed semi truck trailer. The truck was traveling in the westbound lanes of U.S. Highways 12/14/18/151. In this incident (1/13/2006), the three westerly girders (5, 6, and 7) were damaged beyond repair. (See Figures 1 & 2.)

Figure 1: Girders #5, 6, and 7 after impact.

Figure 2: Detailed View of Girder Damage.

The incident occurred at approximately 2:30 p.m. and was first investigated by a Town of Madison police officer. The collision resulted in large pieces of concrete being dislodged from the support girders and striking two other westbound vehicles on U.S. Highways 12/14/18/151. Because of the extent of heavy damage, the police officer reported the incident to the Central District offices of the Wisconsin Department of Transportation (WisDOT) located in Madison, Wisconsin. The call was forwarded to one of the districts regional Bridge Maintenance and Inspection Engineers, Matthew Murphy. Mr. Murphy immediately visited the site, evaluated the severity of the damage, and prepared an inspection report. At this time debris from the collision was removed from the westbound lanes on U.S. Highways 12/14/18/151 and the southbound lanes of Seminole Highway on the bridge were closed. The inspection report was filed with the central WisDOT office in Madison, Wisconsin.

The bridge closure resulted in the establishment of a short term alternate route for traffic on Seminole Highway. This short term alternate route was chosen by the Dane County Highway Commission and the Wisconsin State Patrol. A longer term alternate route was later established by the regional WisDOT Traffic section. The bridge closure and traffic rerouting remained in effect until the repairs to the bridge were completed. Further lane closures and traffic rerouting on U.S. Highways 12/14/18/151 were enacted when bridge repairs were in progress.

The damage to the Seminole Highway Bridge required the removal and replacement of the three westerly girders of the north span as well as several other subsidiary tasks. The work on the girders required a quick response and it was decided to have the repairs performed by an outside contractor, Lunda Construction Co. The contractor quoted a cost of $125,000 to complete all of the necessary repairs. An agreement to complete the work was prepared on January 15, 2006, and was approved by the governor of Wisconsin on January 20, 2006. The repairs were successfully completed on February 20, 2006 and payment was approved on March 8, 2006. No restrictions have been implemented and the bridge retains its original load ratings.

KEYWORDS: impact, girder, concrete, diaphragm, broken concrete, raise bridge, replace girder.

Bridge Incident Response Data (BIRD)
Bridge Information Report: Bridge Number B-13-0264
Generated 1/26/2007

Basic Bridge Information

Structure Name	
Year Built	1971
Municipality	City - Madison (13251)
Section	33
Town	07N
State	WI
Range	09E
Maintenance Agency	State Highway Dept
Owner	State Highway Dept
Replaced Structure Number	
Historical Significance	5
Latitude	430204.69
Longitude	892636.66
County	Dane (13)
District	1

Bridge Geometric Data

Structure Length (ft)	166.2
Number Lanes On	4
Left Sidewalk Width (ft)	6.0
Right Sidewalk Width (ft)	6.0
Median Type	
Median Width (ft)	
Skew Angle (Deg)	6
Direction Skew Angle	Right
Horizontal Curve Radius (ft)	
Direction Horizontal Curve	
Girder Spacing (ft)	8.7
Height (ft)	45
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Semi Retaining
Pile Type	Treated Timber
Pile Size (in)	305 MM
Slope Protection Type	Solid Concrete
Roadway width (ft)	48.0
Deck Width (ft)	60.0
Wing Type	Parallel To Roadway

Abutment Data (Non Cardinal)

Abutment Type	Semi Retaining
Pile Type	Treated Timber
Pile Size (in)	305 MM
Slope Protection Type	Solid Concrete
Roadway width (ft)	48.0
Deck Width (ft)	60.0
Wing Type	Parallel to Roadway

Bridge Capacity

Design MS	HS20
Inventory MS	HS19
Operating MS	HS36
Maximum Vehicle Weight (kips)	190
Load Governing Member	Deck Girder
Deck Composition	None
Deck Membrane	None
Deck Surface	Integral Concrete

Bridge Construction

Beam/Girder Material	Continuous Prestressed Concrete
Beam/Girder Type	Other
Span Type	Other
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Treated Timber

Planning Data

Functional Classification	Collector - Urban (17)
ADT	
ADT Year	
Truck ADT (%)	
Future ADT	
Future ADT Year	

Hydraulic Data

Design Flood Frequency (yrs)	
Design Discharge (cu-ft/s)	
Maximum Velocity (ft/s)	
Drainage Area (sq. ft)	
High Water Elevation (ft)	
Scour Critical Code	
Scour Calculated	

Service Data

Type Service On	Highway, Pedestrian
Type Service Under	Highway

Clearance Data

Vertical Clearance (Cardinal) (ft)	15.35
Vertical Clearance (Non-Cardinal) (ft)	15.35

Condition Data

Deck Condition	5
Super-Structure Condition	5
Sub-Structure Condition	6

Case History Background
State Highway 67 over U.S. Highway 41
Bridge Number B – 14 – 0028
Revision Date: 6/24/2007

The State Highway 67 Bridge is located on the eastern boundary of the Town of Lomira, Wisconsin, where it spans U.S. Highway 41. The bridge was constructed in 1958 and carries two lanes of traffic over four lanes of U.S. Highway 41. In 2003 the average vehicular traffic level (ADT) was recorded as 4,960 vehicles per day on State Highway 67. The ADT for U.S. Highway 41 was recorded as 30,500 vehicles per day in 2003.

The bridge has four continuous prestressed concrete spans with five girders in spans 1 and 4 and six girders in spans 2 and 3. The outer spans (1, 4) are of length 34.6 ft, the inner spans (2, 3) are of length 34.6 ft, and the total structure length is 197.0 ft. The deck width is 36.0 ft and the deck area is 7,092 sq. ft. It has sill with bearings abutments with steel piling of size 10 inches or 10 ¾ inches and a round column bent type pier with 10 inch or 10 ¾ inch diameter steel piling. Load ratings are specified as H20 for the design, HS31 for an operating load rating, and HS20 for the inventory load rating. The bridge was designed for over 2,000,000 stress cycles and the prestressed concrete girders were manufactured to have a compressive strength of 6,000 psi.

The first incident reported for this structure was an impact to span 3 (girder 1) on 10/11/2004 by a truck traveling north on U.S. Highway 41. The 2004 incident caused the bottom flange, at the impact site, to be completely knocked out, thus exposing all of the prestressing strands. Also, a large section of the girder was dislodged from the top flange. The extensive damage to the girder required its replacement on 10/19/2004.

A second incident occurred on Wednesday, March 30, 2005 when the State Highway 67 Bridge was struck by an oversize semi truck trailer. The truck was traveling in the northbound lanes of U.S. Highway 41. In this incident (3/30/2005), the girder (#1, span 3) was damaged beyond repair. (See Figure 1.)

The incident occurred at approximately 9:30 a.m. and was first investigated by a Wisconsin State Patrol officer. The collision resulted in large pieces of concrete being dislodged from girder 1 and damage to the remaining girders in span 3. (See Figure 2.) Several pieces of concrete fell onto the roadway and onto another vehicle traveling next to the truck. Because of the extent of heavy damage, the State Patrol officer reported the incident to the Central District offices of the Wisconsin Department of Transportation (WisDOT) located in Madison, Wisconsin. The call was forwarded to one of the districts regional Bridge Maintenance and Inspection Engineers, Matthew Murphy. Mr. Murphy immediately visited the site, evaluated the severity of the damage, and prepared an inspection report. At this time debris from the collision was removed from the northbound lanes on U.S. Highway 41 and traffic on the eastbound lane of State Highway 67 as diverted from the southern edge of the deck extending over girders 1 and 2. The inspection report was filed with the central WisDOT office in Madison, Wisconsin.

Figure 1: Impact Damage to Bridge # B-14-0028.

Figure 2: Detail of Damage to Girder #1.

The traffic restrictions on State Highway 67 remained in effect until the repairs to the bridge were completed. Further lane closures on the bridge and on U.S. Highway 41 were enacted while the damaged girder was replaced. Alternate traffic routes were established by the regional WisDOT Traffic section.

The damage to the State Highway 67 Bridge required the removal and replacement of girders 1 and 2 of span 3 as well as several other subsidiary tasks. The work on the girder required a quick response and it was decided to have the repairs performed by an outside contractor, Lunda Construction Co. The contractor quoted a cost of $85,000 to complete all of the necessary repairs. An agreement to complete the work was prepared on April 8, 2005, and was approved by the governor of Wisconsin on April 15, 2005. The repairs were successfully completed on June 17, 2005 and payment was approved on June 24, 2005. No restrictions have been implemented and the bridge retains its original load ratings.

KEYWORDS: impact, girder, concrete, exposed rebar, broken concrete, replace girder.

Bridge Incident Response Data (BIRD)
Bridge Information Report: Bridge Number B-14-0028
Generated 1/26/2007

Basic Bridge Information

Structure Name	
Year Built	1958
Municipality	Village - Lomira (14146)
Section	14
Town	13N
State	WI
Range	17E
Maintenance Agency	State Highway Dept
Owner	State Highway Dept
Replaced Structure Number	
Historical Significance	5
Latitude	433513.58
Longitude	882551.78
County	Dodge (14)
District	1

Bridge Geometric Data

Structure Length (ft)	197
Number Lanes On	2
Left Sidewalk Width (ft)	
Right Sidewalk Width (ft)	
Median Type	
Median Width (ft)	
Skew Angle (Deg)	
Direction Skew Angle	
Horizontal Curve Radius (ft)	
Direction Horizontal Curve	
Girder Spacing (ft)	7.8
Height (ft)	36
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Sill With Bearings
Pile Type	Steel
Pile Size (in)	10 or 10 3/4
Slope Protection Type	Solid Concrete
Roadway width (ft)	30
Deck Width (ft)	36
Wing Type	

Abutment Data (Non Cardinal)

Abutment Type	Sill With Bearings
Pile Type	Steel
Pile Size (in)	10 or 10 3/4
Slope Protection Type	Solid Concrete
Roadway width (ft)	30
Deck Width (ft)	36
Wing Type	

Bridge Capacity

Design MS	H20
Inventory MS	HS20
Operating MS	HS31
Maximum Vehicle Weight (kips)	190
Load Governing Member	Deck Girder
Deck Composition	
Deck Membrane	
Deck Surface	Integral Concrete

Bridge Construction

Beam/Girder Material	Continuous Prestressed Concrete
Beam/Girder Type	Cast In Place
Span Type	Continuous
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Steel

Planning Data

Functional Classification	Minor Art - Rural (06)
ADT	4960
ADT Year	2003
Truck ADT (%)	6
Future ADT	8200
Future ADT Year	2023

Hydraulic Data

Design Flood Frequency (yrs)	
Design Discharge (cu-ft/s)	
Maximum Velocity (ft/s)	
Drainage Area (sq. ft)	
High Water Elevation (ft)	
Scour Critical Code	
Scour Calculated	

Service Data

Type Service On	Highway
Type Service Under	Highway

Clearance Data

Vertical Clearance (Cardinal) (ft)	14.7
Vertical Clearance (Non-Cardinal) (ft)	14.73

Condition Data

Deck Condition	4
Super-Structure Condition	4
Sub-Structure Condition	4

Case History Background
County Highway M over State Highway 16
Bridge Number B – 14 – 0044
Revision Date: 6/24/2007

The County Highway M Bridge is located on the northern boundary of the City of Watertown, where it spans State Highway 16. The bridge was constructed in 1960 and carries two lanes of traffic over two lanes of State Highway 16. In 1980 the average vehicular traffic level (ADT) was recorded as 2,550 vehicles per day on County Highway M. The ADT for State Highway 16 was recorded as 6,300 vehicles per day in 2003.

The bridge has three continuous steel girder spans (five girders in each span) of lengths 35.0 ft, 52.0 ft, and 52.0 ft for a total structure length of 143.2 ft. The deck width is 37.0 ft and the deck area is 5,298 sq. ft. The north abutment is an open pedestal type structure and the south abutment is a sill with bearings style. Both abutments are constructed from reinforced concrete without pilings. There are two round column bent piers also without pilings. Load ratings are specified as H20 for the design, HS24 for an operating load rating, and HS14 for the inventory load rating. The bridge was designed for over 2,000,000 stress cycles and the girders were manufactured with ASTM – A572 (AASHTO Grade 50) structural carbon steel.

The first reported incident for this structure was a vehicular impact to span 2 (girders 2 and 5) on 7/10/2003 by a truck traveling westbound on State Highway 16. The 2003 incident resulted in bending and gouging of the girders and a tear in the bottom flange of girder 2. The damaged girders were repaired by 9/18/2003. On Wednesday, July 14, 2004 the County Highway M Bridge was struck in span 2 by an oversize semi truck trailer traveling eastbound on State Highway 16. In this second incident, all five girders in span 2 were damaged beyond repair. (See Figures 1 & 2.)

Figure 1: Impact Damage to Bridge # B-14-0044.

Figure 2: Impact Damage to Bridge Girders.

The incident occurred at approximately 2:30 p.m. and was first investigated by a deputy from the Dodge County Sheriff's office. The collision resulted in extensive twisting of all five girders in span 2 located over the eastbound lane of State Highway 16. Because of the extent of heavy damage, the deputy reported the incident to the Central District offices of the Wisconsin Department of Transportation (WisDOT) located in Madison, Wisconsin. The call was forwarded to one of the districts regional Bridge Maintenance and Inspection Engineers, Matthew Murphy. Mr. Murphy immediately visited the site, evaluated the severity of the damage, and prepared an inspection report. At this time the traffic restrictions on State Highway 16 were removed and the bridge was closed to all traffic on County Highway M. The inspection report was filed with the central WisDOT office in Madison, Wisconsin.

The bridge closure resulted in the establishment of a short term alternate route for traffic on County Highway M. This short term alternate route was chosen by the Dodge County Highway Commission and the Wisconsin State Patrol. A longer term alternate route was later established by the regional WisDOT Traffic section. The bridge closure and traffic rerouting remained in effect until the repairs to the bridge were completed. Further lane closures and traffic rerouting on State Highway 16 were enacted when bridge repairs were in progress.

The damage to the County Highway M Bridge required the removal and replacement of five girders in span 2 as well as several other subsidiary tasks. The work on the girders required a quick response and it was decided to have the repairs performed by an outside contractor, Kraemer Brothers LLC. The contractor quoted a cost of $125,000 to complete all of the necessary repairs. An agreement to complete the work was prepared on July 16, 2004, and was approved by the governor of Wisconsin on September 15, 2004. The repairs were successfully completed on September 26, 2005 and payment was approved on September 30, 2005. No restrictions have been implemented and the bridge retains its original load ratings.

KEYWORDS: impact, girder, steel, twisting, gouging, tears, girder replacement.

Bridge Incident Response Data (BIRD)
Bridge Information Report: Bridge Number B-14-0044
Generated 1/26/2007

Basic Bridge Information

Structure Name	
Year Built	1960
Municipality	Town - Emmet (14016)
Section	28
Town	09N
State	WI
Range	15E
Maintenance Agency	State Highway Dept
Owner	State Highway Dept
Replaced Structure Number	
Historical Significance	5
Latitude	431247.31
Longitude	884255.92
County	Dodge (14)
District	1

Bridge Geometric Data

Structure Length (ft)	143.2
Number Lanes On	2
Left Sidewalk Width (ft)	
Right Sidewalk Width (ft)	6
Median Type	
Median Width (ft)	
Skew Angle (Deg)	25
Direction Skew Angle	Left
Horizontal Curve Radius (ft)	
Direction Horizontal Curve	
Girder Spacing (ft)	7.6
Height (ft)	
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Open
Pile Type	Other
Pile Size (in)	
Slope Protection Type	Solid Concrete
Roadway width (ft)	30
Deck Width (ft)	40.7
Wing Type	Parallel to Roadway

Abutment Data (Non Cardinal)

Abutment Type	Sill With Bearings
Pile Type	Other
Pile Size (in)	
Slope Protection Type	Solid Concrete
Roadway width (ft)	30
Deck Width (ft)	40.7
Wing Type	Parallel to Roadway

Bridge Capacity

Design MS	H20
Inventory MS	HS14
Operating MS	HS24
Maximum Vehicle Weight (kips)	240
Load Governing Member	Deck Girder
Deck Composition	Epoxy Coated Reinforcing
Deck Membrane	None
Deck Surface	Concrete

Bridge Construction

Beam/Girder Material	Continuous Steel
Beam/Girder Type	Other
Span Type	Continuous
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Other

Planning Data

Functional Classification	Major Col - Rural (07)
ADT	2550
ADT Year	1980
Truck ADT (%)	
Future ADT	2805
Future ADT Year	2000

Hydraulic Data

Design Flood Frequency (yrs)	
Design Discharge (cu-ft/s)	
Maximum Velocity (ft/s)	
Drainage Area (sq. ft)	
High Water Elevation (ft)	
Scour Critical Code	
Scour Calculated	

Service Data

Type Service On	HWy. Pedestrian
Type Service Under	Highway

Clearance Data

Vertical Clearance (Cardinal) (ft)	15.44
Vertical Clearance (Non-Cardinal) (ft)	15.44

Condition Data

Deck Condition	6
Super-Structure Condition	7
Sub-Structure Condition	7

Case History Background
U.S. Highway 18 & State Highway 60
over the Mississippi River
Bridge Number B – 12 – 0027
Revision Date: 6/28/2007

Bridge number B-12-0027 is one of two bridges located on the eastern boundary of the City of Prairie du Chien that span the Mississippi River at the Iowa state line. The bridge was constructed in 1974 and carries two lanes of U.S. Highway 18 and State Highway 60 over the river. In 1996 the average vehicular traffic level (ADT) was recorded as 5200 vehicles per day on the bridge.

The bridge has thirteen spans. Spans 1 to 4 and 6 to 13 are continuous steel (two girders in each span) and span 5 is of tied arch steel construction (two girders and arches). Span 1 is 146.8 ft long, spans 2 and 3 are 181.5 ft long, span 4 is 146.0 ft long span 5 is 462.0 ft long, spans 6 to 12 are 184.0 ft long, and span 13 is 151.8 ft long. The total structure length is 2561.4 ft. The deck width varies from 43.8 ft to 53.3 ft and the deck area is 124,355 sq. ft. The bridge has sill with bearings type abutments and twelve cast in place concrete piers. Piers 1 to 6 are a hammerhead style and piers 7 to 12 are a solid shaft style. Load ratings are specified as HS20 for the design, HS28 for an operating load rating, and HS17 for the inventory load rating. The bridge was designed for over 2,000,000 stress cycles and the structural steel girders were manufactured to have a tensile strength of 80,000 psi.

In 1978 cracking developed in the main girders at floor beam connections as a result of out-of-plane bending. Each crack location was visually inspected and holes were drilled into the ends of the cracks at several locations. Also, a retro-fit was performed by removing a portion of the vertical connection stiffener. Furthermore, in 1978, it was discovered that electroslag butt-welds were failing on several bridges in the United States. Since bridge B-12-0027 was identified as having such welds in its construction a contract was implemented with Peabody Testing Company to evaluate the current quality of these welded joints. The results of these tests indicated that several electroslag butt-welds required corrective action.

In October of 1979, a further inspection of the steel in the tied arch span revealed the presence of a four-inch fatigue crack in one of the main support tie girders. Temporary repairs were immediately made but subsequent examination found that the steel was brittle and hence subject to further cracking. Chemical and physical testing determined that the tie girders were contaminated with brittle steel and were unsuitable for use as major elements in a bridge of this design. In January of 1981, the bridge was closed to traffic and remedial measures initiated. While repairs were in progress a ferry service was provided for area residents.

The bridge remained closed for almost seven months as a false-work structure was constructed below the bridge. The bridge deck was then lifted more than five inches off the girders while the defective components were removed and replaced. Also, the rejected electroslag butt-welds identified in the 1979 inspection were bolt-spliced. The bridge was partially reopened to traffic on August 12, 1981 when one lane provided highway travel across the river. The $4.4 million total repair costs were shared by the original steel manufacturer, U. S. Steel (approximately $3 million), the states of Wisconsin and Iowa (about $1.2 million), and various subcontractors involved in the original construction of the bridge. The bridge ratings were maintained at their original levels but the structure was classified as “fracture critical” and additional inspections were specified for monitoring the status of the bridge.

In 1989, an in-depth inspection was performed on bridge B-12-0027 and its companion structure B-12-0028. This inspection included ultrasonic testing of main girders at floor beams and examination of previously rejected electroslag butt-welds. A review of the inspection results indicated that cracking of main girders at floor beams had continued: with cracks now appearing at new locations, cracks progressing past drilled holes, and new cracking that developed at gouges remaining in girder webs after stiffener removal in 1978. Furthermore, the previously observed defects in the electroslag butt-welds had increased in size. It was concluded that minute movements of the welds had occurred even though no cracking was found. Based on these observations it was recommended that a complete retro-fit of the floor beam connections be initiated. Also, it was recommended that all electroslag butt-welds be cover plated. No major repair effort was pursued at this time.

Another interim inspection of both bridges was performed in August of 1992. During this inspection the ends of cracks in main girders at floor beams were located by ultasonic testing. The progression of several cracks was noted and the progression of cracking with time was reported. Serious cracking in the web of the north girder of bridge B-12-0027 was observed. The inspectors also ground out minor cracks at the shelf plates at all hinge locations. Significant corrosion at hanger pins, expansion joint shim plates, and protection plates in expansion joints over the girders were noted. It was requested that the WisDOT bridge design group evaluate the girder web cracking, the cracking at lower lateral gusset plates adjacent to hinges, and design a retro-fit. It was also requested that the finger expansion joints and pins and hangers be replaced. Superstructure repairs were performed in 1993.

An in-depth inspection of bridge B-12-0027, performed in July of 1994, indicated some minor cracking but that the structure was now in an overall good condition. This conclusion was confirmed by a routine inspection performed in April of 1996. No other major incidents have been reported for this bridge. No usage restrictions have been implemented and the bridge retains its original load ratings.

Keywords: steel, girder, cracking, fracture critical, pin and hanger joints, electroslag butt welds, out-of-plane bending, banding.

Bridge Incident Response Data (BIRD)
Bridge Information Report: Bridge Number B-12-0027
Generated 4/24/2007

Basic Bridge Information

Structure Name	
Year Built	1974
Municipality	Town-Bridgeport (12002)
Section	26
Town	07N
State	WI
Range	07W
Maintenance Agency	State Highway Dept
Owner	State Highway Dept
Replaced Structure Number	B-12-0832
Historical Significance	5
Latitude	430237.57
Longitude	911045.45
County	Crawford (12)
District	5

Bridge Geometric Data

Structure Length (ft)	2561.4
Number Lanes On	2
Left Sidewalk Width (ft)	0
Right Sidewalk Width (ft)	0
Median Type	
Median Width (ft)	0
Skew Angle (Deg)	0
Direction Skew Angle	
Horizontal Curve Radius (ft)	0
Direction Horizontal Curve	
Girder Spacing (ft)	48.0
Height (ft)	
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Sill With Bearings
Pile Type	Cast In PL
Pile Size (in)	254 or 273 MM
Slope Protection Type	Heavy Riprap
Roadway width (ft)	40.0
Deck Width (ft)	43.8
Wing Type	Parallel to Roadway

Abutment Data (Non Cardinal)

Abutment Type	Sill With Bearings
Pile Type	Cast In PL
Pile Size (in)	254 or 273 MM
Slope Protection Type	Solid Concrete
Roadway width (ft)	49.5
Deck Width (ft)	53.3
Wing Type	Parallel to Roadway

Bridge Capacity

Design MS	HS20
Inventory MS	HS17
Operating MS	HS28
Maximum Vehicle Weight (kips)	200
Load Governing Member	Floor Beam
Deck Composition	None
Deck Membrane	
Deck Surface	Concrete

Bridge Construction

Beam/Girder Material	Continuous Steel
Beam/Girder Type	Other
Span Type	Other
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Cast In PL

Planning Data

Functional Classification	OTH PRIN ART-RURAL (02)
ADT	
ADT Year	
Truck ADT (%)	
Future ADT	
Future ADT Year	

Hydraulic Data

Design Flood Frequency (yrs)	0
Design Discharge (cu-ft/s)	2350
Maximum Velocity (ft/s)	2.7
Drainage Area (sq. ft)	67500
High Water Elevation (ft)	628.3
Scour Critical Code	5
Scour Calculated	Y

Service Data

Type Service On	Highway
Type Service Under	Highway, Rail Road, Water

Clearance Data

Vertical Clearance (Cardinal) (ft)	23.25
Vertical Clearance (Non-Cardinal) (ft)	23.25

Condition Data

Deck Condition	7
Super-Structure Condition	7
Sub-Structure Condition	7

Case History Background
U.S. Interstate Highway I-90 Eastbound over U.S. Highway 53 and State Highway 35
Bridge Number B – 32 – 0036
Revision Date: 6/28/2007

The eastbound bridge on U.S. Interstate Highway I-90 is located on the northern boundary of the City of La Crosse where it spans the northbound lanes of State Highway 35 (STH 35) and the southbound lanes of U.S. Highway 53/State Highway 35 (USH 53 / STH 35). The bridge was constructed in 1967 and carries two lanes of traffic over four lanes of U.S. Highways 53/35. In 2002 the average vehicular traffic level was recorded as 13,200 vehicles per day on eastbound I-90 and 33,200 vehicles per day for the combined lanes under the bridge.

The bridge has four continuous steel girder spans (five girders in each span) of lengths 48.0 ft, 106.0 ft, 106.0 ft and 52.0 ft for a total structural length of 319.4 ft. The deck width ranges from 42.3 ft to 47.9 ft and the deck area is 14,404 sq. ft. It has reinforced concrete sill abutments with treated timber pilings of 12 in diameter and three reinforced concrete column piers with 12 in diameter treated timber pilings. Load ratings are specified as HS20M for the design, HS34 for an operational load rating and HS22 for the inventory load rating. The bridge was designed for over 2,000,000 stress cycles and the girders were manufactured with ASTM A-36 (AASHTO Grade 36) structural carbon steel.

The first reported incident for this structure occurred on Tuesday, May 4, 2004 when span three of bridge B-32-0036 was damaged by a truck carrying a pedestrian bridge that struck the south fascia girder with the top chord of the pedestrian bridge. The truck was traveling in the northbound lanes of STH 35. This impact caused a hole to be torn in the web of the girder and bending of approximately 8 in out of plane. (See Figures 1 & 2.) Furthermore, six stiffeners were buckled in the impact and a 3/16 in long crack was formed on the bottom flange of the girder.

Figure 1: Span #3 External Girder After Impact.

Figure 2: Out of Plane Deformation After Impact.

The incident occurred at approximately 10:45 a.m. and was first investigated by a City of La Crosse police officer. Because of the obvious damage to the bridge girder the police officer reported the incident to the Southwest Region offices of the Wisconsin Department of Transportation (WisDOT) located in La Crosse, Wisconsin. The call was forwarded to the regional Bridge Engineer, Mr. Dave Bohnsack. Mr. Bohnsack immediately visited the site and prepared a preliminary evaluation of the damage. At this time the damage was documented and the pedestrian bridge framework was removed from the STH 35 roadway. All of the northbound lanes on STH 35 were reopened but the shoulder on eastbound I-90 was closed with drums, signage and a message board. This closure remained in effect until the completion of the bridge repairs.

On Wednesday, May 12, 2004, an inspector from the WisDOT central office (in Madison, Wisconsin), Mr. Joel Alsum, visited the site and inspected the damaged areas using magnetic particle examination. It was at this point that the crack in the bottom flange of the girder was located and removed. An inspection report was filed with the WisDOT central office.

The repairs to bridge number B-32-0036 were performed by a bridge repair crew from the WisDOT central office located in Madison, Wisconsin. (See Figure 3 & 4.) The repairs were completed on October 4, 2004. During the repairs one lane of STH 35 northbound was closed to vehicular traffic. The steel girder deflection was removed by means of a heat straightening process, a plate was bolted over the hole in the fascia girder web, one diaphragm was replaced and another was heat straightened. A post repair interim inspection was performed on October 29, 2004, and the remaining barriers and signage for closing the shoulder of eastbound I-90 were removed. The repairs were judged to be successfully completed and the bridge retains all of its original load ratings.

Figure 3: Repair Activities.

Figure 4: Repaired Girder.

KEYWORDS: impact, girder, steel, stiffener, deformation, hole in web, cracking, heat straighten, plate over hole.

Bridge Incident Response Data (BIRD)
Bridge Information Report: Bridge Number B-32-0036
Generated 1/26/2007

Basic Bridge Information

Structure Name	
Year Built	1967
Municipality	city - La Crosse (32246)
Section	17
Town	16N
State	WI
Range	07W
Maintenance Agency	State Highway Dept
Owner	State Highway Dept
Replaced Structure Number	
Historical Significance	5
Latitude	435150.57
Longitude	911416.13
County	La Crosse (32)
District	5

Bridge Geometric Data

Structure Length (ft)	319.4
Number Lanes On	2
Left Sidewalk Width (ft)	
Right Sidewalk Width (ft)	
Median Type	
Median Width (ft)	
Skew Angle (Deg)	53
Direction Skew Angle	Left
Horizontal Curve Radius (ft)	11459.19
Direction Horizontal Curve	Left
Girder Spacing (ft)	9.7
Height (ft)	
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Sill With Bearings
Pile Type	Treated Timber
Pile Size (in)	12
Slope Protection Type	Solid Concrete
Roadway width (ft)	42.9
Deck Width (ft)	47.9
Wing Type	

Abutment Data (Non Cardinal)

Abutment Type	Sill With Bearings
Pile Type	Treated Timber
Pile Size (in)	12
Slope Protection Type	Solid Concrete
Roadway width (ft)	37.3
Deck Width (ft)	42.3
Wing Type	

Bridge Capacity

Design MS	HS20M
Inventory MS	HS22
Operating MS	HS34
Maximum Vehicle Weight (kips)	197
Load Governing Member	Deck Girder
Deck Composition	NONE
Deck Membrane	Protecto Wrap
Deck Surface	Bituminous

Bridge Construction

Beam/Girder Material	Continuous Steel
Beam/Girder Type	Other
Span Type	Continuous
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Treated Timber

Planning Data

Functional Classification	Interstate - Urban (11)
ADT	15760
ADT Year	2003
Truck ADT (%)	14
Future ADT	27183
Future ADT Year	2023

Hydraulic Data

Design Flood Frequency (yrs)	
Design Discharge (cu-ft/s)	
Maximum Velocity (ft/s)	
Drainage Area (sq. ft)	
High Water Elevation (ft)	
Scour Critical Code	
Scour Calculated	

Service Data

Type Service On	Highway
Type Service Under	Highway

Clearance Data

Vertical Clearance (Cardinal) (ft)	15.09
Vertical Clearance (Non-Cardinal) (ft)	14.59

Condition Data

Deck Condition	7
Super-Structure Condition	6
Sub-Structure Condition	6

Case History Background
U.S. Interstate Highway I-90 Westbound over
U.S. Highway 53 and State Highway 35
Bridge Number B – 32 – 0037
Revision Date: 6/28/2007

The westbound bridge on U.S. Interstate Highway I-90 is located on the northern boundary of the City of La Crosse where it spans the northbound lanes of State Highway 35 (STH 35) and the southbound lanes of U.S. Highway 53/State Highway 35 (USH 53 / STH 35). The bridge was constructed in 1967 and carries two lanes of traffic over four lanes of U.S. Highways 53/35. In 2003 the average vehicular traffic level (ADT) was recorded as 15,280 vehicles per day on westbound I-90 and 27,700 vehicles per day for the combined lanes under the bridge.

The bridge has four continuous steel girder spans (five girders in each span) of lengths 52.0 ft, 109.0 ft, 109.0 ft and 52.0 ft for a total structural length of 329.3 ft. The deck has a width of 45.2 ft and the deck area is 14,884 sq. ft. It has reinforced concrete sill abutments with treated timber pilings of 12 inch diameter and three reinforced concrete column piers with 12 inch diameter treated timber pilings. Load ratings are specified as HS20M for the design, HS28 for an operational load rating and HS16 for the inventory load rating. The bridge was designed for over 2,000,000 stress cycles and the girders were manufactured with ASTM A-36 (AASHTO Grade 36) structural carbon steel.

The first incident recorded for this structure was an impact which occurred on Wednesday, August 25, 2004, when a truck carrying a prefabricated home struck the north exterior girder while traveling southbound on STH 35. The damage resulting from this incident consisted of some out-of-plumb deformation and several scrapes on the flanges of all five girders. Immediate repairs were performed with no restrictions placed on the operation of the bridge.

On Thursday, November 17, 2005 span three of bridge B-32-0037 was damaged when a truck carrying a quarry loader struck the north exterior girder while merging onto southbound STH 35. In this incident the exterior girder was bent 5.5 inches out-of-plumb and several stiffeners in the inside of the girder were bent, broken, or separated from the girder. (See Figures 1 & 2). Furthermore, two other girders were struck resulting in small amounts of out-of-plumb deformation and several bent stiffeners.

Figure 1: Damage to Exterior Girder.

Figure 2: Damage to Exterior Girder (out-of-plumb).

The incident occurred at approximately 10:30 a.m. and was first investigated by a City of La Crosse police officer. Because of the nature of the damage, the police officer reported the incident to the Southwest Region offices of the Wisconsin Department of Transportation (WisDOT) located in La Crosse, Wisconsin. The call was forwarded to the regional Assistant Bridge Engineer, Mr. Allan Johnson. Mr. Johnson immediately visited the site, documented the incident, and prepared a preliminary evaluation of the damage. All of the southbound lanes on STH 35 were reopened and no traffic restrictions were initiated on westbound I-90.

On Tuesday, November 22, 2005, an inspector from the WisDOT central office (in Madison, Wisconsin), Mr. Joel Alsum, visited the site and inspected the damaged areas for any evidence of fatigue cracking. No fatigue cracks were found but Mr. Alsum did grind out the rough edges on the exterior girder that had resulted from the impact. (See Figure 3). An inspection report was filed with the WisDOT central office.

Figure 3: Damage to Exterior Girder (out-of-plumb).

No further repairs to bridge number B-32-0037 have been performed as of April 15, 2006. An interim inspection was performed on February 13, 2006, and the status of the previous damages was verified. The bridge remains in operation and retains all of its original load ratings.

KEYWORDS: impact, girder, stiffener, deformation, scrapes.

Bridge Incident Response Data (BIRD)
Bridge Information Report: Bridge Number B-32-0037
Generated 1/26/2007

Basic Bridge Information

Structure Name	
Year Built	1967
Municipality	CITY-La Crosse (32246)
Section	17
Town	16N
State	WI
Range	07W
Maintenance Agency	
Owner	
Replaced Structure Number	
Historical Significance	
Latitude	
Longitude	
County	
District	5

Bridge Geometric Data

Structure Length (ft)	329.3
Number Lanes On	2
Left Sidewalk Width (ft)	0
Right Sidewalk Width (ft)	0
Median Type	
Median Width (ft)	
Skew Angle (Deg)	53
Direction Skew Angle	left
Horizontal Curve Radius (ft)	
Direction Horizontal Curve	
Girder Spacing (ft)	
Height (ft)	
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Sill With Bearings
Pile Type	Treated Timber
Pile Size (in)	12
Slope Protection Type	
Roadway width (ft)	
Deck Width (ft)	
Wing Type	

Abutment Data (Non Cardinal)

Abutment Type	Sill With Bearings
Pile Type	Treated Timber
Pile Size (in)	12
Slope Protection Type	
Roadway width (ft)	
Deck Width (ft)	
Wing Type	

Bridge Capacity

Design MS	HS20
Inventory MS	HS16
Operating MS	HS28
Maximum Vehicle Weight (kips)	197
Load Governing Member	Deck Girder
Deck Composition	None
Deck Membrane	Protector Wrap
Deck Surface	Bituminous

Bridge Construction

Beam/Girder Material	Continuous Steel
Beam/Girder Type	Other
Span Type	Other
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Treated Timber

Planning Data

Functional Classification	Interstate-Urban (11)
ADT	
ADT Year	
Truck ADT (%)	
Future ADT	
Future ADT Year	

Hydraulic Data

Design Flood Frequency (yrs)	
Design Discharge (cu-ft/s)	
Maximum Velocity (ft/s)	
Drainage Area (sq. ft)	
High Water Elevation (ft)	
Scour Critical Code	
Scour Calculated	

Service Data

Type Service On	
Type Service Under	

Clearance Data

Vertical Clearance (Cardinal) (ft)	
Vertical Clearance (Non-Cardinal) (ft)	

Condition Data

Deck Condition	7
Super-Structure Condition	6
Sub-Structure Condition	6

Case History Background
State Highway 80 over the Wisconsin River
Bridge Number B – 52 – 0111
Revision Date: 6/28/2007

The State Highway 80 Bridge is located on the northern boundary of the Town of Muscoda, Wisconsin, where it spans the Wisconsin River. The bridge was constructed in 1990 and carries two lanes of traffic over the waterway. In 2003 the average vehicular traffic level (ADT) was recorded as 4,450 vehicles per day on State Highway 80.

The bridge has nine continuous prestressed concrete spans with five girders in each span. The outer spans (1, 9) are of length 121.2 ft, the other spans (2 – 8) are of length 122.0 ft, and the total structure length is 1,101.8 ft. The deck width is 39.0 ft and the deck area is 42,970 sq. ft. It has sill with bearings abutments with steel piling of size 10 inches or 10 ¾ inches in the cardinal abutment and no pilings in the non-cardinal abutment. There are eight hammerhead type reinforced concrete piers seated on sound rock with a combined seal and footing type foundation. Load ratings are specified as H20 for the design, HS52 for an operating load rating, and HS24 for the inventory load rating. The bridge was designed for over 2,000,000 stress cycles and the prestressed concrete girders were manufactured to have a compressive strength of 6,000 psi.

On Thursday, May 25, 1995 and on Monday, June 19, 1995 an underwater substructure inspection was performed by a diver from Westbrook Associated Engineers, Inc. It was during the dive portion that the footing at pier #2 was found to be exposed and undermined. Westbrook recommended that a structural analysis be undertaken to determine the structural integrity of the pier. A Bridge Scour Analysis was also performed by Westbrook and submitted to the Wisconsin Department of Transportation (WisDOT) office in LaCrosse, Wisconsin, on June 17, 1996. This report gave the bridge an NBIS #13 Scour Code = 2. The report stated that pier #2 was deemed to be scour critical and that countermeasures should be employed immediately.

Based on the information presented in the Westbrook report an additional underwater inspection of the site was commissioned. The supplemental inspection was performed by Westbrook which indicated that the upstream remnants from a number of existing piers were concentrating the flows at pier #2. Further evaluation of the condition of the pier was obtained when WisDOT obtained cores for pier #2 on July 28 and 29, 1996. The cores taken from the pier substantiated what Westbrook had found during the initial underwater inspection: that 40% - 60% of the footing was not in contact. Recommendations from the WisDOT Geotechnical Section required that full contact be established between the footing and the sandstone bedrock.

Several design concepts were offered by Westbrook for correcting the scour critical condition of pier #2 on Bridge Number B – 52 – 0111. Eventually these were reduced to either anchoring the footing/seal to bedrock with steel bars or pressure grouting the voided footing/seal through core holes. In addition, it was decided that the broken concrete, timber piling, and sandstone from the old pier foundations would be “knocked down” in order to more uniformly distribute the flow about pier #2.

On September 24, 1996, a meeting was held in Muscoda, Wisconsin, to discuss the proposed repairs to pier #2. The meeting was attended by the regional WisDOT Bridge Maintenance Engineer, Mr. Ed Fitzgerald, representatives from the WisDOT Bridge and Geotechnical sections, several Wisconsin-based contractors, and representatives from Westbrook Associated Engineers. The relevant issues concerning the scour critical condition of the pier were reviewed and the group toured the bridge and inspected the pier location. The contractors were then asked to prepare competitive bids for both options to include redistributing the old pier materials in the vicinity of the present pier #2. All bids were due at the LaCrosse, WI, WisDOT office by 4:00 p.m. on October 18, 1996. It was required that construction begin on November 1, 1996 and be completed by December 15, 1996. Westbrook provided an estimated cost for the anchor bar option of $213,000 and $216,125 for the pressure grouted process.

Several other agencies were contacted by the regional WisDOT office staff in order to obtain necessary approvals. These agencies included the Wisconsin Department of Natural Resources, the Wisconsin office of the U.S. Corps of Engineers, and the U.S. Coast Guard. The contract for the anchor bolt option was approved by the Governor of Wisconsin in the latter part of October, 1996, and awarded to Edward Kraemer and Sons for a total cost of $202,825. As part of the retrofit operations it was necessary to drill through the bridge deck itself in order to correctly place the anchor bolts in the pier. This required a lane reduction to a single lane during daylight hours. The bridge was returned to its full roadway status for night time driving operations.

The repairs were successfully completed as specified in the contract and an underwater bridge inspection performed on September 5, 2000, indicated that the retrofit was still in good condition. No other major incidences have been reported for this bridge. No restrictions have been implemented and the bridge retains its original load ratings.

KEYWORDS: scour, footing, pier, concrete, anchor bars.

Bridge Incident Response Data (BIRD)
Bridge Information Report: Bridge Number B-52-0111
Generated 6/28/2007

Basic Bridge Information

Structure Name	STH 80
Year Built	1989
Municipality	Town - Eagle
Section	01
Town	08N
State	WI
Range	01W
Maintenance Agency	State Highway Dept.
Owner	State Highway Dept.
Replaced Structure Number	B520832
Historical Significance	5
Latitude	431154.01
Longitude	902634.01
County	Richland
District	5

Bridge Geometric Data

Structure Length (ft)	1101.8
Number Lanes On	2
Left Sidewalk Width (ft)	0.0
Right Sidewalk Width (ft)	0.0
Median Type	
Median Width (ft)	0.0
Skew Angle (Deg)	0
Direction Skew Angle	
Horizontal Curve Radius (ft)	0.0
Direction Horizontal Curve	
Girder Spacing (ft)	8.5
Height (ft)	70.0
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Sill With Bearings
Pile Type	Steel
Pile Size (in)	10 or 10 3/4
Slope Protection Type	Heavy Riprap
Roadway width (ft)	36.0
Deck Width (ft)	39.0
Wing Type	Parallel to Roadway

Abutment Data (Non Cardinal)

Abutment Type	Sill With Bearings
Pile Type	Other
Pile Size (in)	
Slope Protection Type	Heavy Riprap
Roadway width (ft)	36.0
Deck Width (ft)	39.0
Wing Type	Parallel to Roadway

Bridge Capacity

Design MS	HS20
Inventory MS	HS24
Operating MS	HS52
Maximum Vehicle Weight (kips)	190
Load Governing Member	Deck Girder
Deck Composition	Epoxy Coated Reinforcing
Deck Membrane	
Deck Surface	Concrete

Bridge Construction

Beam/Girder Material	Continuous Prestressed Concrete
Beam/Girder Type	Precast
Span Type	Continuous
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Other

Planning Data

Functional Classification	Minor Art. - Rural
ADT	4540
ADT Year	2003
Truck ADT (%)	6
Future ADT	6110
Future ADT Year	2023

Hydraulic Data

Design Flood Frequency (yrs)	100
Design Discharge (cu-ft/s)	8040
Maximum Velocity (ft/s)	5.5
Drainage Area (sq. ft)	10400.0
High Water Elevation (ft)	678.5
Scour Critical Code	7
Scour Calculated	Y

Service Data

Type Service On	Highway
Type Service Under	Waterway

Clearance Data

Vertical Clearance (Cardinal) (ft)	
Vertical Clearance (Non-Cardinal) (ft)	

Condition Data

Deck Condition	7
Super-Structure Condition	8
Sub-Structure Condition	8

KEYWORDS: steel, girder, cracking, fracture, high constraint joint, explosive demolition.

Case History Background
Daniel Webster Hoan Bridge
Bridge Number B – 40 – 0400
Revision Date: 6/19/07

The Daniel Webster Hoan Bridge (also known as the Milwaukee Harbor Bridge), located on Interstate Highway I-794, was under construction from 1970 through 1974 but was not opened to traffic until 1977. The Hoan Bridge (officially designated as Bridge # B – 40 – 0400 by the Wisconsin Department of Transportation, WISDOT) is located in the City of Milwaukee near the downtown area along the shores of Lake Michigan. It carries six lanes of traffic and 36,000 vehicles daily over the entryway to Milwaukee's inner harbor and the mouths of the Menomonee and Kinnikinnic Rivers. In 2003 the average daily traffic for unit S2A (the focus of this report) was recorded as 11,150 vehicles per day. The bridge has a vertical clearance of 120 feet over the navigable waterway and a clear span of 600 feet. Eighteen bridge units are continuous steel three-girder spans. Beyond that, the remaining units are of a multi-girder configuration. The main unit is a three span tied arch crossing the harbor inlet. The structure was designed for over 2,000,000 stress cycles and the girders were manufactured with ASTM A-588 (AASHTO Grade 50) structural carbon steel. In 2001 the Hoan Bridge required a retrofit (State Project Number 1300 – 07 – 72) that specified ASTM A-709 (AASHTO Grade 50) high strength structural steel.

The Hoan Bridge has often been the subject of various studies related to possible failure mechanisms. As is typical the bridge has been inspected on a regular basis and several problems have been observed and corrected. In 1994 an intensive inspection of the entire structure was performed by a structural engineering consulting firm. The results of this inspection indicated the presence of numerous cracks in various bridge members and indicated that, if not arrested, these cracks might cause serious damage to the bridge. Further, the report stated that the estimated life of the structure (specifically Unit S2A) was less than fifteen years without structural repairs and if the amount of traffic did not increase. Another inspection performed by an outside firm in July of 2000 located further cracking in the northbound section of Unit S2A leading to removal and arrest of such cracks in October of 2000. Earlier, in the fall of 1996, the Infrastructure Technology Institute (ITI), located at Northwestern University, initiated a four-month-long test on the tied arch span where several cracks had been located. The objective of the test was to determine if thermally driven stresses were sufficient to drive fatigue cracks that were observed in the tie chords at the location penetrated by the arch. The data obtained from 18 strain gages and 9 thermocouples indicated that thermally induced stresses were the primary driving force for fatigue cracking.

On Wednesday, December 13, 2000, the City of Milwaukee experienced a second day of frigid winter weather. The low temperature for the 13th was $-4^{\circ}F$ after a recorded low of $-2^{\circ}F$ on the previous day. A snowstorm on Monday, the 11th , had deposited 13.6 inches of snow and a further 3.5 inches fell on the 13th. In the midst of these severe conditions the Hoan Bridge suffered a major failure in two of three girders supporting Unit S2A on the northbound lanes and located between piers 3S and 2S as one approaches the main span. The incident occurred at approximately 7:00 am and was reported by drivers to the Milwaukee County Sheriff's Office by means of a 911 emergency call. A sheriff's deputy was dispatched to the scene of the reported "buckling" and was able to confirm that the deck was sagging from three to five feet. The entire roadway, both northbound and southbound, was immediately closed to traffic. All vehicles were re-routed to alternate surface roadways through the city.

Upon dispatching a deputy to the bridge, the County Sheriff's Office also contacted Mr. Herb Szatmary, a bridge inspector assigned to the Southeast District of the WISDOT offices located in Waukesha, Wisconsin. Mr. Szatmary responded immediately and verified that two of the three girders in the failed span had full depth fractures, leaving the span near collapse. He then informed Mr. John Bolka, the Bridge Maintenance and Inspection Engineer at the district offices. Mr. Bolka then informed Mr. Leslie Fafard, the Director of the WISDOT office for the Southeast District. Mr. Gerry Anderson, another representative from the Southeast District, and Mr. Fafard arrived at the bridge, confirmed the extent of the problem, and proceeded to organize an emergency response plan. They immediately informed Mr. Finn Hubbarb, the Structure Design Supervisor for the Central WISDOT offices in Madison, Wisconsin as well as the Milwaukee County Executive, the Mayor of the City of Milwaukee, and the Wisconsin Governor's Office. Further notification was issued to the Federal Highway Administration Office in Madison (Mr. Thomas Strock). In addition, Mr. Phillip Fish from the Central Bridge Maintenance Office and Mr. Bruce Karow, the Chief Maintenance Engineer assisted with the planning for safely stabilizing the bridge and determining future repairs. Later on notification was also given to the firm of Lichtenstein Consulting Engineers, to the contracting firms of Zenith Tech. Inc. and Lunda Inc., and the Milwaukee Municipal Sewerage District which maintains a facility under the bridge.

Initially, it was suggested that the damaged span might be supported by scaffolding in order to reduce the possibility of collapse. After review by the WISDOT engineers and representatives from Lichtenstein Consulting Engineers, the assembled team agreed that the use of scaffolding would be of minimal benefit and should not be pursued. Further planning focused on two issues: a process for repairing and reopening the bridge and the organization of an intensive failure analysis in order to determine the root cause of the girder cracking.

Beginning on Thursday, December 14, 2000, it was decided to consider partial demolition of the failed span prior to eventual repair efforts. In consultation with representatives from Control Demolition Inc., a series of trial charges were positioned at various locations near the failed span and their effects evaluated. On December 28, 2000, the critically damaged section of the northbound roadway was successfully removed by explosive demolition.

With the failed section removed and the remainder of the bridge completely inspected for similar problems, the southbound lanes were reopened on February 17, 2001, with one lane of traffic in each direction. Upon approval of the repair plan by the governor of Wisconsin, work on the bridge was begun by the contracting firm of Zenith Tech. Inc.

As construction progressed on the bridge a forensic investigation of various structural members was performed. This investigation was a joint effort of Lichtenstein Consulting Engineers, the Center for Advanced Structural Systems at Lehigh University, Northwestern University, and the Turner-Fairbank Research Center of the Federal Highway Administration. The results of the investigation and subsequent analysis indicated that the fractures initiated in the web plate, most likely the interior girder, at the joint where the lower lateral bracing system framed into the web. The initiation site was located in the gap between the gusset (shelf) plate and the transverse connection/stiffener plate. Figure 1 shows the fracture initiation site in the web gap area.

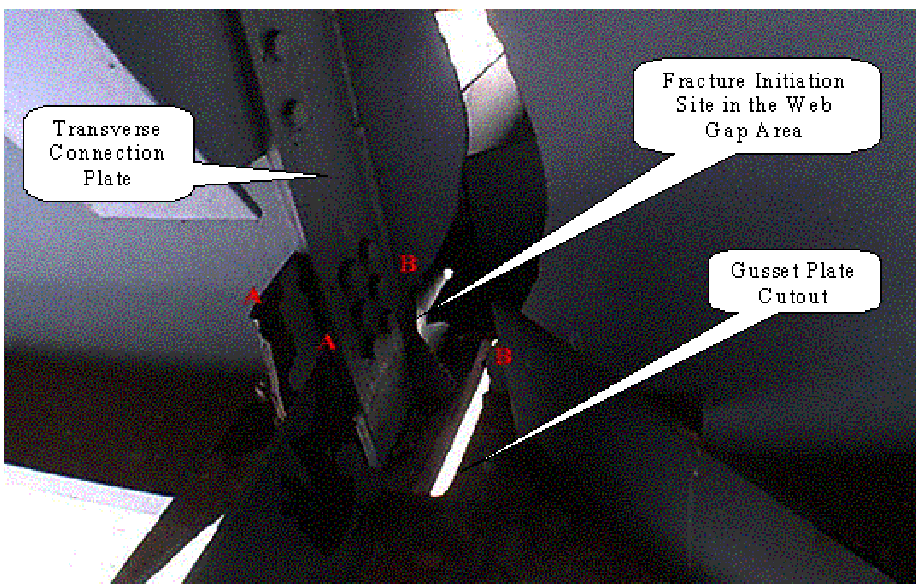


Figure 1. Fracture initiation site in the web gap area.

The primary cause of fracture initiation was determined to be the geometry and fabrication tolerance of the joint where the lateral bracing frames into the web. The joint was detailed with a narrow web gap that caused local high constraint, increased stiffness, and reduced the apparent fracture resistance. As ideally detailed, the joint has only 1/8 inch separating the welds on the two plates. The fabrication tolerance resulted in reduced gaps as well as intersecting welds in many locations throughout the structure. This local triaxial constraint condition prevented yielding and redistribution of the local stress concentrations occurring in this region. As a result, the local stress state in the web gap was forced well beyond the yield strength of the material. Stress analysis showed that the intersecting welds increased the rigidity of the joint and made the constraint problem even worse. Figure 2 shows a view of the joint assembly where the fracture initiated.

Figure 2. Joint assembly where the lateral brace system frames into the girder web.

Also, the high constraint in the joint assembly caused a reduction in fracture initiation resistance that was relatively insensitive to temperature. Although low temperature probably had a minor effect on the fracture initiation it significantly reduced the ability of the structure to arrest dynamic cracks. Therefore, low temperature at the time of failure was the significant factor that allowed the web fracture to progress to a chain reaction failure of the structure.

The research results from the failed Hoan Bridge span were communicated to state departments of transportation and other transportation officials throughout the United States in an effort to prevent further incidences of this nature.

Repairs and modifications to the bridge were pursued during the summer of 2001. On October 11, 2001, the bridge was officially reopened with two lanes of traffic in each direction. All six lanes were cleared and made available on November 1, 2001. Overall, the cost for stabilizing, repairing, and evaluating the cause of failure exceeded $12.4 million. The repairs and retrofits were successfully accomplished and the bridge retains its original load ratings.

Bridge Incident Response Data (BIRD)
Bridge Information Report: Bridge Number B-40-0400
Generated 1/26/2007

Basic Bridge Information

Structure Name	Daniel Webster Hoan Bridge
Year Built	
Municipality	Milwaukee (40251)
Section	33
Town	07N
State	WI
Range	22E
Maintenance Agency	State Highway Dept
Owner	State Highway Dept
Replaced Structure Number	
Historical Significance	5
Latitude	430118.0
Longitude	875354.0
County	Milwaukee (40)
District	2

Bridge Geometric Data

Structure Length (ft)	676.0
Number Lanes On	3
Left Sidewalk Width (ft)	0
Right Sidewalk Width (ft)	0
Median Type	GM Barrier
Median Width (ft)	0.2
Skew Angle (Deg)	0
Direction Skew Angle	
Horizontal Curve Radius (ft)	0.0
Direction Horizontal Curve	
Girder Spacing (ft)	8.2
Height (ft)	
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Open
Pile Type	Other
Pile Size (in)	
Slope Protection Type	
Roadway width (ft)	52.0
Deck Width (ft)	55.8
Wing Type	

Abutment Data (Non Cardinal)

Abutment Type	Open
Pile Type	Other
Pile Size (in)	
Slope Protection Type	
Roadway width (ft)	52.0
Deck Width (ft)	55.8
Wing Type	

Bridge Capacity

Design MS	HS20M
Inventory MS	HS20
Operating MS	HS33
Maximum Vehicle Weight (kips)	250 kips
Load Governing Member	Deck Girder
Deck Composition	NONE
Deck Membrane	Protecto Wrap
Deck Surface	Bituminous

Bridge Construction

Beam/Girder Material	Continuous Steel
Beam/Girder Type	Other
Span Type	Continuous
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Concrete

Planning Data

Functional Classification	Interstate - Urban (11)
ADT	11150
ADT Year	2003
Truck ADT (%)	3
Future ADT	14995
Future ADT Year	2023

Hydraulic Data

Design Flood Frequency (yrs)	
Design Discharge (cu-ft/s)	
Maximum Velocity (ft/s)	
Drainage Area (sq. ft)	
High Water Elevation (ft)	
Scour Critical Code	
Scour Calculated	

Service Data

Type Service On	Highway
Type Service Under	Land

Clearance Data

Vertical Clearance (Cardinal) (ft)	
Vertical Clearance (Non-Cardinal) (ft)	

Condition Data

Deck Condition	5
Super-Structure Condition	6
Sub-Structure Condition	5

Case History Background
Interstate Highway 43 at Milwaukee Marquette Interchange
Bridge Number B – 40 – 0285 – 004C
Revision Date: 6/19/2007

The Interstate Highway 43 (I43) Bridge was located near the central part of the City of Milwaukee at the Milwaukee Marquette Interchange which connects with Interstate Highway 94 (I94). The bridge was constructed in 1968 and carried two lanes of traffic southbound from I43 through the interchange. In 2003 the average vehicular traffic level (ADT) was recorded as 56,695 vehicles per day on unit 004C. This unit was demolished in 2006 during construction of the new Marquette Interchange.

This unit of the bridge had four continuous prestressed concrete spans with a box girder configuration in each span. Spans 1 and 4 were a supporting type of length 15.0 ft and the remaining two spans (2 and 3) were each 96.0 ft. long. The total structure length was 222.0 ft. The deck width varied from 50.1 ft. to 72.5 ft. and the deck area was 13,608 sq. ft. There were three piers supporting this unit. Piers 1 and 2 were individual columns in line with 14 in. steel pilings. Pier 3 was a single column with a 12 in. cast – place concrete piling. The load ratings were HS20 for the design, HS42 for an operating load rating, and HS25 for the inventory load-rating. The bridge was designed for over 2,000,000 stress cycles and the prestressed continuous concrete box girders were manufactured to have a compressive strength of 4,000 psi. The photograph shown below gives a general view of the Marquette Interchange structure after the incident discussed in this document.

Figure 1: General View of a Portion of the Marquette Interchange Ramps.

On Friday, November 27, 1992 a gasoline truck went out of control shortly before 10:00 am while in the Marquette Interchange after exiting eastbound I94 and entering northbound I43. The truck plunged through a concrete guard wall and fell 33 ft. to a parking lot, where it burst into flames and damaged several nearby vehicles. The driver was thrown from the cab, later located, and pronounced dead at the scene. Prior to this incident several cases of minor damage had occurred because of vehicles entering the interchange at too high a speed but no major repair actions were required. In the present incident the fire resulting from the gasoline explosion resulted in heavy scaling and delamination of concrete on unit 4C and other portions of the interchange.

The incident was first reported by a 911 emergency call to the Milwaukee Fire Department at 9:54 a.m. resulting in the dispatch of a fire battalion at 9:56 a.m. and the activation of a Hazardous Material team at 10:00 a.m. The fire was contained in about 30 minutes. Personnel from the Milwaukee County Sheriff's Office arrived on the scene at 9:56 a.m. and assisted with traffic control, locating the truck driver, and questioning of witnesses. The Sheriff's Office and the Milwaukee Police Department cooperated in securing the accident site. The Milwaukee County Sheriff's Office contacted the Milwaukee County Department of Public Works (DPW) and the local Wisconsin Department of Transportation (WisDOT) regional office to obtain assistance with short term site cleanup and inspection.

A WisDOT representative, Mr. John Rapestrieter, responded to the notification and performed a detailed visual examination of the portions of the structure involved in the incident. By utilizing an available Milwaukee County DPW bucket truck he was able to verify that the fire damage was restricted to the outermost surfaces and that the deeper portions of the nearby columns and box girders were still intact. Some loose concrete was knocked off elevated surfaces but it was decided to reopen the interchange as soon as the possibility of further fires or explosions was eliminated. Arrangements were made to have a detailed inspection of the damaged structures performed on Monday, November 30, 1992.

Upon arrival at the accident scene the Milwaukee County Sheriff's Office diverted traffic from I-94 and I-43 onto other county and city roadways. After extinguishing the fire, removing the residual gasoline, and locating the remains of the truck driver, the roadways and interchange ramps were reopened. Traffic restrictions were enforced for approximately four hours. Further intermittent ramp closures were enforced over a period of two weeks in order to complete inspections and remove or replace damaged guard rails and signage.

The inspection was performed by the WisDOT region Bridge Maintenance and Inspection Specialist, Mr. Herb Szatmary. His summary report (issued on December 10, 1992) indicated damage to several units of the Marquette Interchange, especially units 4B, 4C, 4E, and 5D. On unit 5D the east pier shaft suffered heavy scaling with delamination to a depth of 2 – 3.5 in. over an area of approximately 160 sq. ft. (See Fig. 2).

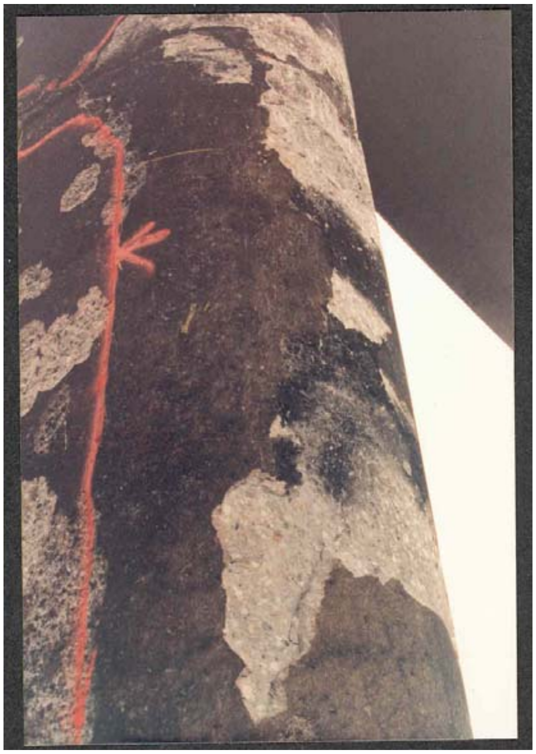


Figure 2: Unit 5D Column with Scaling and Delamination.

The east column of the south pier of unit 4C suffered similar damage (See Fig. 3).

Figure 3: Unit 4C Column with Scaling and Delamination.

On units 4B, 4C, and 4E some of the edges of the bottom floor of the concrete box girders were spalled during the fire. Other edges were cracked and knocked off during the inspection. Similar damage was observed on the edges at the expansion joint openings, the bottom edges of the deck overlays, and some edges in the exterior face of the parapets. In general, little or no delamination from the reinforcing steel occurred in these areas. The following figure shows an example of edge damage for units 4B and 4C.

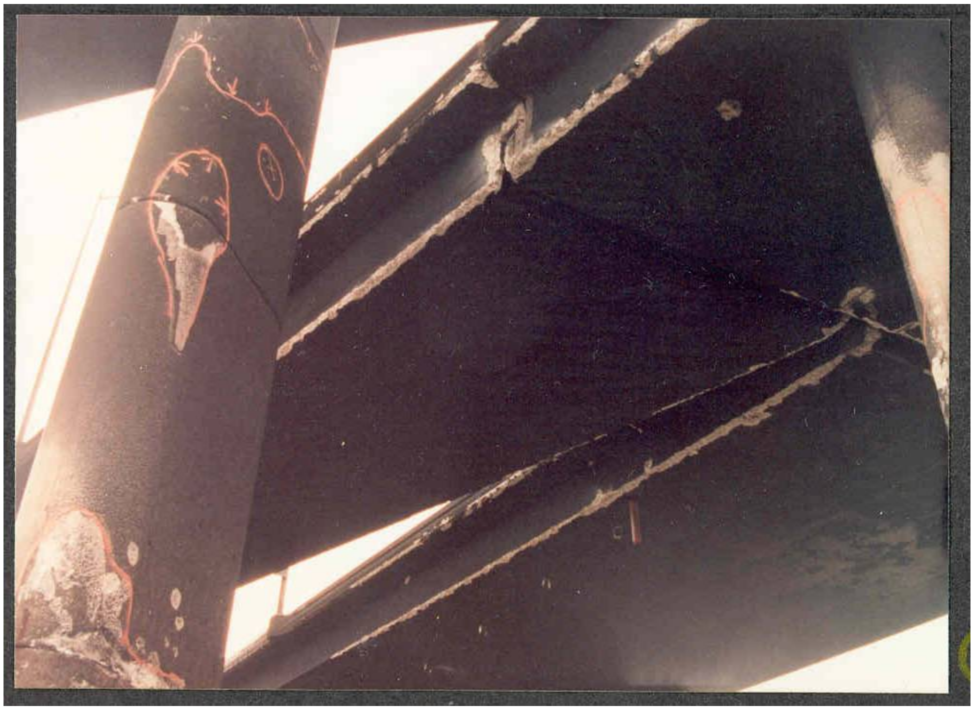


Figure 4: Units 4B and 4C Box Girders with Scaling.

In addition to the visual inspection, five cores were drilled for the purpose of material parameter analysis. Two cores were obtained from the underside of box girders in units 4C and 4B and tested at American Petrographic Services, Inc. located in St. Paul, MN. The petrographic analysis and air content test results indicated that the damage to the box girders was mainly cosmetic and that no structural repairs were necessary. Three further cores were taken from piers and pier columns on units 4C and 5D. The compressive strength of the concrete in all three cores was in the normal range for ultimate strength.

The relatively mild damage incurred at the time of this incident allowed for unrestricted use of the affected units with a minimal repair effort. The repair operation focused on removing loose concrete and replacing fixtures such as guard rails and signage that were struck by the truck or exposed to fire and smoke. The columns which showed evidence of significant spalling were treated to remove all delaminated material down to sound concrete and then encased with fresh concrete to cover the reinforcing steel to acceptable depths. These efforts were successfully completed early in 1993 and the bridge retained its original load ratings until demolition of the structure was initiated in 2006.

KEYWORDS: fire, box girder, concrete, spalls, exposed rebar, cracked edges.

Bridge Incident Response Data (BIRD)
Bridge Information Report: Bridge Number B-40-0285
Generated 4/9/2007

Basic Bridge Information

Structure Name	Marquette Int. Unit 4C
Year Built	1968
Municipality	City-Milwaukee
Section	29
Town	07N
State	WI
Range	22E
Maintenance Agency	State Highway Dept
Owner	State Highway Dept
Replaced Structure Number	
Historical Significance	5
Latitude	430212.0
Longitude	875530.0
County	Milwaukee(40)
District	2

Bridge Geometric Data

Structure Length (ft)	222.0
Number Lanes On	2
Left Sidewalk Width (ft)	0.0
Right Sidewalk Width (ft)	0.0
Median Type	
Median Width (ft)	0.0
Skew Angle (Deg)	0.0
Direction Skew Angle	0.0
Horizontal Curve Radius (ft)	636.62
Direction Horizontal Curve	Right
Girder Spacing (ft)	5.5
Height (ft)	
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Other
Pile Type	Other
Pile Size (in)	
Slope Protection Type	
Roadway width (ft)	45.1
Deck Width (ft)	50.1
Wing Type	

Abutment Data (Non Cardinal)

Abutment Type	Other
Pile Type	Other
Pile Size (in)	
Slope Protection Type	
Roadway width (ft)	67.5
Deck Width (ft)	72.5
Wing Type	

Bridge Capacity

Design MS	HS20
Inventory MS	HS25
Operating MS	HS42
Maximum Vehicle Weight (kips)	190
Load Governing Member	SLAB
Deck Composition	NONE
Deck Membrane	NONE
Deck Surface	LOW SLUMP CONCRETE

Bridge Construction

Beam/Girder Material	Concrete
Beam/Girder Type	Precast
Span Type	Continuous
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Steel

Planning Data

Functional Classification	Interstate - Urban (11)
ADT	56695
ADT Year	2003
Truck ADT (%)	1
Future ADT	71310
Future ADT Year	2023

Hydraulic Data

Design Flood Frequency (yrs)	
Design Discharge (cu-ft/s)	
Maximum Velocity (ft/s)	
Drainage Area (sq. ft)	
High Water Elevation (ft)	
Scour Critical Code	
Scour Calculated	

Service Data

Type Service On	2ND Level INTRCH
Type Service Under	Highway

Clearance Data

Vertical Clearance (Cardinal) (ft)	14.92
Vertical Clearance (Non-Cardinal) (ft)	14.92

Condition Data

Deck Condition	5
Super-Structure Condition	5
Sub-Structure Condition	7

Case History Background
U.S. Interstate Highway I-43 116th Street Bridge
Bridge Number B – 40 – 0377
Revision Date: 6/19/2007

The 116th Street Bridge is located on the western boundary of the City of Milwaukee and spans U.S. Interstate Highway I-43. The bridge was constructed in 1967 and carries two lanes of traffic over four lanes of I-43. The average vehicular traffic level was recorded as 49,090 vehicles per day in 2003.

The bridge has two continuous prestressed concrete spans (six girders in each span) each with a length of 82.5 ft. and a total structure length of 165.5 ft. The deck width is 50 ft and the deck area is 8276 sq. ft. It has sill flexible abutments with treated timber piling of size 12 inches and a round column bent type pier with no piling. Load ratings are specified as HS20 for the design, HS43 for an operating load rating, and HS21 for the inventory load rating. The bridge was designed for over 2,000,000 stress cycles and the prestressed concrete girders were manufactured to have a compressive strength of 5,000 psi.

From the date of construction till October of 2003 this bridge had suffered ten impacts: six by vehicles traveling in the northbound lanes and four in the southbound lanes. Detailed damage reports are not available but information provided by the maintenance engineers at the Wisconsin Department of Transportation (WisDOT) regional office indicated the presence of spalls and broken strands, cracking, and complete pre-cast girder replacement.

On Sunday, October 12, 2003 the 116th Street Bridge was struck by a piece of construction equipment loaded on a flatbed semi truck trailer. The truck was traveling in the northbound lanes of Interstate Highway I-43. In the present incident, the west fascia girder, line 1, sustained damage to the portion of the web and bottom flange located over the northbound lanes of I-43. Furthermore, five concrete reinforcement rods were exposed and three were severed. The east fascia girder, line 6, was also damaged, with an 18”x3” deep spall in the bottom flange resulting in two exposed reinforcement rods.

The incident occurred at approximately 4:00 p.m. and was first investigated by a City of Milwaukee police officer. Because of the extent of heavy damage, the police officer reported the incident to the Southeast Region offices of WisDOT located in Waukesha, Wisconsin. The call was forwarded to the district’s Bridge Maintenance and Inspection Specialist, Herb Szatmary. Mr. Szatmary immediately visited the site and prepared a preliminary evaluation of the damage. On Monday, October 13, 2003, Mr. Szatmary, revisited the site and prepared an inspection report. At this time, debris from the collision was removed and the shoulder of the southbound lane on 116th Street was closed. The inspection report was filed with the central WisDOT office in Madison, Wisconsin.

Prior to the initiation of the repairs to the bridge, there were no alternate traffic routings specified for either I-43 or 116th Street traffic. While repairs were underway, traffic control on northbound I-43 consisted of single lane closures on Monday through Thursday between the hours of 9:30 a.m. to 2:30 p.m., on Friday from 9:30 a.m. to 1:00 p.m., and 10:00 p.m. to 10:00 a.m. on Saturday. For removal and replacement of the prestressed concrete girder the northbound lanes of I-43 were completely closed on a Friday at 10:00 p.m. until the following Saturday at 10:00 a.m. and then at 10:00 p.m. Saturday to 10:00 a.m. on Sunday morning. During these times, the northbound I-43 detour route consisted of exiting at Layton Avenue, proceeding on Layton to Highway 100, then south on Highway 100 to the I-43 interchange, and re-entering I-43.

The damage to the 116th Street Bridge required the removal and replacement of the west fascia girder as well as several subsidiary tasks. The work on the girder could not be accomplished using Milwaukee County resources, which led to a request for quotation being sent to four bridge construction firms in Wisconsin. Three firms submitted bids, which were opened on Thursday, August 26, 2004 at the Southeast Region WisDOT offices. The winning bid was submitted by Zenith Tech, Inc., with a quote of $82,390. An agreement to complete the work was prepared on September 20, 2004, and was approved by the governor of Wisconsin on September 29, 2004. The repairs were successfully completed on November 18, 2004 and payment was approved on December 8, 2004. No restrictions have been implemented and the bridge retains its original load ratings.

KEYWORDS: impact, girder, concrete, spalls, exposed strands, cracking, broken strands.

Bridge Incident Response Data (BIRD)
Bridge Information Report: Bridge Number B-40-0377
Generated 1/26/2007

Basic Bridge Information

Structure Name	
Year Built	1967
Municipality	City - Greenfield (40236)
Section	30
Town	06N
State	WI
Range	21E
Maintenance Agency	State Highway Dept
Owner	State Highway Dept
Replaced Structure Number	
Historical Significance	5
Latitude	425730.0
Longitude	880330.0
County	Milwaukee (40)
District	2

Bridge Geometric Data

Structure Length (ft)	165.5
Number Lanes On	2
Left Sidewalk Width (ft)	7.0
Right Sidewalk Width (ft)	7.0
Median Type	
Median Width (ft)	
Skew Angle (Deg)	
Direction Skew Angle	
Horizontal Curve Radius (ft)	
Direction Horizontal Curve	
Girder Spacing (ft)	7.8
Height (ft)	45.0
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Sill Flexible
Pile Type	Treated Timber
Pile Size (in)	12
Slope Protection Type	Solid Concrete
Roadway width (ft)	36.0
Deck Width (ft)	50.0
Wing Type	Parallel to Roadway

Abutment Data (Non Cardinal)

Abutment Type	Sill Flexible
Pile Type	Treated Timber
Pile Size (in)	12
Slope Protection Type	Solid Concrete
Roadway width (ft)	36.0
Deck Width (ft)	50.0
Wing Type	Parallel to Roadway

Bridge Capacity

Design MS	H20
Inventory MS	HS21
Operating MS	HS43
Maximum Vehicle Weight (kips)	250
Load Governing Member	Deck Girder
Deck Composition	NONE
Deck Membrane	
Deck Surface	Low Slump Concrete

Bridge Construction

Beam/Girder Material	Continuous Prestressed Concrete
Beam/Girder Type	Other
Span Type	Other
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Other

Planning Data

Functional Classification	Collector - Urban (17)
ADT	3100
ADT Year	2002
Truck ADT (%)	0
Future ADT	0
Future ADT Year	0

Hydraulic Data

Design Flood Frequency (yrs)	
Design Discharge (cu-ft/s)	
Maximum Velocity (ft/s)	
Drainage Area (sq. ft)	
High Water Elevation (ft)	
Scour Critical Code	
Scour Calculated	

Service Data

Type Service On	Highway Pedestrian
Type Service Under	Highway

Clearance Data

Vertical Clearance (Cardinal) (ft)	14.63
Vertical Clearance (Non-Cardinal) (ft)	14.63

Condition Data

Deck Condition	5
Super-Structure Condition	3
Sub-Structure Condition	5

Case History Background
Menomonee River – North 25th Street Bridge
Bridge Number P – 40 – 0654
Revision Date: 6/18/2007

The 25th Street Bridge is located in the north central portion of the City of Milwaukee and spans the Menomonee River. The bridge was constructed in 1980 and carries two lanes of traffic over the river. The average vehicular traffic level was recorded as 12,400 vehicles per day in 2000.

The bridge has two continuous steel girder spans (five girders in each span), each of a length of 120 ft. and a total length of 242.1 ft. The deck width is 38.5 ft. and the deck area is 9,320 sq. ft. It has full retaining abutments with a steel piling of 12 inch diameter, a concrete hammerhead type pier, and a T-305A expansion joint. Load ratings are specified as HS20 for the design, HS44 for an operational load rating, and HS27 for the inventory load rating. The bridge was designed for over 2,000,000 stress cycles and the girders were manufactured with ASTM A-588 (AASHTO Grade 50W) structural carbon steel.

On Monday, June 17, 1996, the 25th Street Bridge was struck by equipment loaded on a river barge. The barge had been moored on the river but broke its lines during a period of heavy rainfall which raised the river height and increased the river current velocity. Prior to this date, there was no serious damage to the bridge reported. In the present incident the easternmost girder of the south span was struck by the barge. (See Figure 1.) The impact resulted in a deflection of 3.25 inches of the bottom flange of the plate girder. (See Figure 2.) Also, the stiffener at the intermediate diaphragm failed at its connection to the bottom horizontal angle, and the bolt hole in the bottom horizontal angle was elongated where the angle connects to the stiffener. Some minor damage to a concrete pier was sustained.

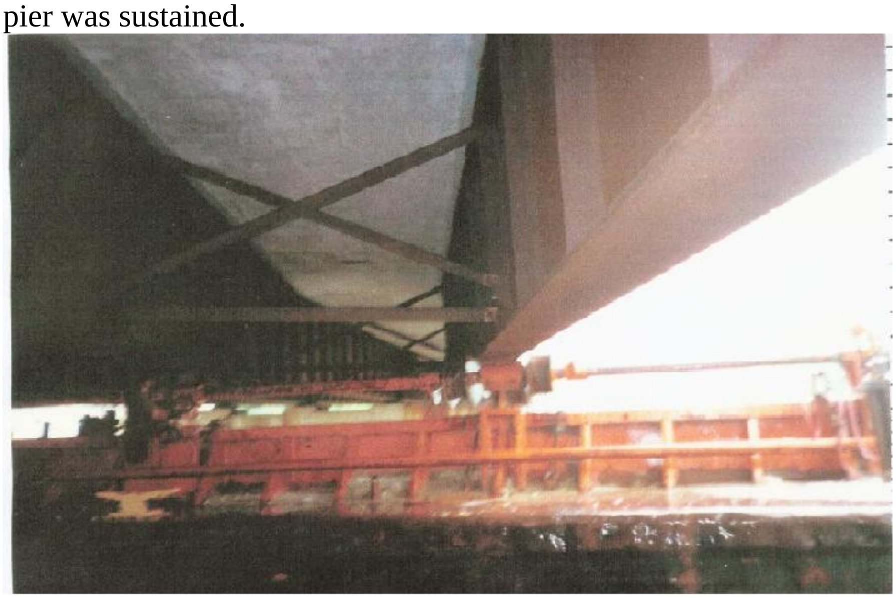


Figure 1: Equipment on Barge Impacted Easternmost Girder of South Span.

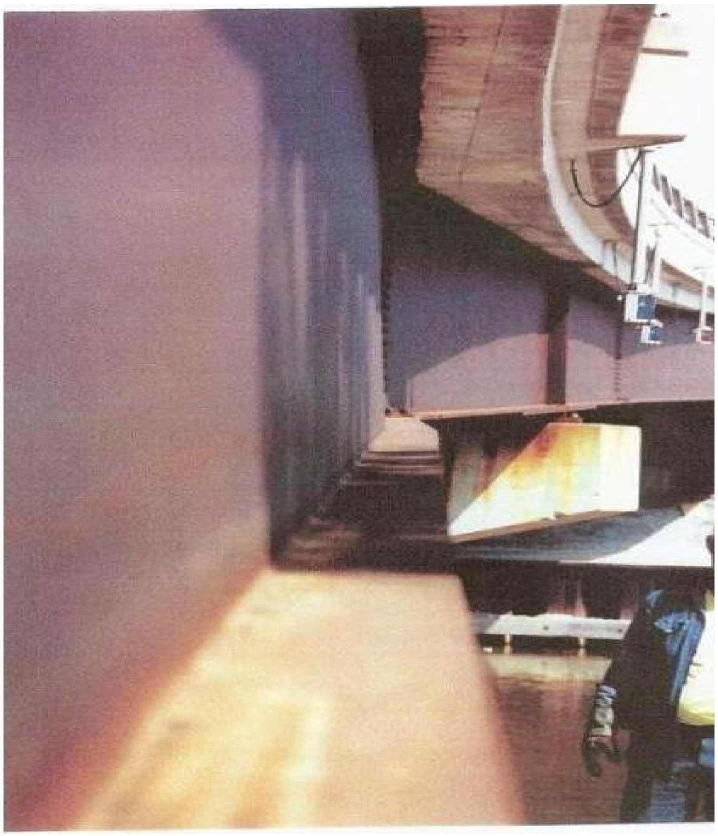


Figure 2: Looking North along Easternmost Girder: Max Deflection.

The incident was first investigated by a City of Milwaukee police officer. The officer notified the emergency call center at the City of Milwaukee City Hall who then contacted the Bridge Maintenance group in the Department of Public Works. This office forwarded the call to the Bridge Maintenance Manager, Jeff Dellemann. Mr. Dellemann visited the site, made a preliminary evaluation of the damage, and requested that the bridge be closed until an inspection could be completed. All traffic was diverted to other city roadways. On Tuesday, June 18, 1996, an inspector from the Bridge Design Section visited the site and prepared an inspection report. At this time, the bridge was reopened to traffic. The inspection report was filed with the central Wisconsin Department of Transportation (WisDOT) office in Madison, Wisconsin.

The repairs to the 25th Street Bridge were performed by personnel from the Bridge Maintenance group. There was no need to reroute vehicular traffic on 25th Street or water transport on the Menomonee River while repairs were underway. The steel girder deflection was removed by means of a heat straightening process performed by WisDOT personnel, a defective expansion joint was repaired, and several other miscellaneous repairs were performed. The repairs were successfully completed and the bridge retains all of its original load ratings.

KEYWORDS: impact, girder, steel, deflection, stiffener, heat straighten.

Integrated Bridge Failure Response System
Bridge Information Report: Bridge Number P-40-0654
Generated 12/27/2006

Basic Bridge Information

Structure Name	
Year Built	1980
Municipality	City - Milwaukee (40251)
Section	30
Town	07N
State	WI
Range	22E
Maintenance Agency	CITY
Owner	CITY
Replaced Structure Number	
Historical Significance	5
Latitude	0.0
Longitude	0.0
County	Milwaukee (40)
District	2

Bridge Geometric Data

Structure Length (ft)	242.1
Number Lanes On	2
Left Sidewalk Width (ft)	0
Right Sidewalk Width (ft)	7
Median Type	
Median Width (ft)	
Skew Angle (Deg)	11
Direction Skew Angle	Left
Horizontal Curve Radius (ft)	848.83
Direction Horizontal Curve	Right
Girder Spacing (ft)	8.5
Height (ft)	
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Full Retaining
Pile Type	Steel
Pile Size (in)	12
Slope Protection Type	Stab CR Stone
Roadway width (ft)	30
Deck Width (ft)	38.5
Wing Type	

Abutment Data (Non Cardinal)

Abutment Type	Other
Pile Type	Steel
Pile Size (in)	12
Slope Protection Type	Stab CR Stone
Roadway width (ft)	30
Deck Width (ft)	38.5
Wing Type	

Bridge Capacity

Design MS	HS20
Inventory MS	HS27
Operating MS	HS44
Maximum Vehicle Weight (kips)	
Load Governing Member	Deck Girder
Deck Composition	none
Deck Membrane	
Deck Surface	Concrete

Bridge Construction

Beam / Girder Material	Continuous Steel
Beam / Girder Type	Other
Span Type	Continuous
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Steel

Planning Data

Functional Classification	Local-Urban (19)
ADT	12400
ADT Year	2000
Truck ADT (%)	0
Future ADT	0
Future ADT Year	0

Hydraulic Data

Design Flood Frequency (yrs)	
Design Discharge (cu-ft/s)	
Maximum Velocity (ft/s)	
Drainage Area (sq. ft)	
High Water Elevation (ft)	
Scour Critical Code	8
Scour Calculated	

Service Data

Type Service On	HWY. Pedestrian
Type Service Under	Waterway

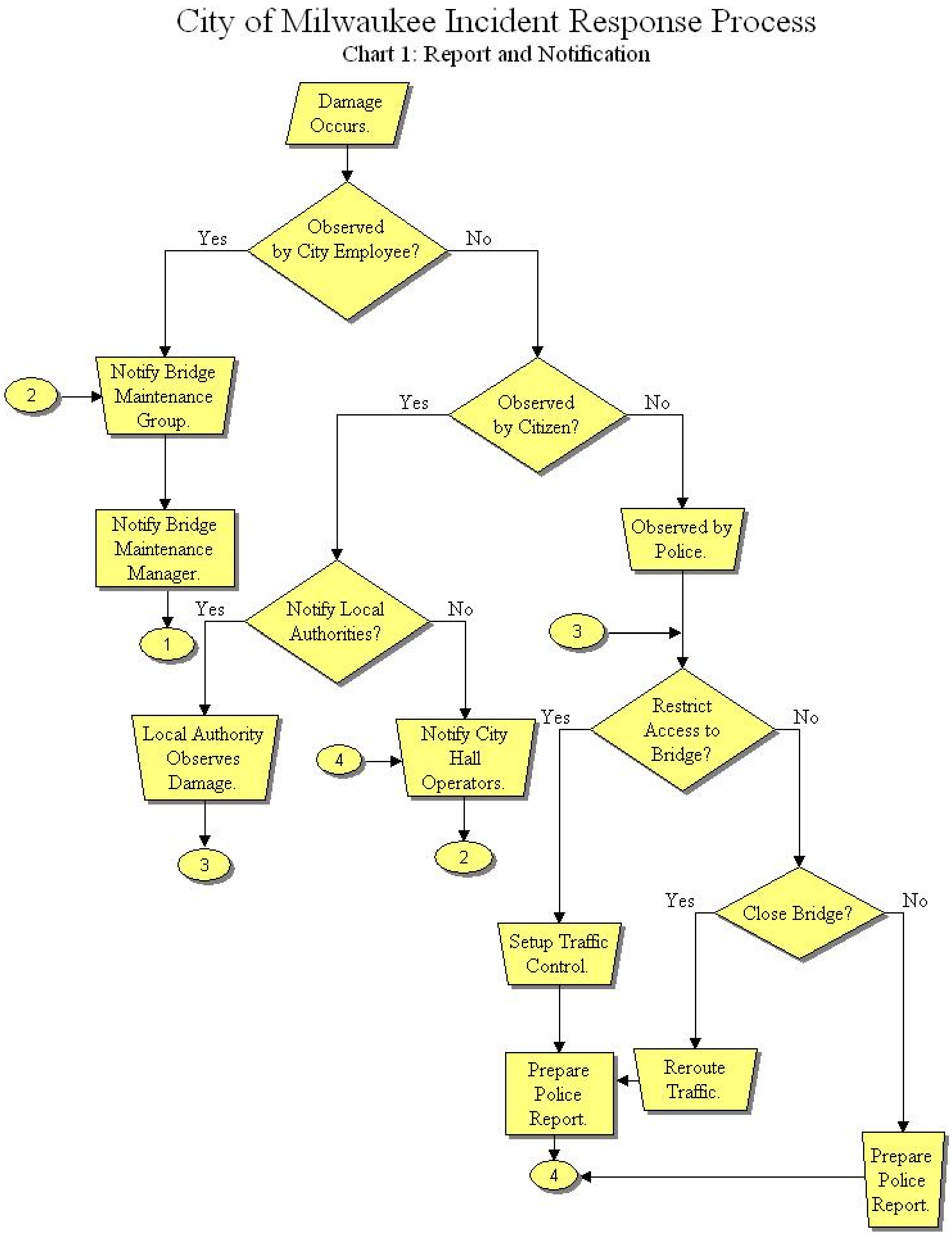
Clearance Data

Vertical Clearance (Cardinal) (ft)	
Vertical Clearance (Non-Cardinal) (ft)	

Condition Data

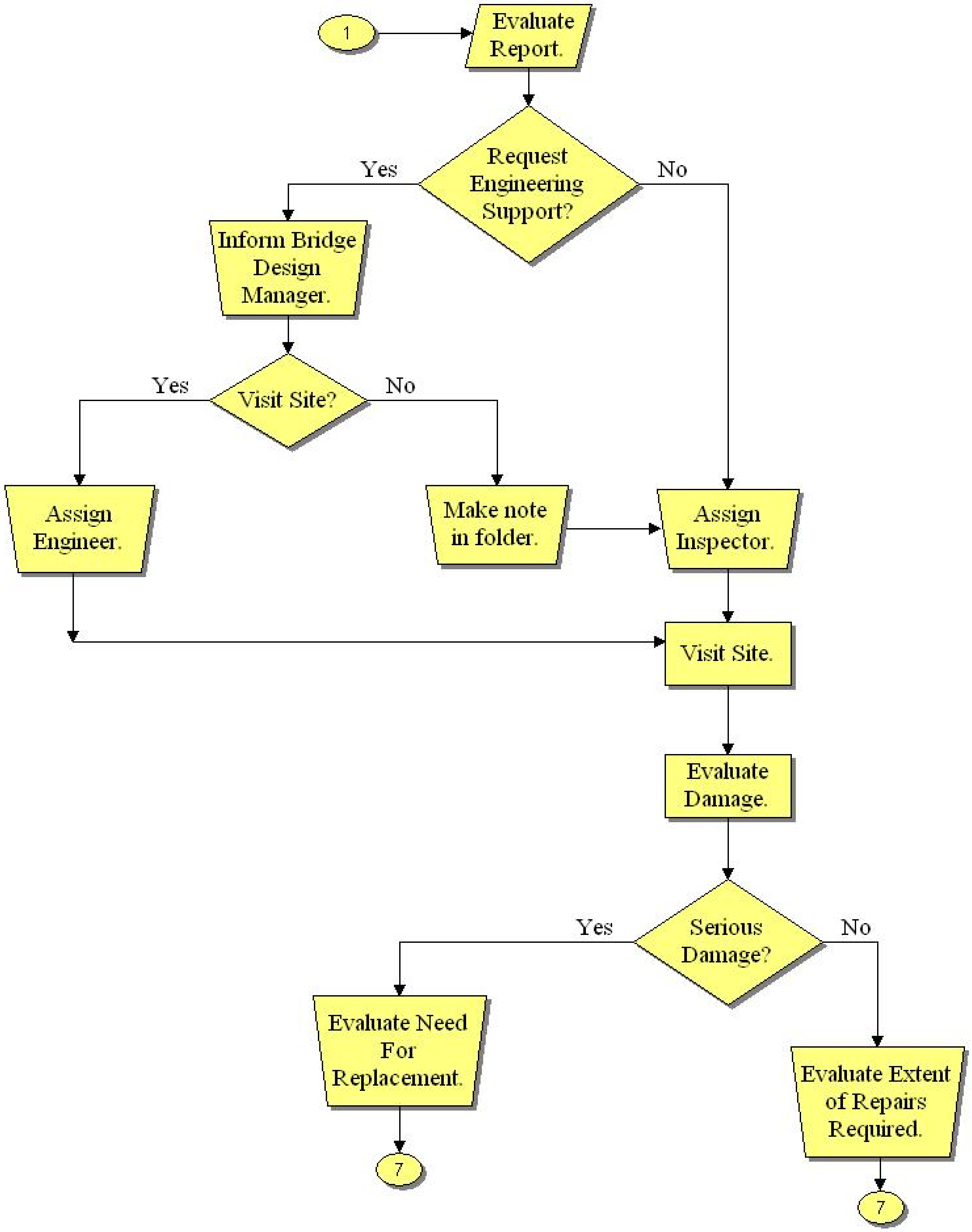
Deck Condition	5
SuperStructure Condition	7
Sub-Structure Condition	6

Appendix 7.1.2: Process Flow Diagram – City of Milwaukee



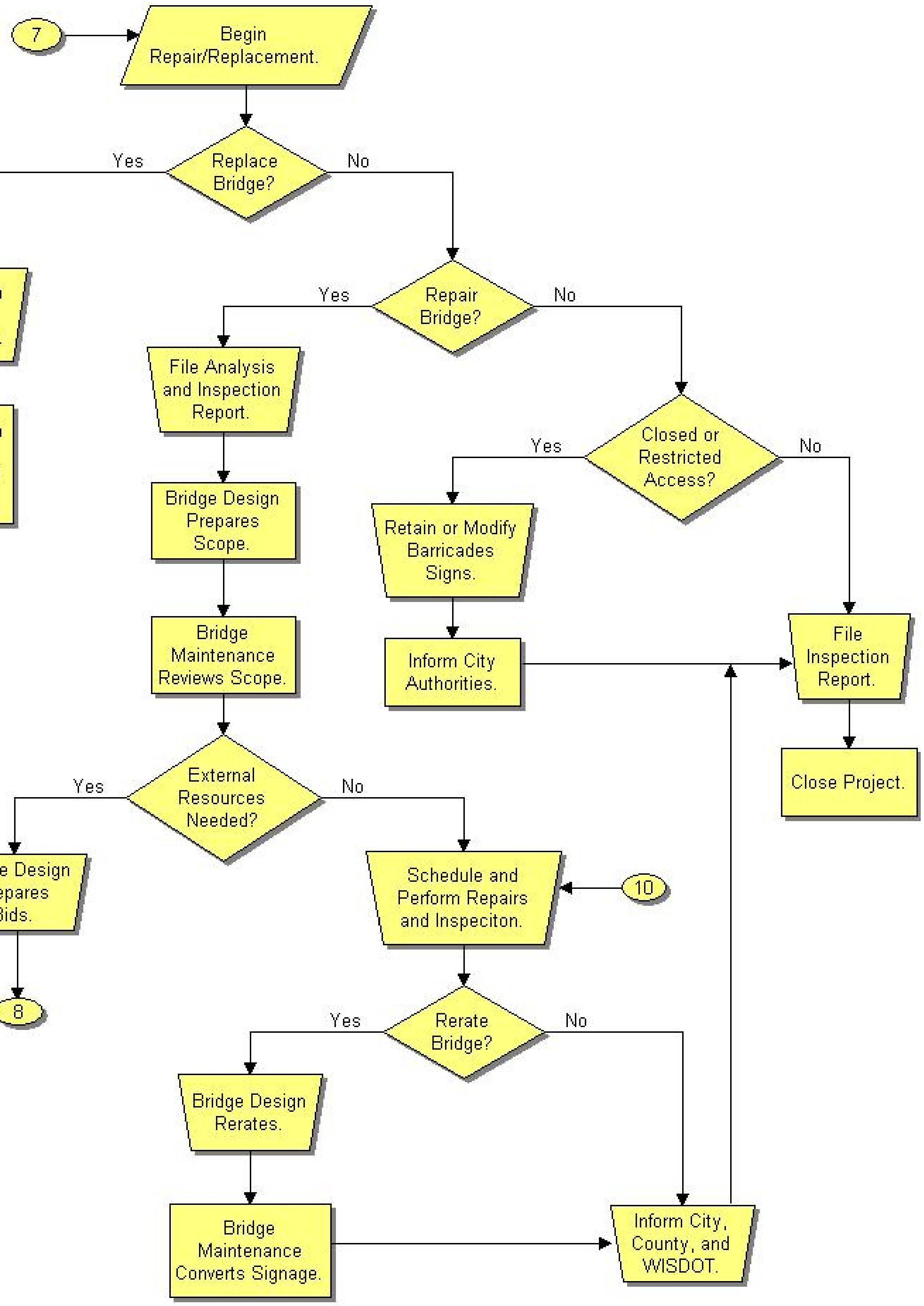
City of Milwaukee Incident Response Process

Chart 2: Damage Evaluation



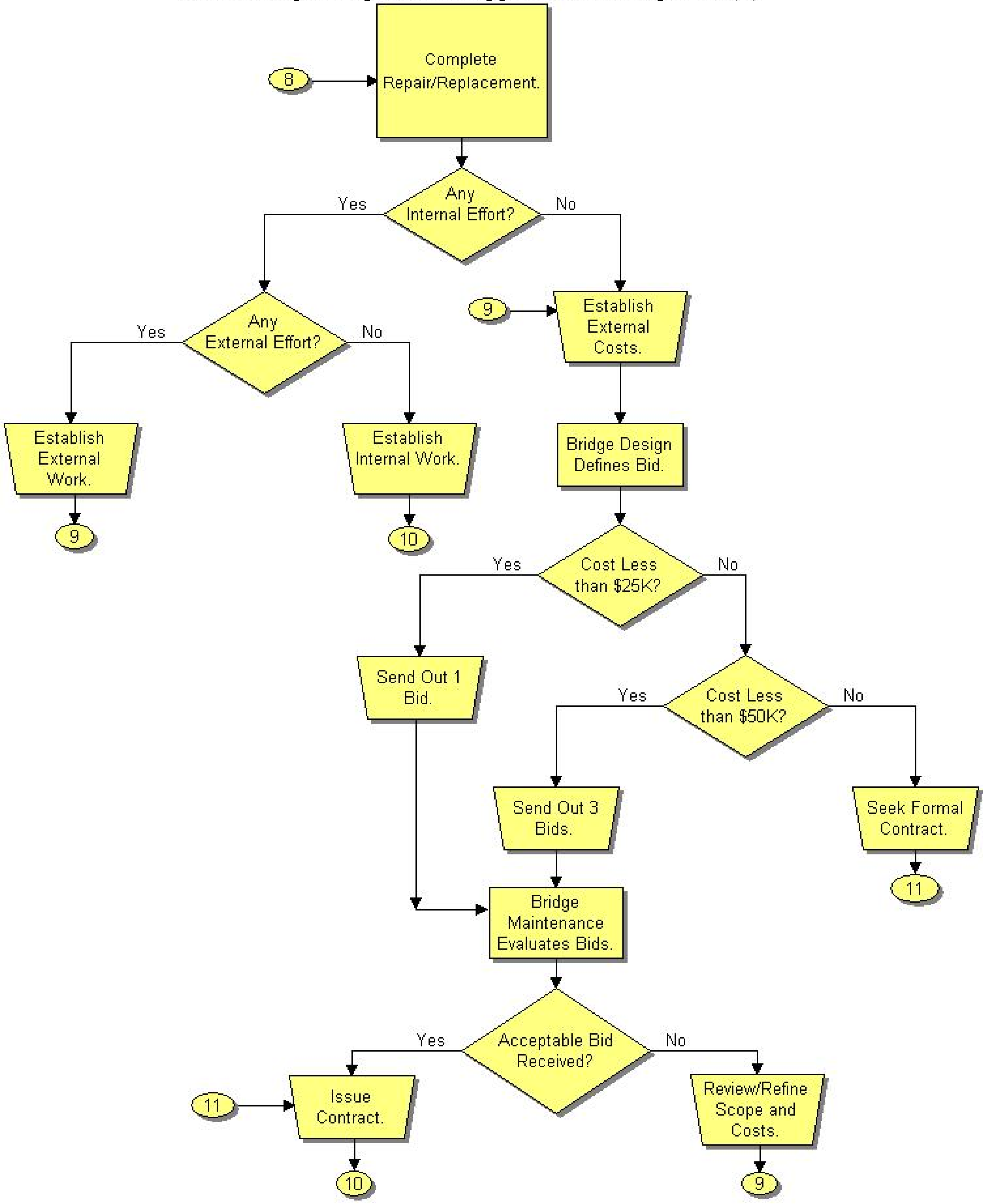
City of Milwaukee Incident Response Process

Chart 3: Repair/Replacement Approval and Completion (I)

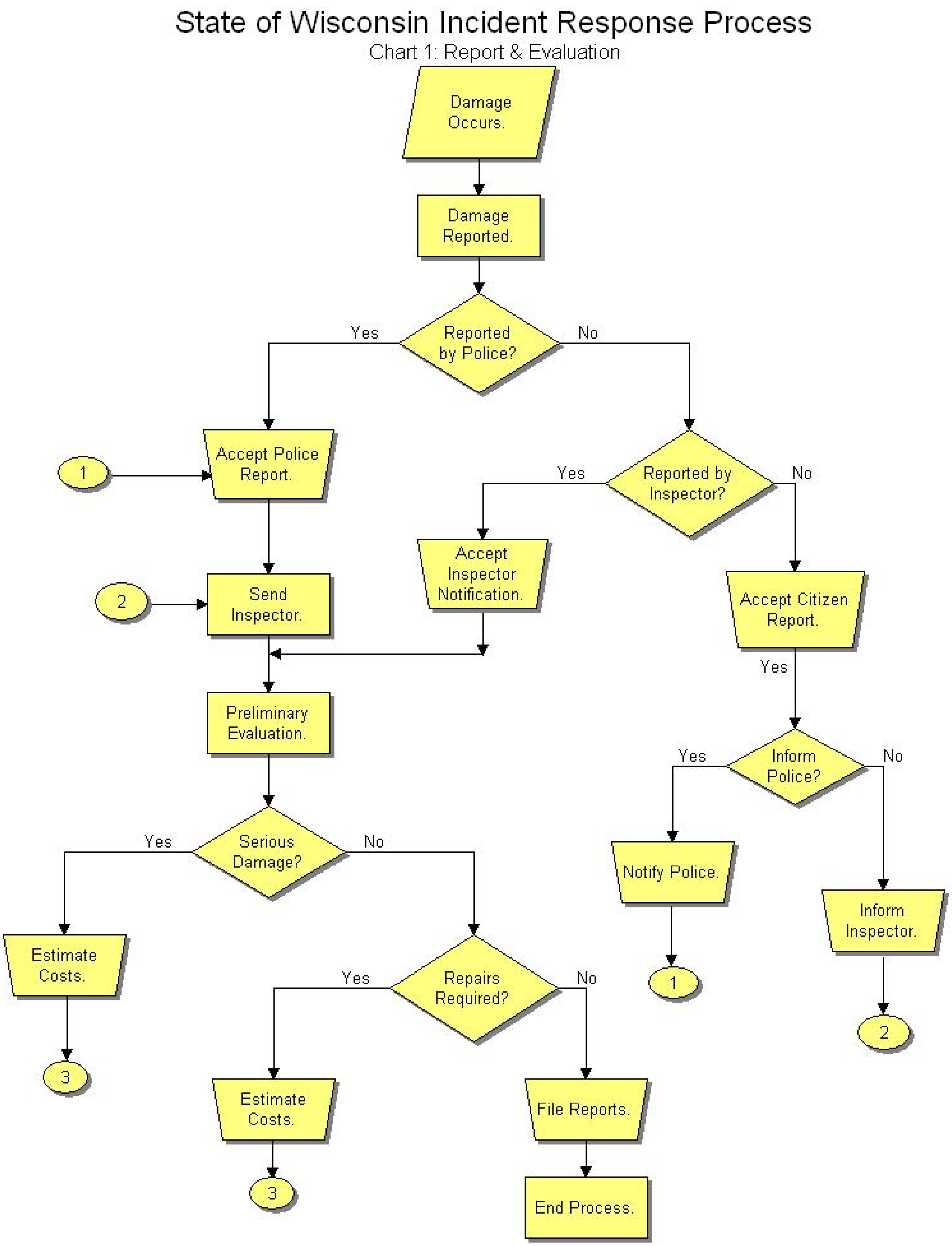


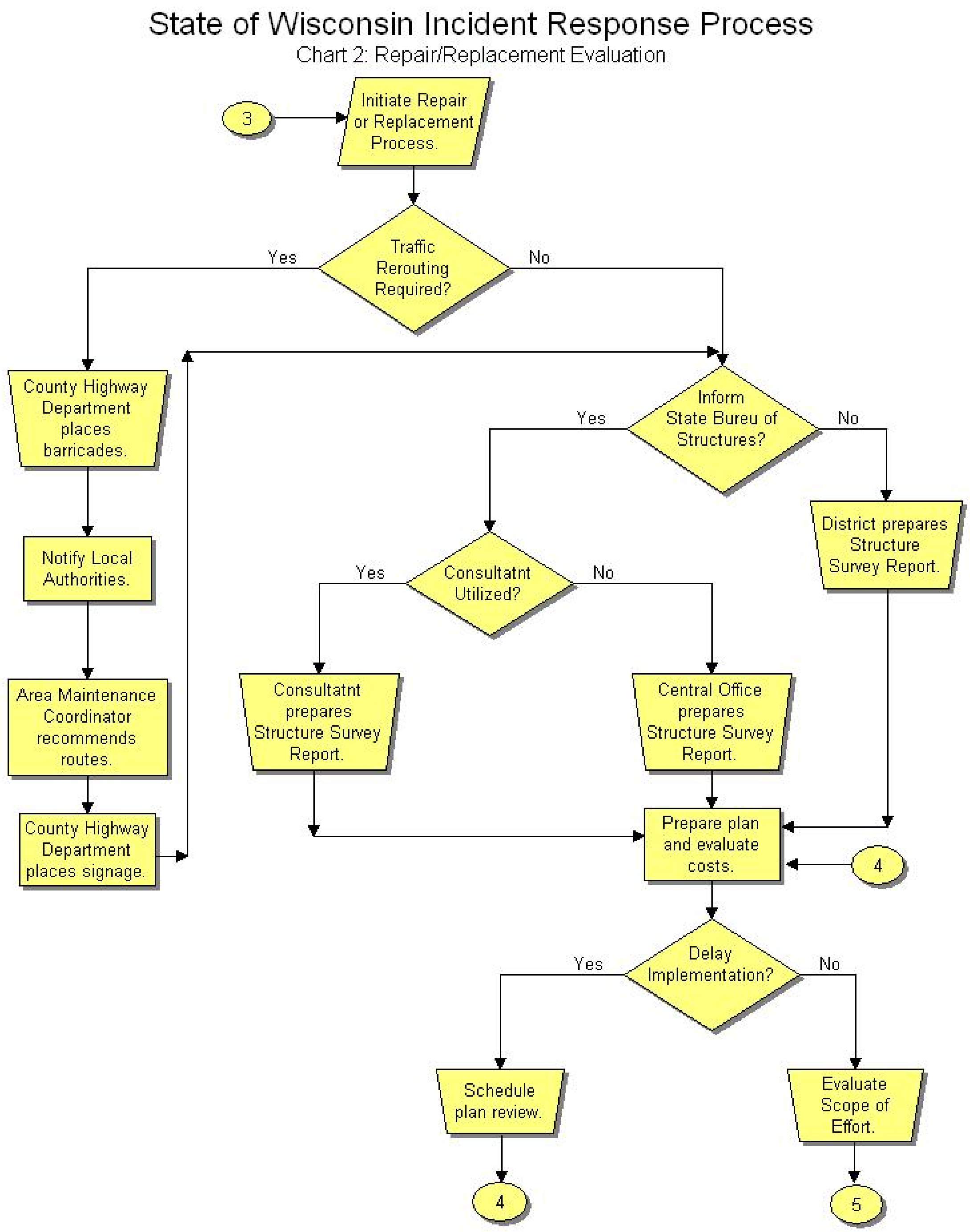
City of Milwaukee Incident Response Process

Chart 4: Repair/Replacement Approval and Completion (II)



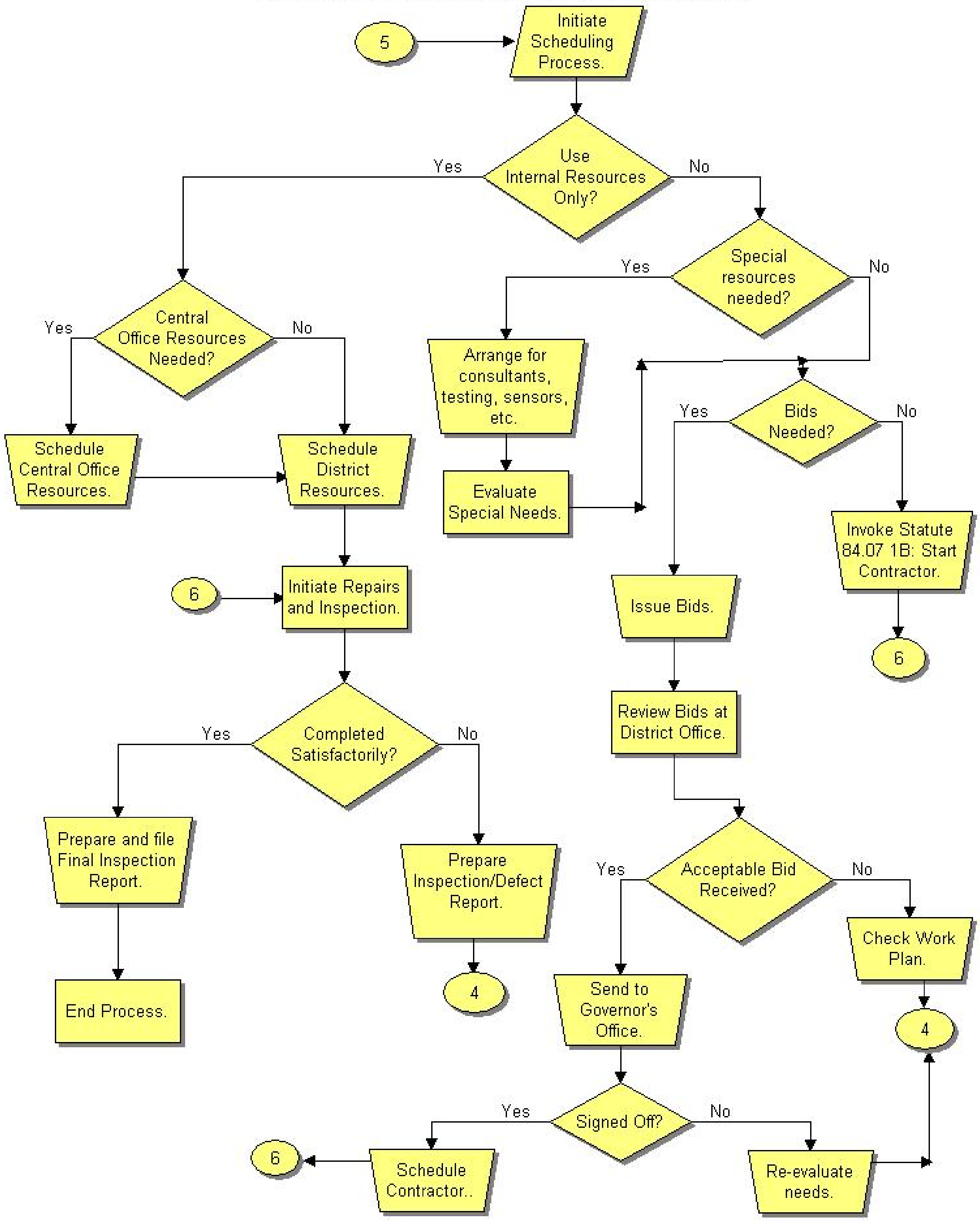
Appendix 7.1.2: Process Flow Diagram – State of Wisconsin




State of Wisconsin Incident Response Process
Chart 2: Repair/Replacement Evaluation
3
Initiate Repair or Replacement Process.
Traffic Rerouting Required?
Yes
No
County Highway Department places barricades.
Notify Local Authorities.
Area Maintenance Coordinator recommends routes.
County Highway Department places signage.
Inform State Bureu of Structures?
Yes
No
District prepares Structure Survey Report.
Consultatnt Utilized?
Yes
No
Consultatnt prepares Structure Survey Report.
Central Office prepares Structure Survey Report.
Prepare plan and evaluate costs.
4
Delay Implementation?
Yes
No
Schedule plan review.
Evaluate Scope of Effort.
4
5

State of Wisconsin Incident Response Process

Chart 3: Repair/Replacement Approval and Completion



Appendix 7.2:

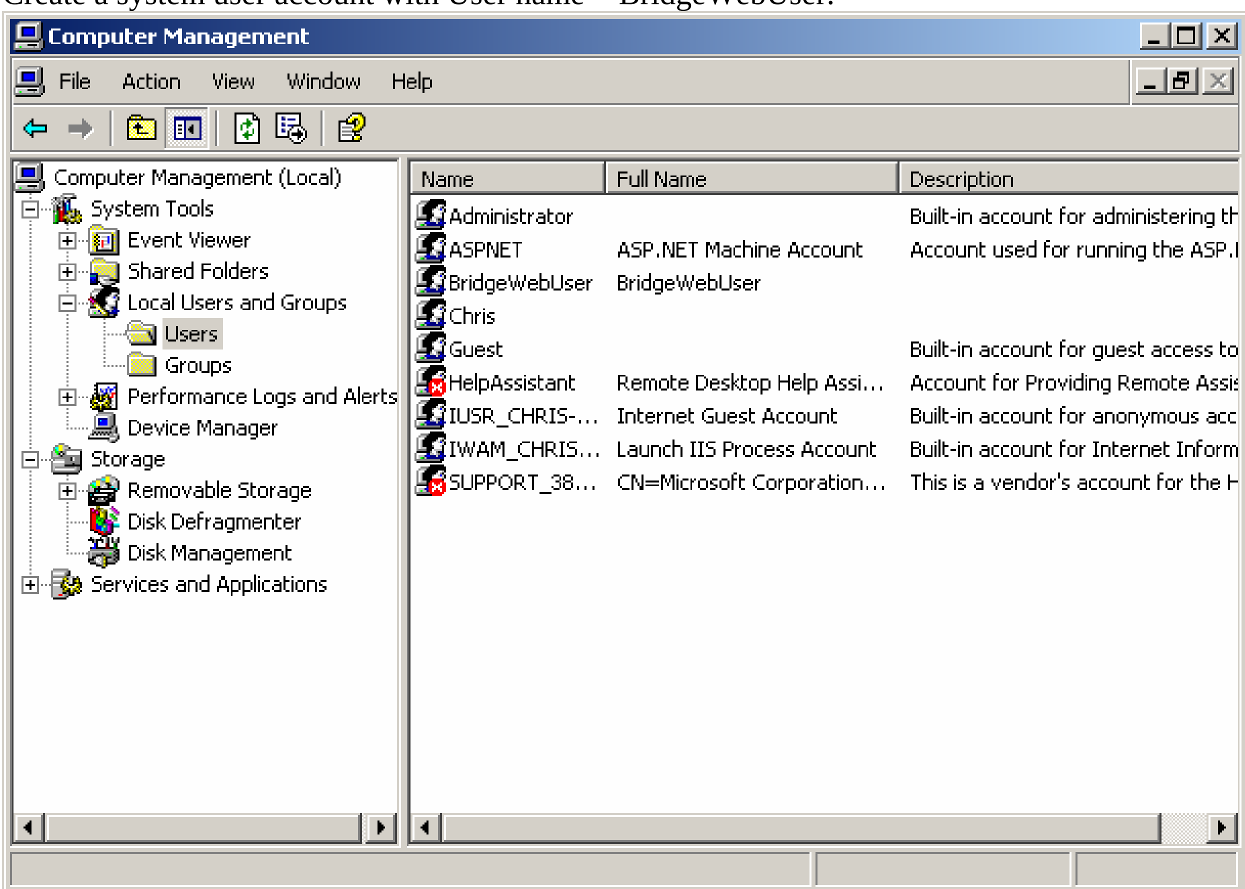
1.0 BIRD Web & SQL Server Installation Manual

1.1 *Web Server Installation Process*

1. Install Internet Information Services (IIS) on the computer.
2. Install Microsoft .NET Framework 2.0
3. Install Microsoft Office 2003
4. Install Microsoft Office 2003 Primary Interop Assembly

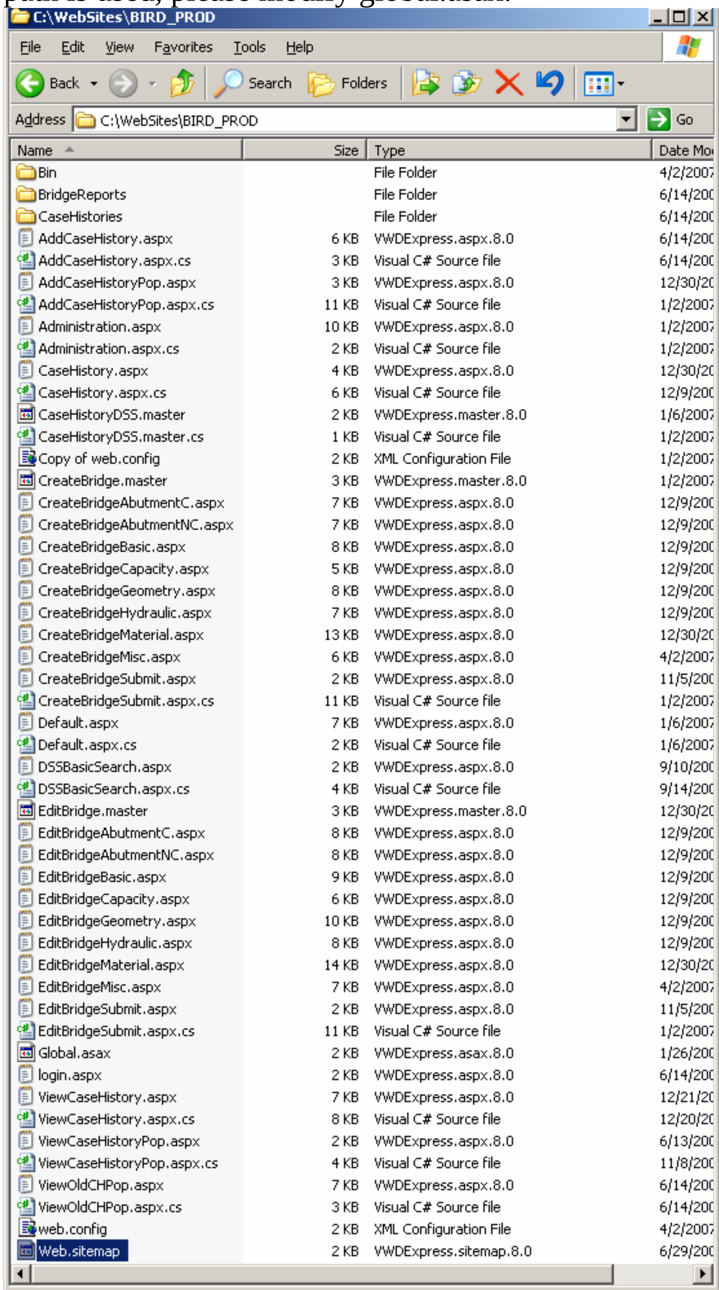
The website files should be placed on the web server. The default location is C:\WebSites\BIRD_PROD this is a website root directory. The path to the root directory may be different, but the adjustments will have to be made to the location of the subsequent components. There is also a default user account that has access privileges to the SQL Server and Directories within the website root. The account name is BridgeWebUser. If a different account is being used, then changes must be made to Web.config, IIS and Users of the BIRD_PROD database.

1. Create a system user account with User name = BridgeWebUser.

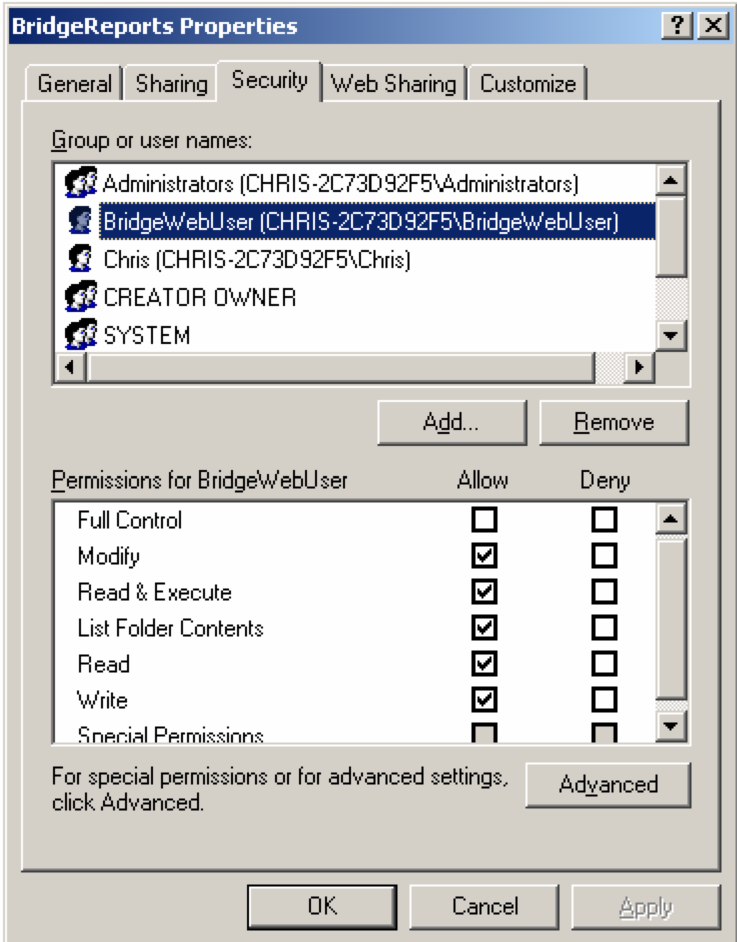


2. Set a password. This password has to be set in the web.config

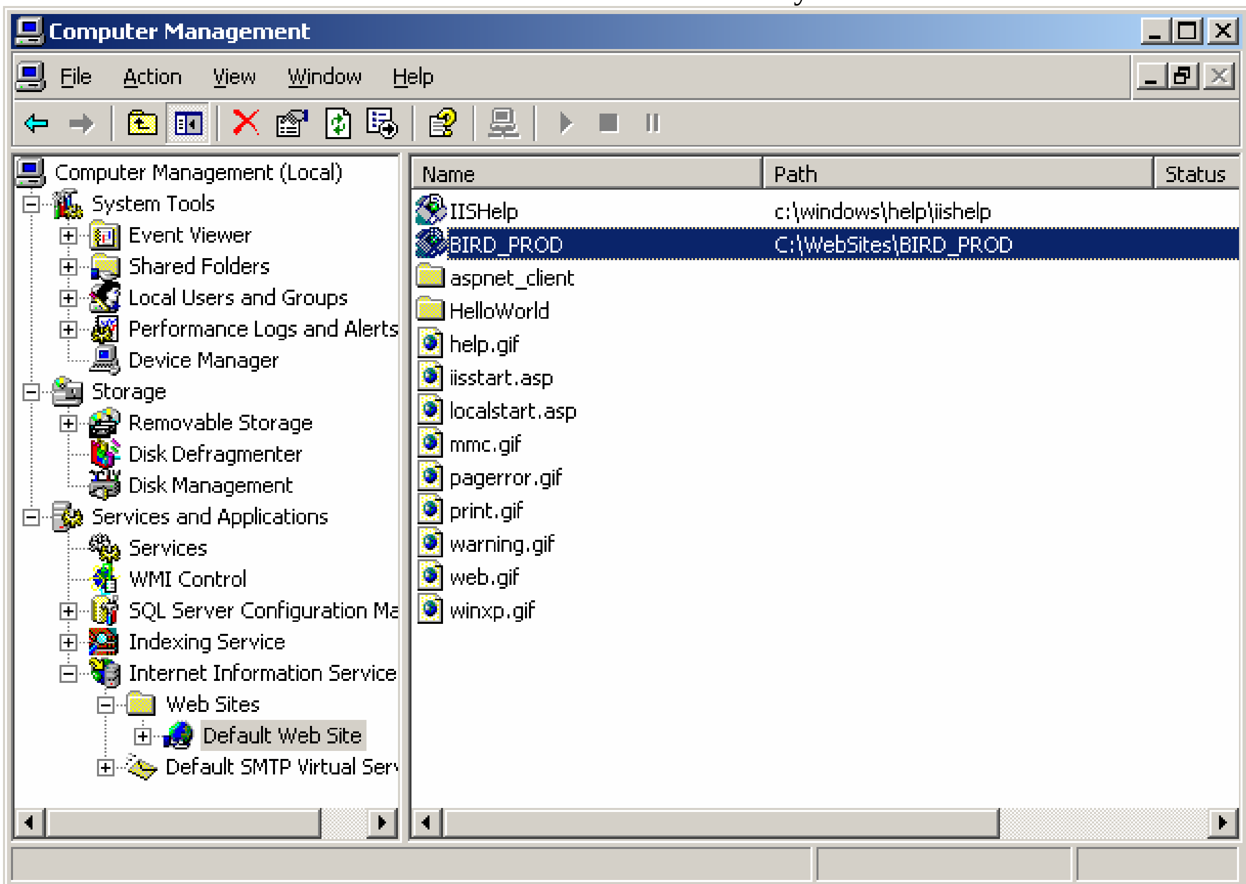
3. Copy files from BIRD PROD FILES.rar to C:\WebSites\BIRD_PROD If different path is used, please modify global.asax.



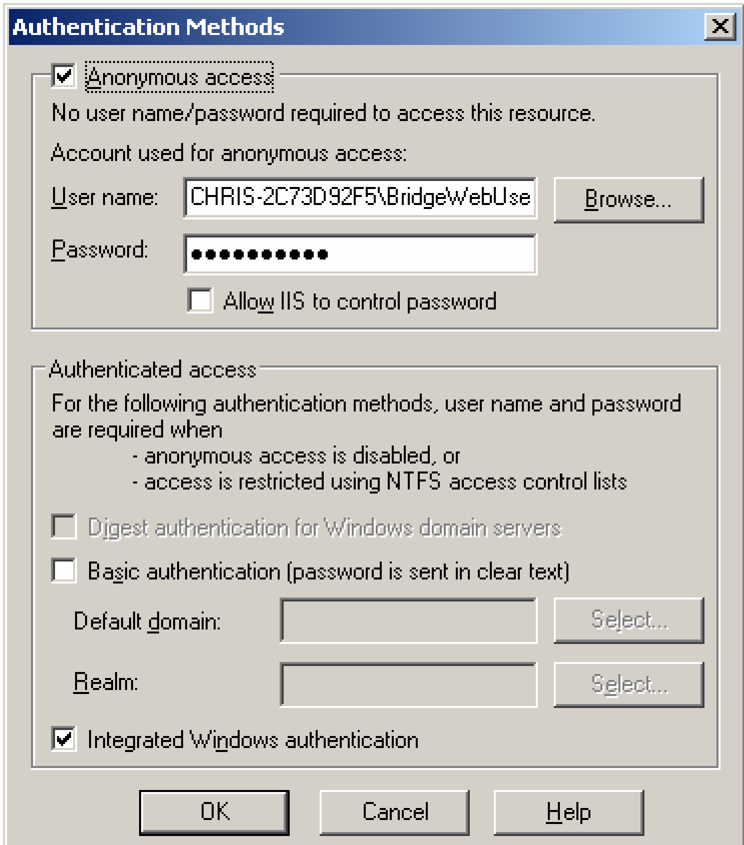
4. Edit Security tab of BridgeReports and CaseHistories folders. Add Modify, Read, Write, Read & Executeand List Folder Contents rights.


BridgeReports Properties
General
Sharing
Security
Web Sharing
Customize
Group or user names:
Administrators (CHRIS-2C73D92F5\Administrators)
BridgeWebUser (CHRIS-2C73D92F5\BridgeWebUser)
Chris (CHRIS-2C73D92F5\Chris)
CREATOR OWNER
SYSTEM
Add...
Remove
Permissions for BridgeWebUser
Allow
Deny
Full Control
Modify
Read & Execute
List Folder Contents
Read
Write
Special Permissions
For special permissions or for advanced settings, click Advanced.
Advanced
OK
Cancel
Apply

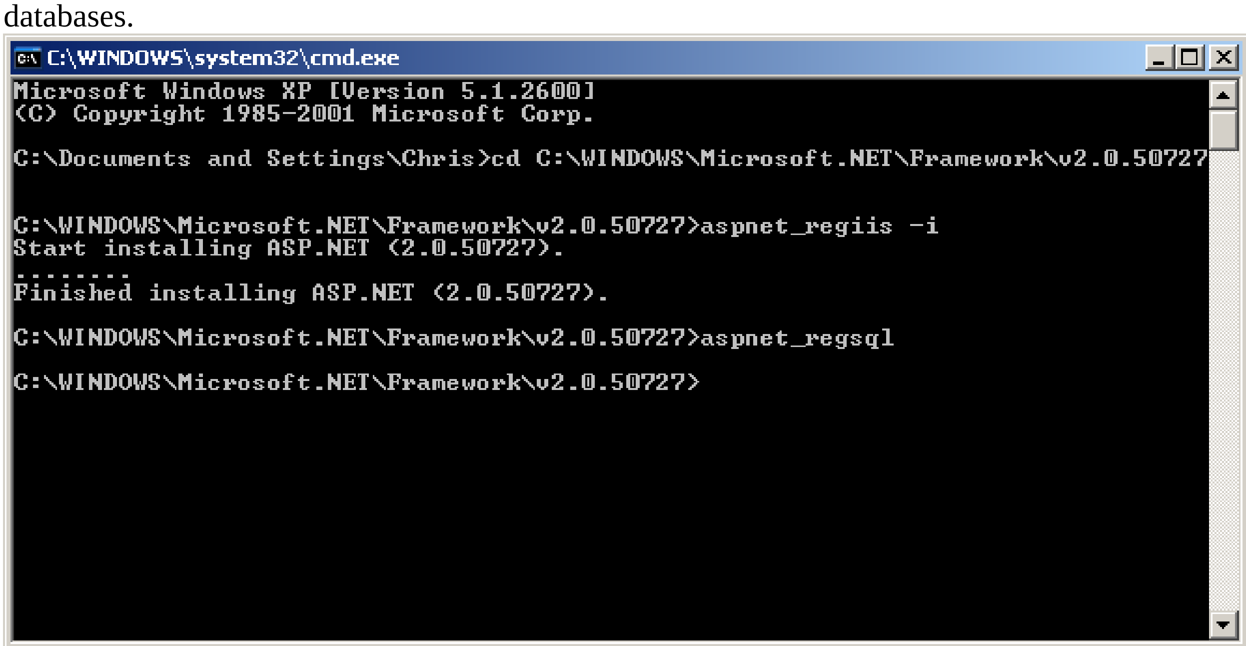
5. Create a New Site or New Virtual Directory in IIS, depending on the desired location and name as BIRD. Point to the website root directory.



6. On the Directory Security tab in IIS, edit Anonymouis access and authentication control. Enable Integrated Windows authentication and Asnonymous access. Set User name to BridgeWebUser and password to the corresponding password.

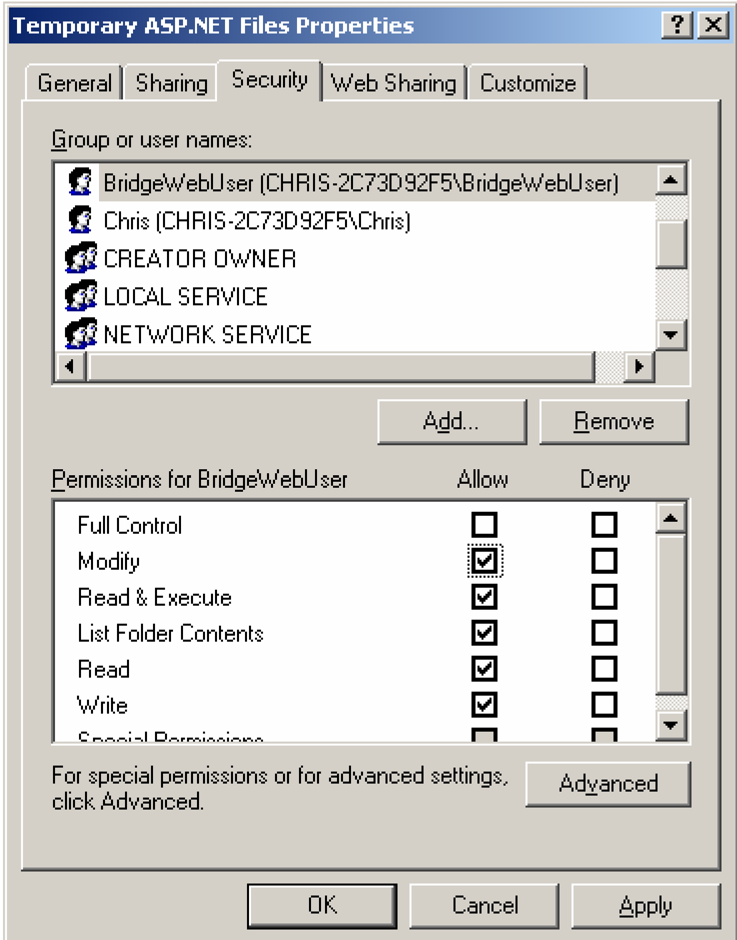


7. Run the following commands to install ASP.NET in IIS and in BIRD_PROD databases.

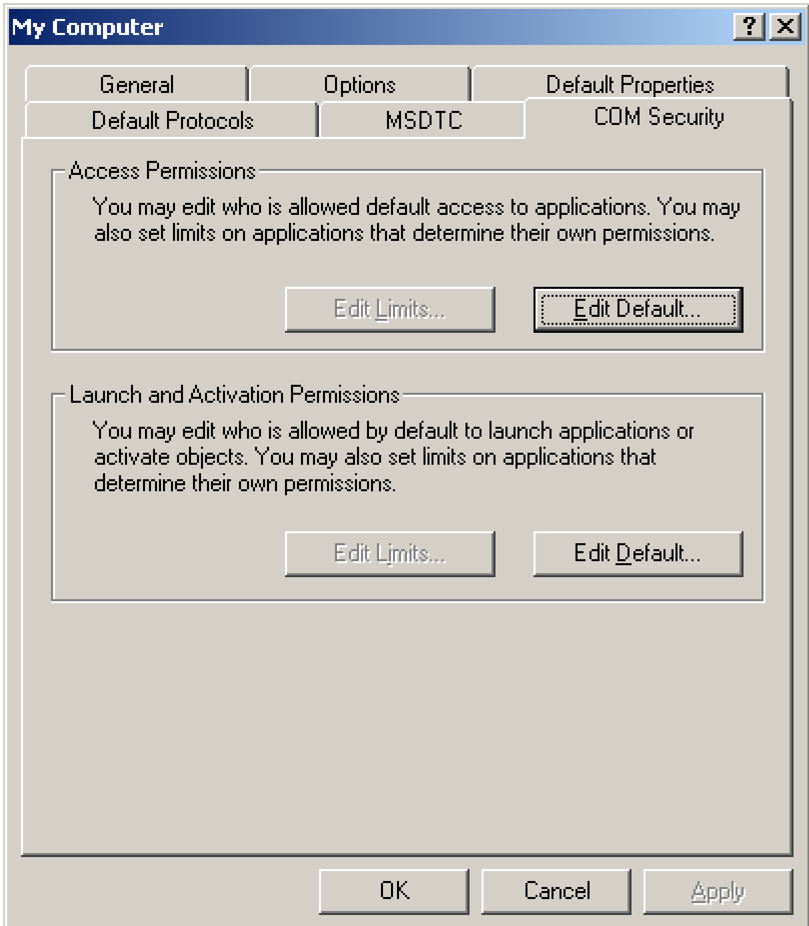


8. Add BridgeWebUser account to C:\WINDOWS\Microsoft.NET\Framework\v2.0.50727\Temporary ASP.NET Files. Since the BIRD application is running under that User Account, it should be

able to write into ASP.Net cache.



9. Microsoft Word requires that a user would always be interactively logged on in order to work. Open DCOM Config and add BridgeWebUser to DCOM Config COM Security



Add BridgeWebUser to Microsoft Word Document. Add BridgeWebUser to Launchand Activation Permissions and Access Permissions.

10. Login to the Web Server as BridgeWebUser and run Microsoft Office at least one. It will customize Microsoft Office to be used by BridgeWebUser.
11. as stated above, Microsoft Office needs one account to be logged in interactively. Add BridgeWebUser or any other account to be logged in automatically when the computer is rebooted. See the article below for details.

2.0 How to turn on automatic logon in Windows XP

View products that this article applies to.

Article ID : 315231

Last Review : May 7, 2007

Revision : 4.6

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Important This article contains information about modifying the registry. Before you modify the registry, make sure to back it up and make sure that you understand how to restore the registry if a problem occurs. For information about how to back up, restore, and edit the registry, click the following article number to view the article in the Microsoft Knowledge Base:
256986 Description of the Microsoft Windows Registry

INTRODUCTION

This article describes how to configure Microsoft Windows XP to automate the logon process by storing your password and other pertinent information in the registry database. This feature permits other users to start your computer and to use the account that you establish to automatically log on.

Important If you turn on autologon, using Windows XP becomes more convenient. However, using this feature can pose a security risk.

MORE INFORMATION

Warning If you use Registry Editor incorrectly, you may cause serious problems that may require you to reinstall your operating system. Microsoft cannot guarantee that you can solve problems that result from using Registry Editor incorrectly. Use Registry Editor at your own risk.
If you set a computer for automatic logon, anyone who can physically gain access to the computer can also gain access to everything that is on the computer, including any network or networks that the computer is connected to. Additionally, if you turn on automatic logon, the password is stored in the registry in plain text. The specific registry key that stores this value is remotely readable by the Authenticated Users group. Therefore, only use this setting if the computer is physically secured and if you make sure that users who you do not trust cannot remotely see the registry.

You can use Registry Editor to add your log on information. To do this, follow these steps:

1. Click **Start**, click **Run**, type **regedit**, and then click **OK**.
2. Locate the following registry key:
   HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\WindowsNT\CurrentVersion\Winlogon
3. Using your account name and password, double-click the **DefaultUserName** entry, type your user name, and then click **OK**.
4. Double-click the **DefaultPassword** entry, type your password under the value data box, and then click **OK**.

   If there is no **DefaultPassword** value, create the value. To do this, follow these steps:
   a. In Registry Editor, click **Edit**, click **New**, and then click **String Value**.
   b. Type **DefaultPassword** as the value name, and then press ENTER.
   c. Double-click the newly created key, and then type your password in the **Value Data** box.
   If no DefaultPassword string is specified, Windows XP automatically changes the value of the AutoAdminLogon registry key from **1** (true) to **0** (false) to turn off the AutoAdminLogon feature.
5. Double-click the **AutoAdminLogon** entry, type **1** in the **Value Data** box, and then click **OK**.

   If there is no AutoAdminLogon entry, create the entry. To do this, follow these steps:
   a. In Registry Editor, click **Edit**, click **New**, and then click **String Value**.
   b. Type **AutoAdminLogon** as the value name, and then press ENTER.

c. Double-click the newly created key, and then type **1** in the **Value Data** box.

6. Quit Registry Editor.
7. Click **Start**, click **Restart**, and then click **OK**.

After your computer restarts and Windows XP starts, you can log on automatically.

If you want to bypass the automatic logon to log on as a different user, hold down the SHIFT key after you log off or after Windows XP restarts. Note that this procedure applies only to the first logon. To enforce this setting for future logoffs, the administrator must set the following registry key:
HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\WindowsNT\CurrentVersion\Winlogon

Value:ForceAutoLogon
Type: REG_SZ
Data: 1
You can also use turn on automatic logon without editing the registry in Microsoft Windows XP Home Edition and in Microsoft Windows XP Professional on a computer that is not joined to a domain. To do this, follow these steps:

1. Click **Start**, and then click **Run**.
2. In the **Open** box, type **control userpasswords2**, and then click **OK**.

   Note When users try to display help information in the User Accounts window in Windows XP Home Edition, the help information is not displayed. Additionally, users receive the following error message:
   Cannot find the *Drive*:\Windows\System32\users.hlp Help file. Check to see that the file exists on your hard disk drive. If it does not exist, you must reinstall it.
3. Clear the "Users must enter a user name and password to use this computer" check box, and then click **Apply**.
4. In the **Automatically Log On** window, type the password in the **Password** box, and then retype the password in the **Confirm Password** box.
5. Click **OK** to close the **Automatically Log On** window, and then click **OK** to close the **User Accounts** window.

APPLIES TO

- Microsoft Windows XP Home Edition
- Microsoft Windows XP Professional
- Microsoft Windows XP Professional for Itanium-based systems

Back to the top

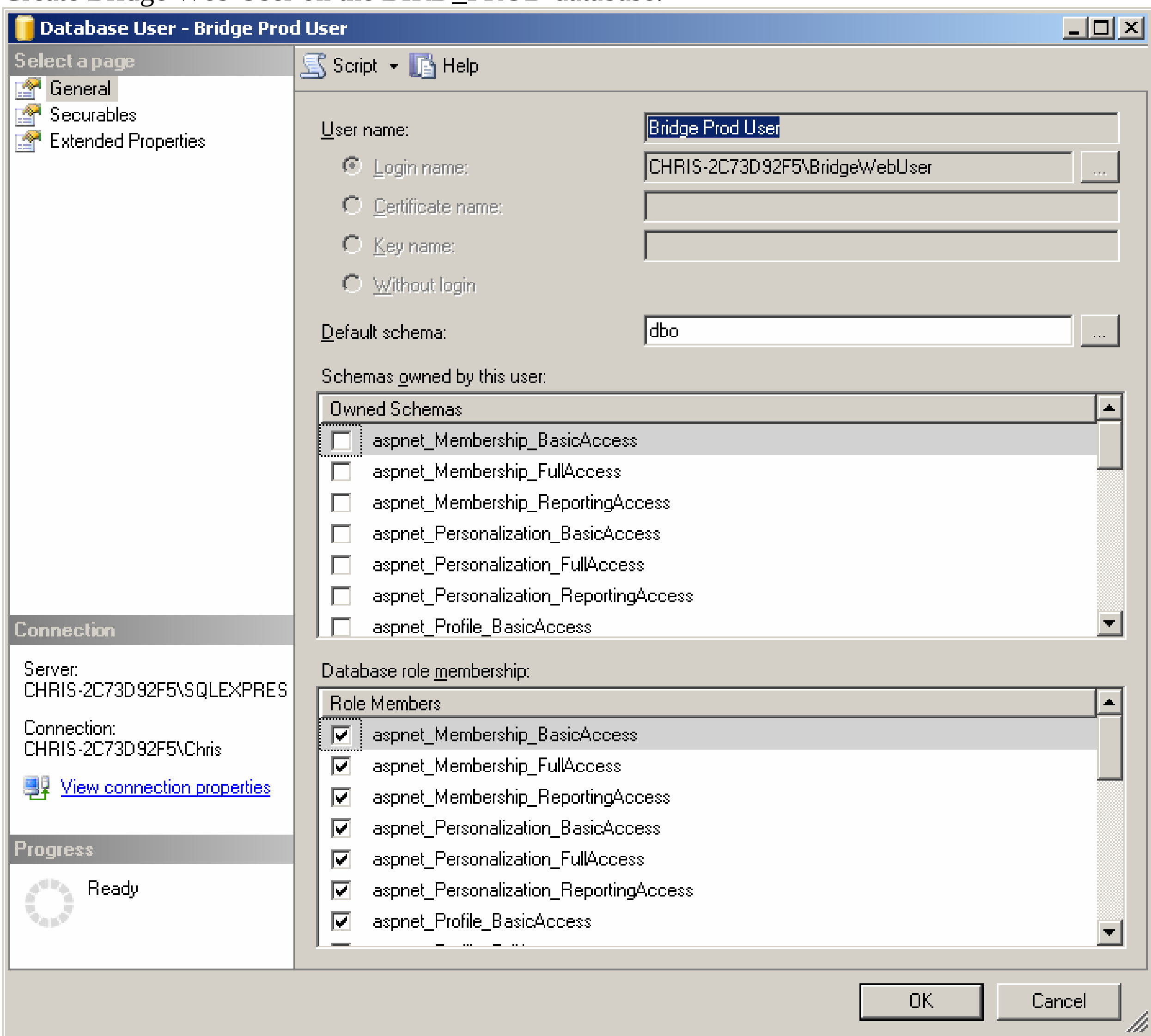
Keywords: kbacwsurvey kbregistry kbhowto kbenv kbinfo kbui KB315231

2.1 *SQL Server Installation Process*

SQL Server may be installed on the same machine as the Website or on a dedicated Database Server. These directions assume the same machine. If new machine is chosen, please edit the connection string in web.config.

1. Install Microsoft SQL Server 2005 Express. It is recommended that SQL Server Management Studio Express to be installed to facilitate the access and management of the BIRD database.

2. Extract the database backup from BIRD PROD_DATA.rar to any temporary folder and restore it on the SQL Server as BIRD_PROD
3. Create a BridgeWebUser Login on the SQL Server.
4. Create Bridge Web User on the BIRD_PROD database:



5. Allow all. Db_denydatareader and db_denydatawriter should remain unchecked.
6. Make sure Global.asa and Web.config on the Web Server are pointing to the correct database.

Appendix 7.3: Database User Manual

BIRD Operating Manual
Contents

I. Introduction

With BIRD (Bridge Incidence Response Database) a user can access the case history documents that have already been generated and add new case histories to the database. With the appropriate access level a user may also edit or delete previously generated case histories. The database can be expanded to include new structures or previously generated case histories can be enhanced with new information as it becomes available.

In this manual we describe the features of BIRD available for various users. Each database entry contains several documents which are described in section 2. The structure of the database is examined in section 3. In section 3 the subsections discuss the specifics of access and login, administrative activities, managing case history background and bridge information files, and viewing, printing, or storing file elements.

All of the file structures in BIRD have been created using Microsoft WORD. Access to the database is restricted to users who have received a logon user name and password from the system administrator. Requests for database access should be sent to John A. Dudek at the University of Wisconsin – Milwaukee (jadudek@uwm.edu, 414-229-4638).

II. BIRD Documents

There are two classes of documents that are stored in BIRD. The first is the Bridge Structure Information document and the second in the Bridge Case History document. Both documents are stored in the database using the Microsoft WORD format. Each document is labeled with the standard bridge designator B-XX-XXXX or P-XX-XXXX.

The data for the Bridge Structure Information document is obtained from the WisDOT Highway Information System (HIS) database using the Bridge Inventory and inspection records. The user creates this document by inserting the relevant information into several screens with a tabular format. A BIRD file for a bridge is initiated by preparing a Bridge Structure Information document. A sample of a completed Bridge Structure Information document is shown at the end of this section.

Once the Bridge Structure Information document has been initiated the user can then insert a Bridge Case History document into BIRD. A Bridge Case History document is less formally structured but is created using the following guidelines. The document is written in the form of a narrative that summarizes the features of the bridge and various incidents that affected the physical integrity of the structure. In general, the first paragraph indicates the location, construction date, general features, and average vehicular traffic level. The next paragraph provides further details as to the number and type of spans, the abutments and piers, and the load ratings.

The next portion of the document gives a brief history of incidents for which repairs were required that occurred before the situation of principal concern. For the incident requiring an emergency response the cause of the damage, a description of immediate responses, details of repair or replacement efforts, and final status are presented. It is possible to update the case history background by including subsequent events as desired by the database owners. Further, a string of keywords for the search function are added either at the start or the end of the narrative. Photographs and drawings may be inserted using standard Microsoft WORD features. Lastly, a process flow diagram summarizing the procedures followed by the responsible authority is appended. At the current time this process flow diagram is either for the City of Milwaukee or a generic version for the State of Wisconsin. A sample Bridge Case History document is shown at the end of this section.

Bridge Incident Response Data (BIRD)
Bridge Information Report
Bridge Number B-05-0086
Generated 6/13/2007

Basic Bridge Information

Structure Name	Mason Street Bridge
Year Built	1966
Municipality	City of Green Bay
Section	28
Town	24N
State	WI
Range	20E
Maintenance Agency	State Highway Dept.
Owner	State Highway Dept.
Replaced Structure Number	
Historical Significance	5
Latitude	443126.53
Longitude	880456.37
County	Brown
District	3

Bridge Geometric Data

Structure Length (ft)	185.7
Number Lanes On	6
Left Sidewalk Width (ft)	6.0
Right Sidewalk Width (ft)	6.0
Median Type	Concrete > 6”
Median Width (ft)	8.0
Skew Angle (Deg)	3
Direction Skew Angle	Left
Horizontal Curve Radius (ft)	0.0
Direction Horizontal Curve	
Girder Spacing (ft)	4.7
Height (ft)	45.0
NBI Bridge Length Met	TRUE

Abutment Data (Cardinal)

Abutment Type	Semi Retaining
Pile Type	Treated Timber
Pile Size (in)	12
Slope Protection Type	Solid Conc.
Roadway width (ft)	80.0
Deck Width (ft)	100.0
Wing Type	

Abutment Data (Non Cardinal)

Abutment Type	Semi Retaining
Pile Type	Treated Timber
Pile Size (in)	12
Slope Protection Type	Solid Conc.
Roadway width (ft)	80.0
Deck Width (ft)	100.0
Wing Type	

Bridge Capacity

Design MS	HS20
Inventory MS	HS20
Operating MS	HS41
Maximum Vehicle Weight (kips)	190
Load Governing Member	Deck Girder
Deck Composition	NONE
Deck Membrane	NONE
Deck Surface	Integral Concrete

Bridge Construction

Beam/Girder Material	Continuous Prestressed Concrete
Beam/Girder Type	Precast
Span Type	Continuous
Span Configuration	Deck Girder
Pier Type	Concrete
Piling Type	Treated Timber

Planning Data

Functional Classification	OTH Prin Art-Urban
ADT	20890
ADT Year	1992
Truck ADT (%)	10
Future ADT	32500
Future ADT Year	2018

Hydraulic Data

Design Flood Frequency (yrs)	
Design Discharge (cu-ft/s)	
Maximum Velocity (ft/s)	
Drainage Area (sq. ft)	
High Water Elevation (ft)	
Scour Critical Code	
Scour Calculated	

Service Data

Type Service On	Hwy. Pedestrian
Type Service Under	Highway

Clearance Data

Vertical Clearance (Cardinal) (ft)	15.0
Vertical Clearance (Non-Cardinal) (ft)	15.1

Condition Data

Deck Condition	8
Super-Structure Condition	6
Sub-Structure Condition	6

Case History Background
Mason Street Bridge (State Highway 54) over U.S. Highway 41
Bridge Number B – 05 – 0086
Revision Date: 6/14/2007

The Mason Street (State Highway 54) Bridge is located on the southwestern boundary of the City of Green Bay, Wisconsin. The bridge was constructed in 1966 and carries six lanes of traffic over four lanes of U.S. Highway 41 (USH 41). The average daily vehicular traffic level (ADT) was recorded as 20,890 vehicles per day in 1992 on the bridge and 69,490 vehicles per day in 2003 under the bridge. (See Figure 1.)

Figure 1: General View of Bridge B-05-0086.

The bridge has two prestressed concrete girder spans with twenty girders in each span. Span 1 has a length of 92.0 ft. and span 2 has a length of 90.0 ft. The total structure length is 185.7 ft. The deck width is 100.0 ft. and the deck area is 18,570 sq. ft. It has retaining type abutments with 12 in. treated timber pilings and a round column bent type pier with 12 in. treated timber pilings. Load ratings are specified as H20 for the design, HS41 for an operating load rating, and HS20 for the inventory load rating. The bridge was designed for over 2,000,000 stress cycles and the prestressed concrete girders were manufactured to have a compressive strength of 5,000 psi.

Since the date of construction the Mason Street Bridge has suffered numerous impacts requiring significant repairs. These are summarized in the following listing.

Number	Year	Description
1	1974	Patch girders 1 and 4 over northbound USH 41.
2	1975	Patch girders over northbound USH 41.
3	1976	Patch several girders over southbound USH 41.
4	1979	Replace the south exterior girder over northbound USH 41.
5	1980	Patch the south exterior girder over southbound USH 41.
6	1980	Patch the south exterior girder over northbound USH 41.
7	1984	Replace a damaged girder.
8	1984	Patch several girders over southbound USH 41.
9	1989	Replace three girders.
10	1996	Patch the south exterior girder over northbound USH 41.
11	1998	Replace girders 1 and 2 over northbound USH 41.

The latest incident occurred in October of 2005. On Wednesday, October 26, 2005, the Mason Street Bridge was struck by a backhoe/excavator that was too high for sufficient clearance. The vehicle pulling the trailer containing the backhoe was traveling in the northbound lanes of USH 41. The impact resulted in extensive damage to several concrete girders with debris scattered over the roadway and striking another vehicle immediately behind the truck. There were no injuries but the driver of the truck/trailer did not stop or report the incident and was cited for a hit-and-run.

The incident occurred at approximately 3:20 p.m. and was reported to the City of Green Bay Police Department at 3:22 p.m. An officer was immediately dispatched to the site and arrived at 3:25 p.m. Because of the extent of heavy damage, the incident was reported to the Brown County Highway Department who then contacted the Northeast Region offices of the Wisconsin Department of Transportation (WisDOT) located in Green Bay, Wisconsin. The call was forwarded to the region's Structure Maintenance Engineer, Dale S. Weber. Mr. Weber immediately visited the site and prepared a preliminary evaluation of the damage. It was decided not to restrict the use of the structure after debris from the impact was removed from the roadway.

Mr. Weber noted severe damage to girder 1 with six exposed reinforcing steel strands and one severed strand. (See Figure 2.) The bottom flange of girder 1 has severe cracking that extended into the web. It was recommended that because of the extensive cracking the girder be replaced. Furthermore, the impact caused patches placed over previously damaged areas on girders 6 and 7 to fall off. (See Figure 3.) It was recommended that both of these girders be repaired. Although the damage, especially to girder 1, was extensive it was decided that the bridge was still structurally sound and no restrictions were placed on its use. In an effort to repair these damages before another impact occurred it was decided to use an outside contractor to complete the repairs as quickly as possible.

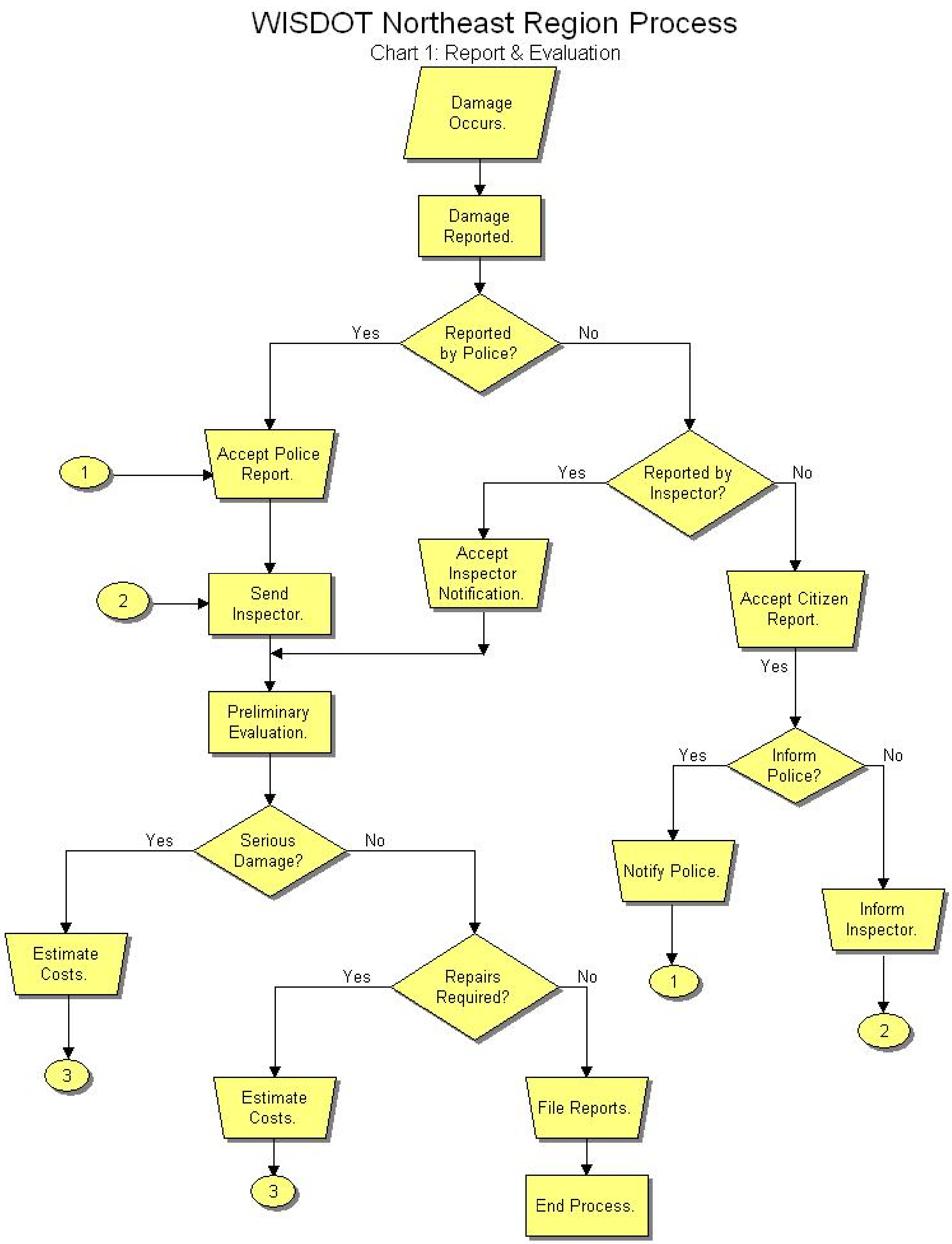
Figure 2: Detailed View of Severely Damaged Girder #1.

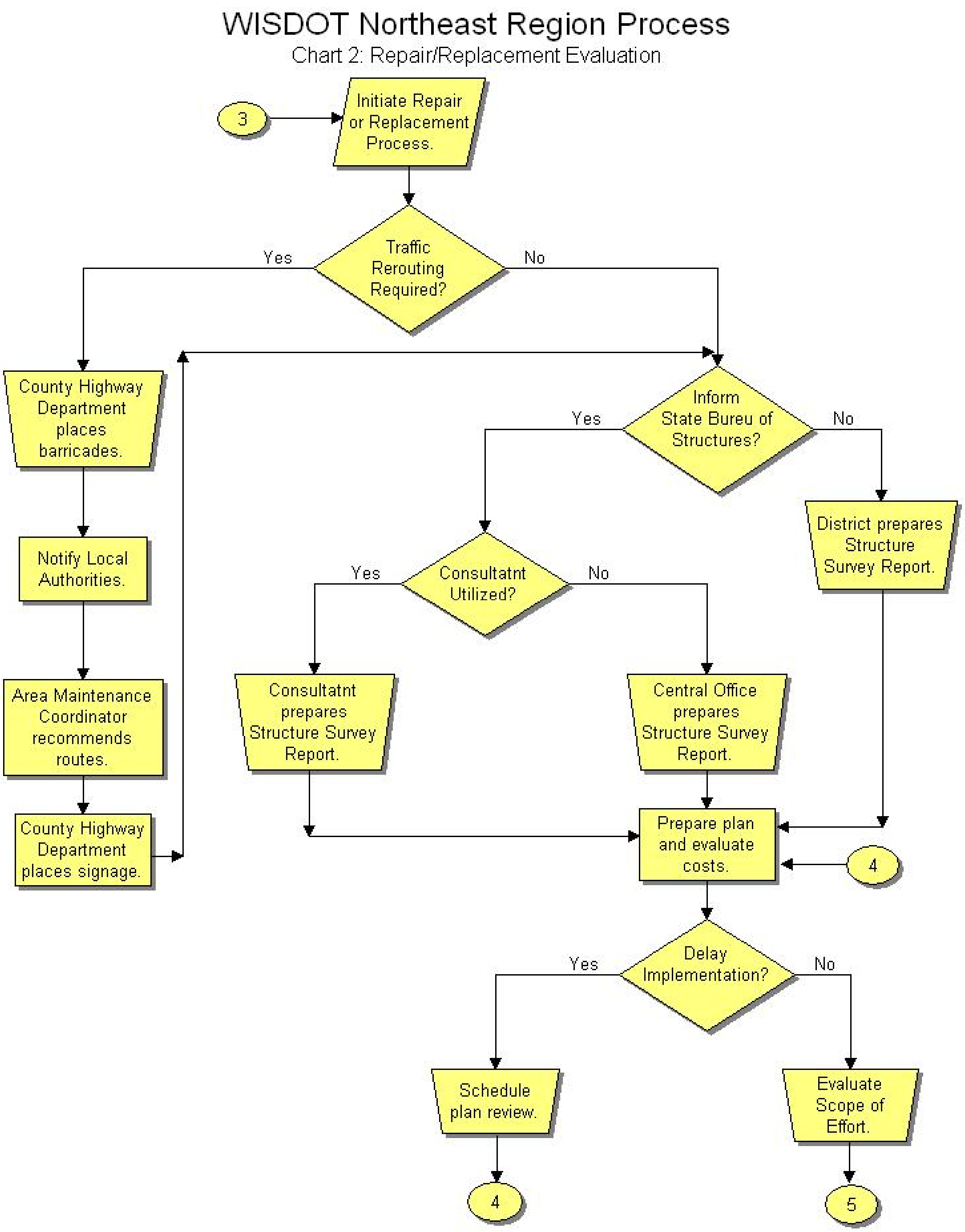
Figure 3: Detailed View of Damaged Area with Lost Patch in Girder #7.

After receiving plans and specifications from the WisDOT Central Office in Madison, Wisconsin, a request for bid was issued on November 15, 2005 to three local contractors. The work was awarded to Pheiffer Brothers Construction Company for their low bid of $77,565.74 on December 5, 2005. The contract was approved by the Governor of Wisconsin on December 21, 2005.

The repair operations began on Monday, February 6, 2006 and were completed by February 23, 2006. During repairs the right lane on eastbound State Highway 54 (STH 54 – Mason Street) was closed. When the replacement girder was installed all lanes on STH54 were closed for approximately one-half hour. The USH 41 northbound lane restrictions were in place during repair and the northbound lanes were closed while setting the girder. All repairs were successfully completed. No restrictions remain on the use of the bridge and it retains its original load ratings.

KEYWORDS: impact, girder, concrete, cracking, exposed strands, severed strands, replacement, patching.

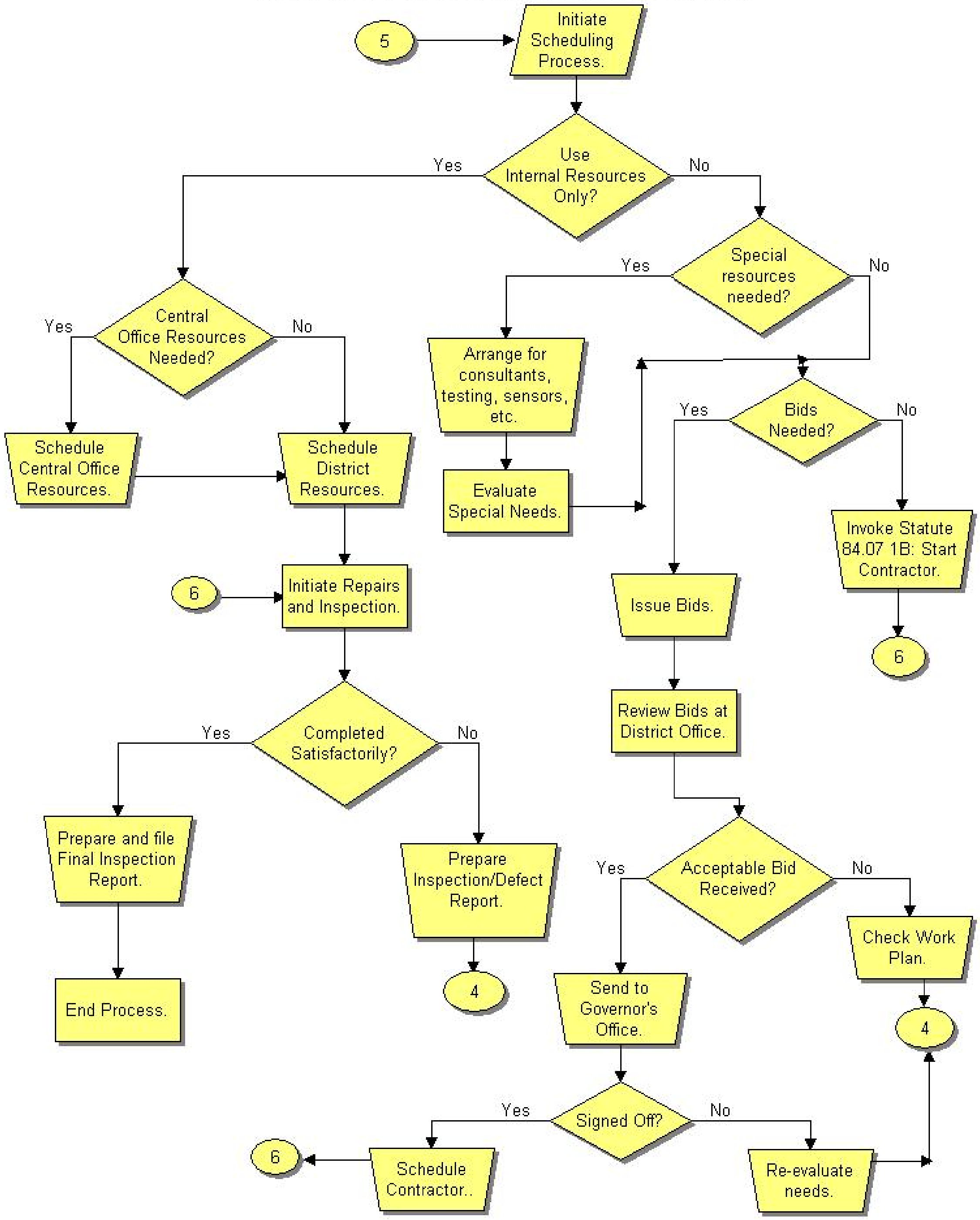

WISDOT Northeast Region Process
Chart 1: Report & Evaluation
Damage Occurs.
Damage Reported.
Reported by Police?
Yes
No
Accept Police Report.
1
Reported by Inspector?
Yes
No
Accept Inspector Notification.
2
Send Inspector.
Accept Citizen Report.
Yes
Preliminary Evaluation.
Inform Police?
Yes
No
Serious Damage?
Yes
No
Notify Police.
Inform Inspector.
Estimate Costs.
Repairs Required?
Yes
No
1
2
3
Estimate Costs.
File Reports.
3
End Process.



WISDOT Northeast Region Process
Chart 2: Repair/Replacement Evaluation
3
Initiate Repair or Replacement Process.
Traffic Rerouting Required?
Yes
No
County Highway Department places barricades.
Notify Local Authorities.
Area Maintenance Coordinator recommends routes.
County Highway Department places signage.
Inform State Bureu of Structures?
Yes
No
District prepares Structure Survey Report.
Consultatnt Utilized?
Yes
No
Consultatnt prepares Structure Survey Report.
Central Office prepares Structure Survey Report.
Prepare plan and evaluate costs.
4
Delay Implementation?
Yes
No
Schedule plan review.
Evaluate Scope of Effort.
4
5

WISDOT Northeast Region Process

Chart 3: Repair/Replacement Approval and Completion

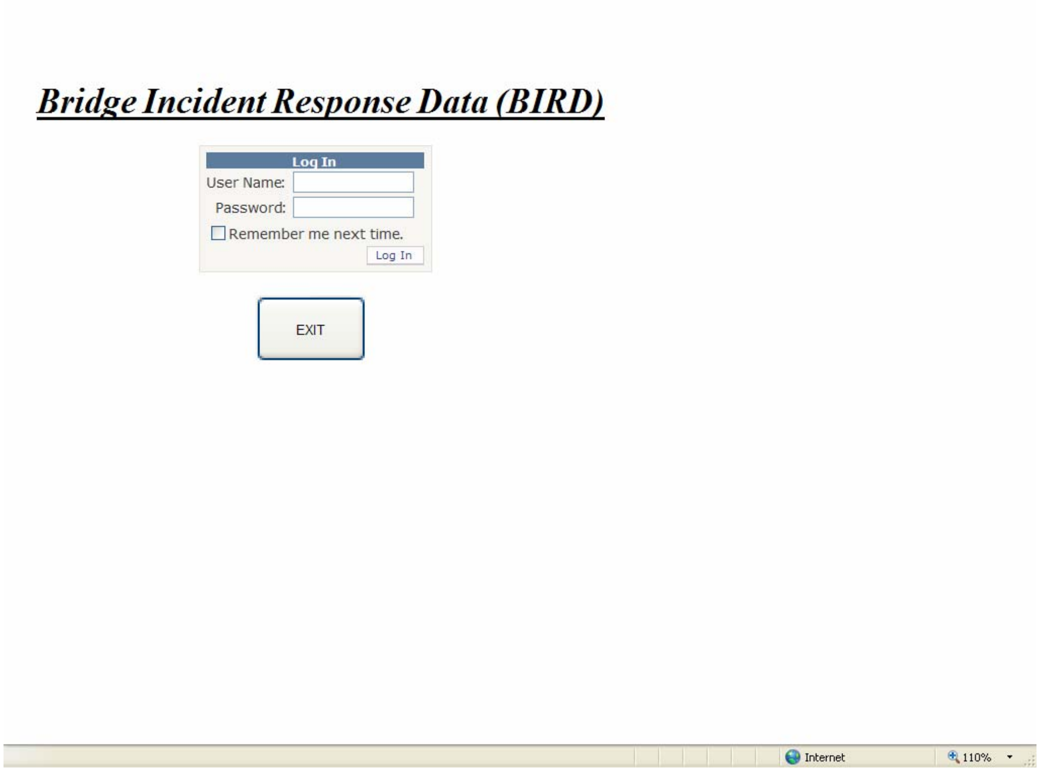


III. Database Structure

The following subsections give specific information for accessing and using BIRD.

III.1 Access & Login

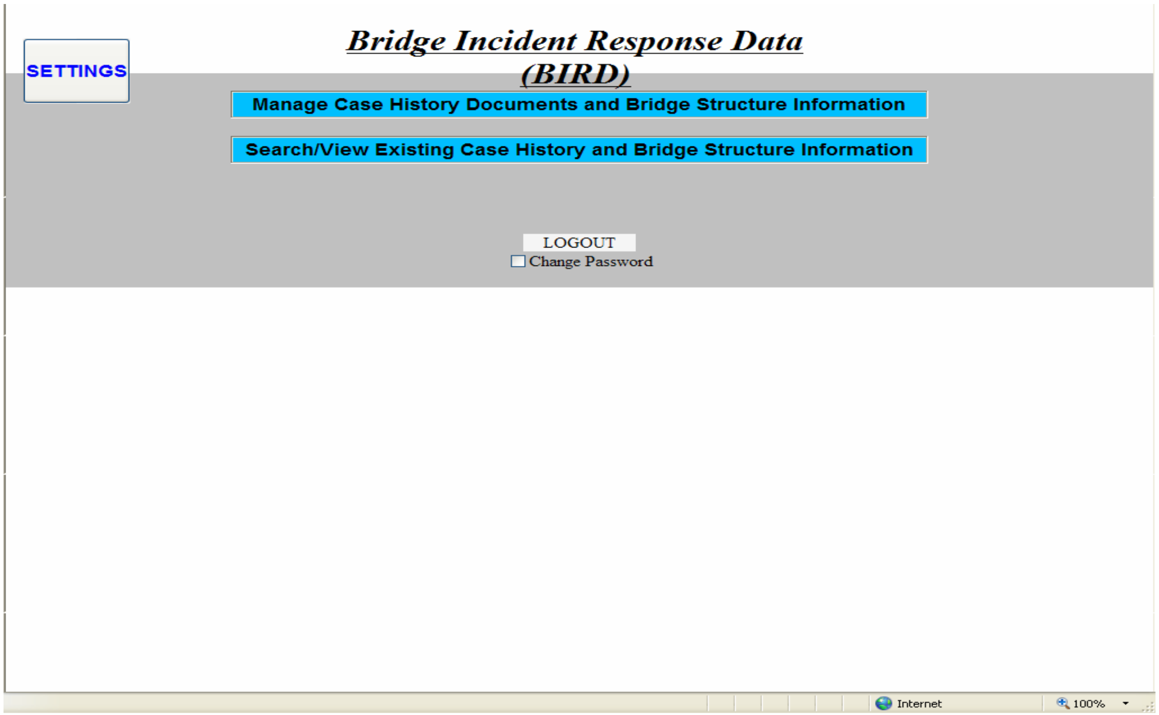
The BIRD system is resident on a server computer located in the College of Engineering and Applied Science at the University of Wisconsin – Milwaukee. Access is obtained via the BIRD website: http://www.uwm.edu/CEAS/bird with a User Name and Password provided by the system administrator. The login screen is shown below.



The accessibility to the database is limited to three levels called USER, MANAGER, and ADMINISTRATOR. The appropriate level is assigned to each user by the system administrator at the time when the user name and password are generated. The basic access level (USER) allows the individual to view and retrieve files on any structure that is currently listed in the database. At the second level (MANAGER) the individual may, in addition to viewing current elements and adding new elements, may edit previously created file structures. At the highest level (ADMINISTRATOR) the individual has increased capabilities for editing, deleting, and other database administration activities.

After inputting the User name and Password the user clicks on the Log In button. The user can now access the various features of BIRD through the Main Information Screen.

III.2 Main Information Screen

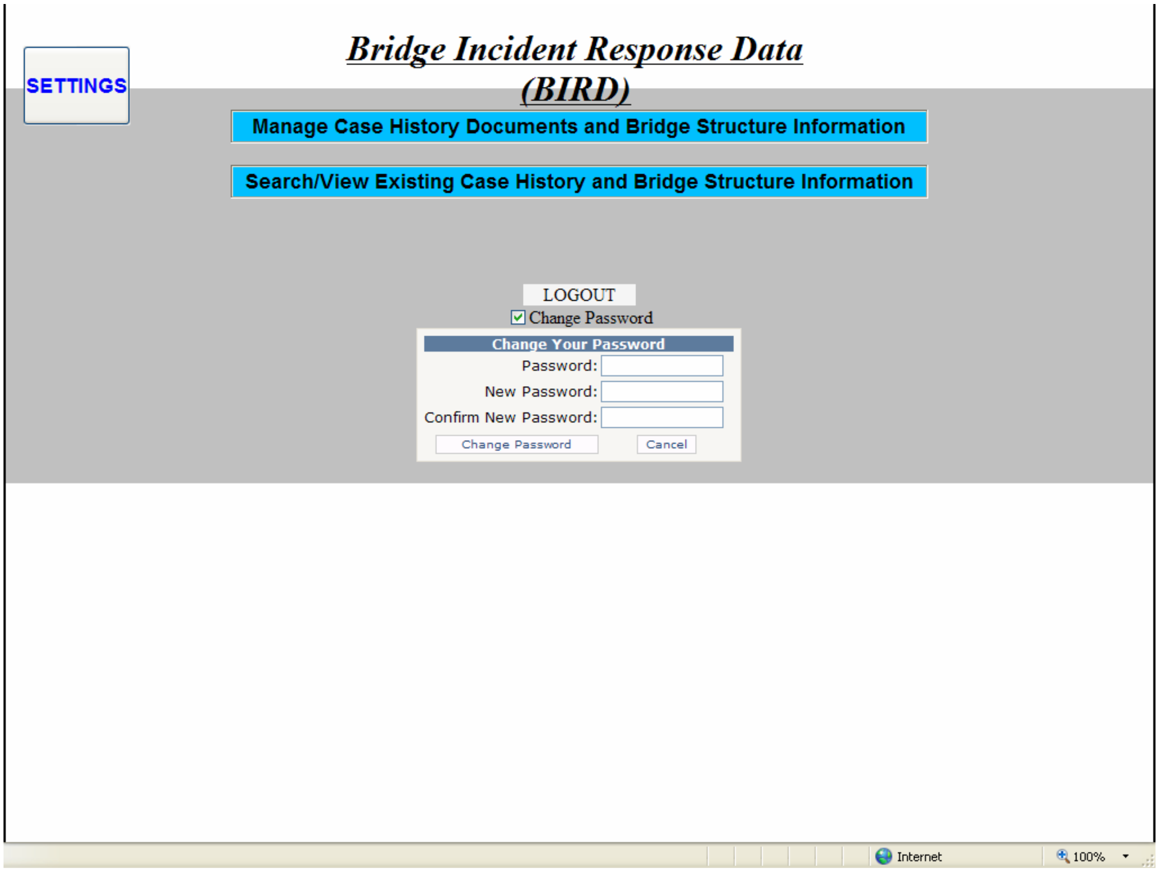


This is the first screen for choosing BIRD options. Various options are available depending on the user's access level. For a USER only the "Search/View Existing Case History and Bridge Structure Information" tab will appear. If the user clicks on this tab the "View Case History and Bridge Information" screen will appear. The options available with this screen are described in section III.2.A of this manual.

For a MANAGER both the "Search/View …" and "Manage Case History Documents and Bridge Structure Information" tabs appear. If the user clicks on the "Manage Case History …" tab the "Manage Case History Documents" screen will appear. The options available with this screen are described in section III.2.B of this manual.

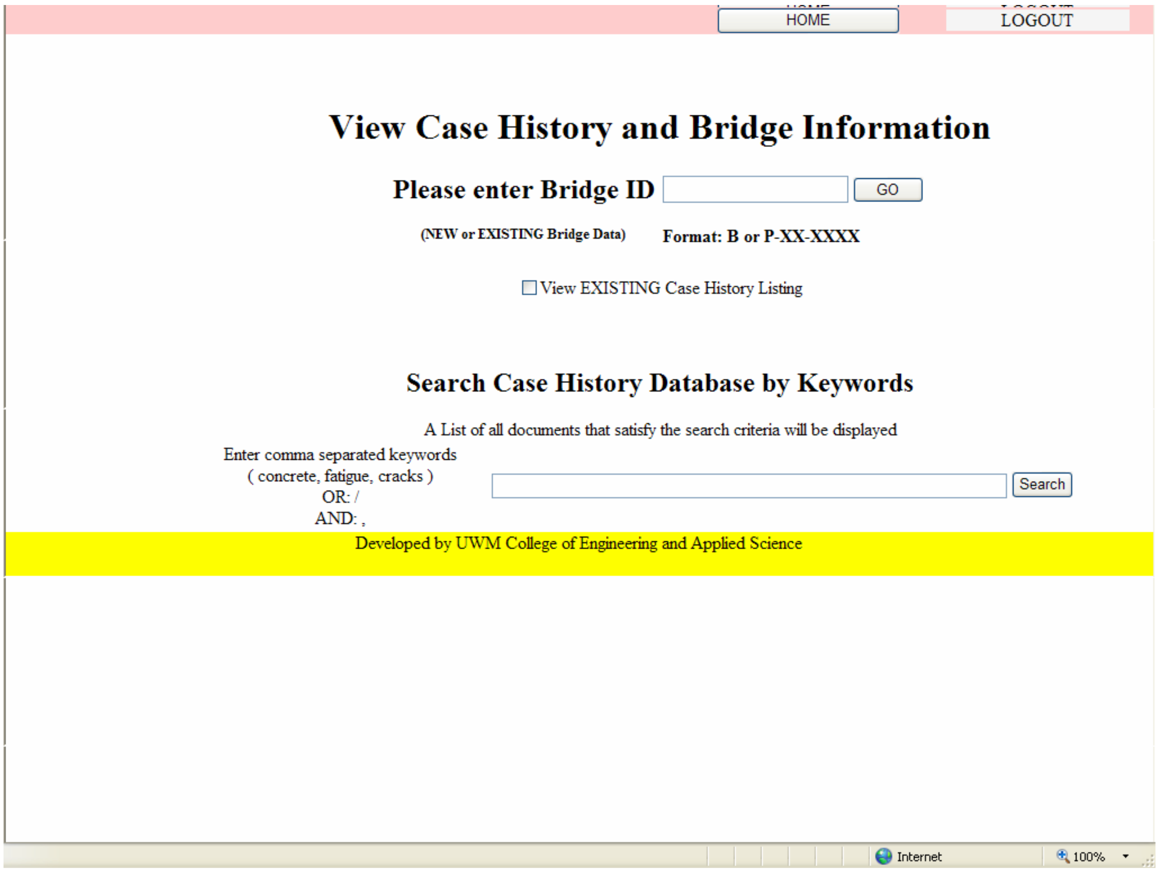
For an ADMINISTRATOR the entire main information screen (shown above) is displayed. In addition to the other options the ADMINISTRATOR will also be able to perform database activities of adding or deleting users by clicking on the "SETTINGS" tab. These activities are described in section III.2.C of this manual.

All users have access to the "LOGOUT" and "Change Password" features. If the user clicks on "LOGOUT" the initial login screen reappears (see section III.1). After clicking the box next to "Change Password" the screen shown below appears. By following these instructions the user may change his/her password as desired. The User Name and database access level can only be changed by the system administrator.



SETTINGS
Bridge Incident Response Data
(BIRD)
Manage Case History Documents and Bridge Structure Information
Search/View Existing Case History and Bridge Structure Information
LOGOUT
Change Password
Change Your Password
Password:
New Password:
Confirm New Password:
Change Password
Cancel
Internet
100%

III.2.A Search/View Case History and Bridge Information

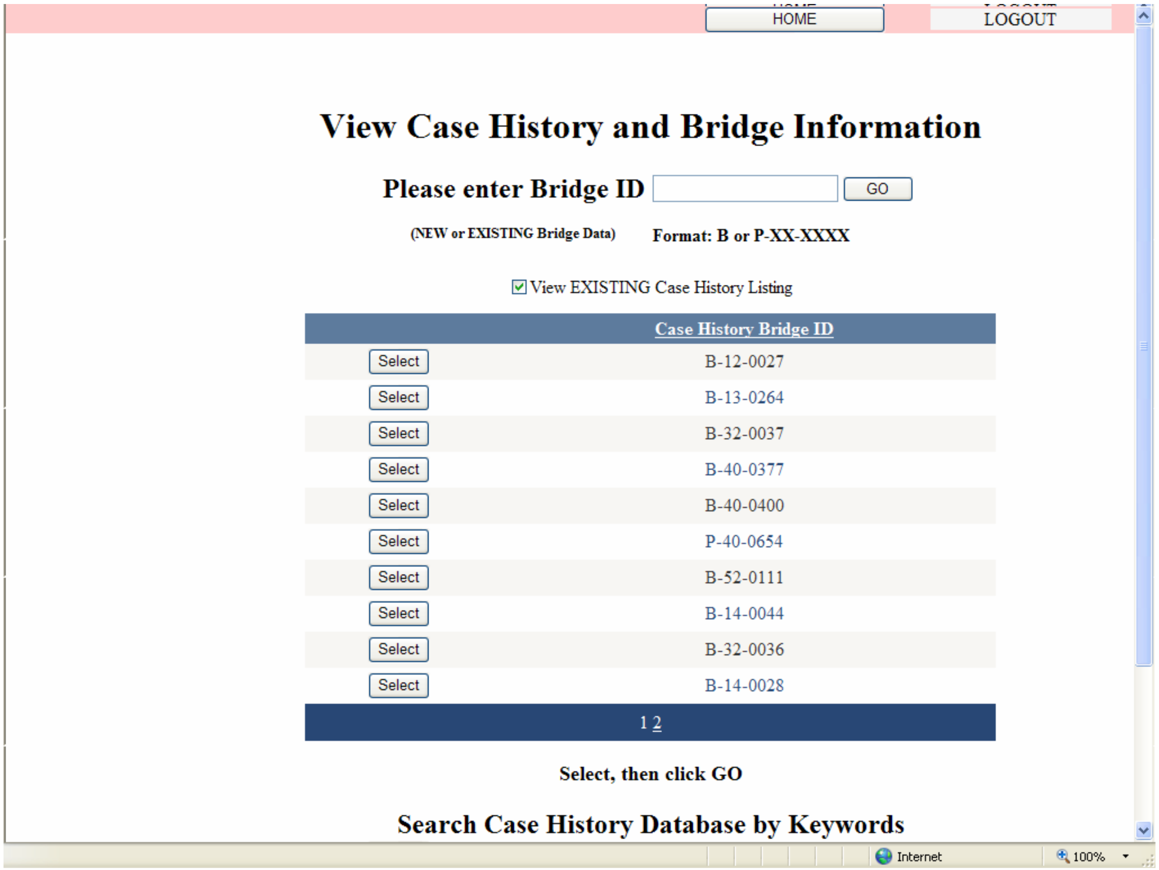


The first Search/View screen offers the user the option to either view existing files or search the database for existing case history background documents that contain specific keywords, combinations of keywords, in their keyword listing.

To view a case history background or bridge information document the user may proceed in two ways. If the user is aware of a specific bridge number that is in the database the documents can be viewed by inserting the bridge number in the indicated space. After clicking on the GO button the user will see the “Case History and Bridge Information for Bridges” screen overlay or will receive a message indicating that the requested document does not exist in the database.

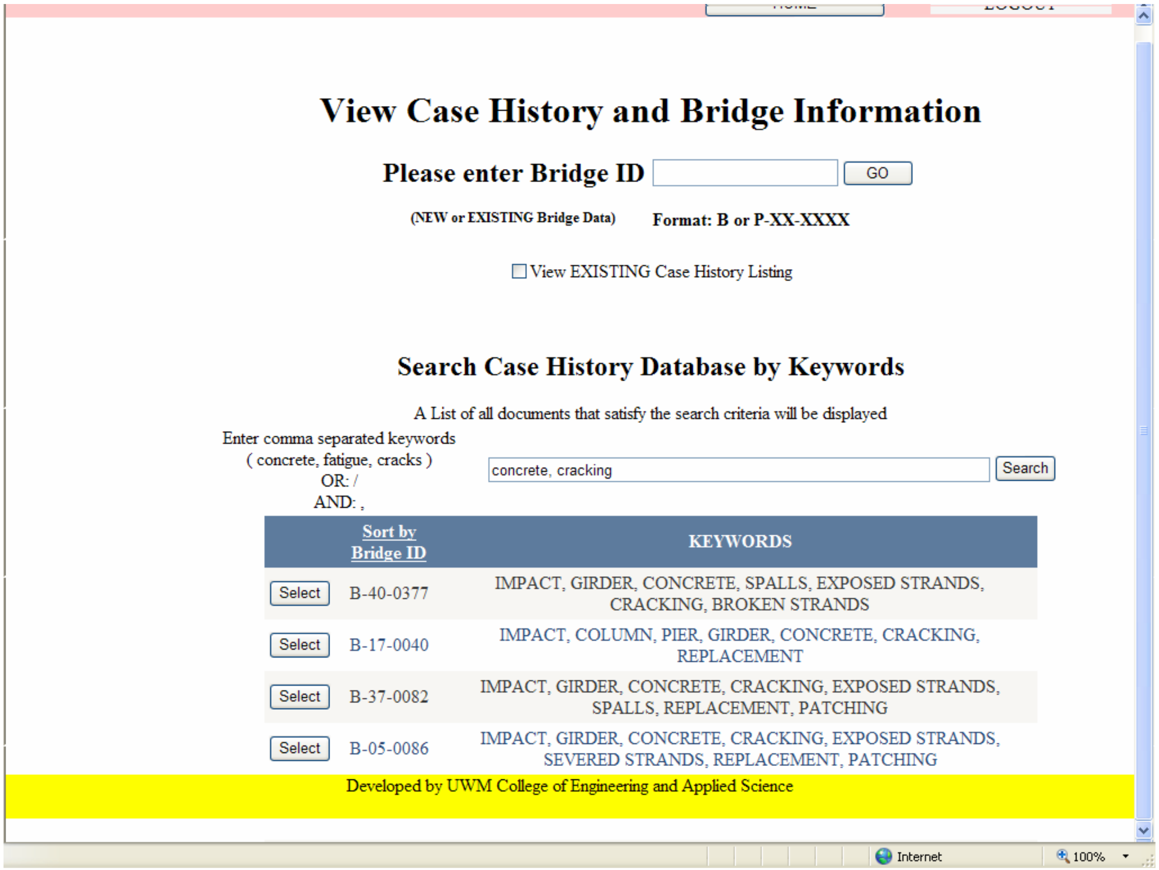
If the desired bridge is in the database the user will have the option of downloading the Case History Document, downloading the Bridge Structure Report, of canceling the request. If a download of either document is requested (by clicking on the appropriate tab) the user will see the usual Microsoft WORD File Download screen. At that point the user may Open the file for immediate viewing, Save the file as desired, or Cancel the request. The documents can be manipulated in the standard ways associated with Microsoft WORD.

Alternatively, the user may click on the box next to "View EXISTING Case History Listing". This results in the following screen to appear.



In this screen all of the bridge numbers for which documents are available are listed in columns of 10 bridge numbers. By clicking on the page number under the listing the user can scan the entire contents of the database. To select a specific bridge the user clicks on the "Select" tab next to the chosen bridge number. This will place that number in the Bridge ID space. After clicking the GO button the "Case History and Bridge Information for Bridges" screen overlay will appear. The user then proceeds in the same manner as discussed above.

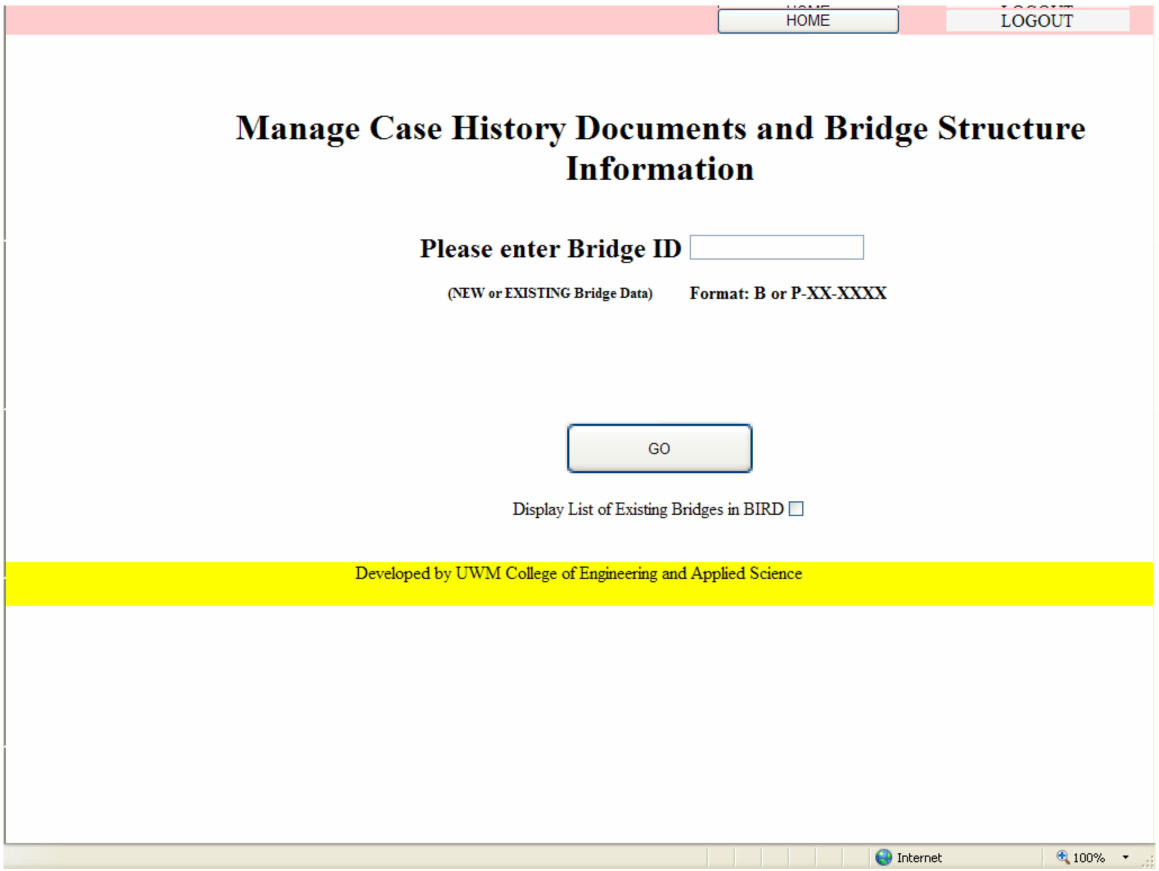
From either of the previous two screens the use can initiate a keyword search of the database by entering desired keywords separated by commas. The logical OR is achieved by separating two keywords with a "/". The logical AND is achieved with the comma. After inserting the keywords in the open space the user then clicks the "Search" button. If the search is successful a listing of bridge numbers that meet the specified search criteria are displayed. By clicking one of the "Select" buttons the user will see the usual MICROSOFT File Download screen as described above. For example, if the user inserts "concrete, cracking" the screen shown below appears. If the search is unsuccessful the screen will not change. In such a case the user may wish to simplify the search by using a basic keyword such as "concrete" or "steel" to produce a preliminary listing showing typical keywords.



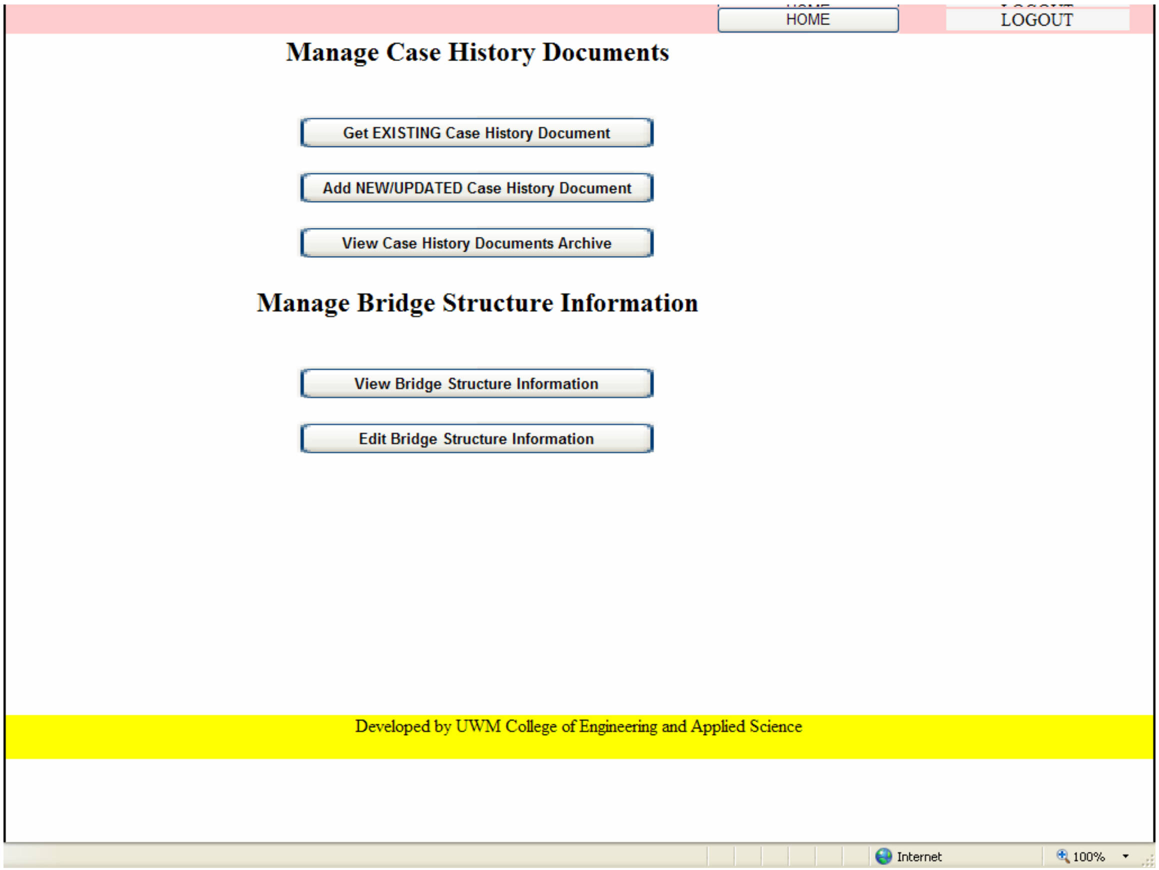
Lastly, the user can click on the “HOME” button to return to the Main Information Screen or on the “LOGOUT” button to return to the Login screen.

III.2.B Manage Case History Documents and Bridge Structure Information.

The following screen is available to MANAGERS and ADMINISTRATORS for modifying the database and adding Case History and Bridge Structure Information documents.



The user begins the editing process by inserting a new or existing bridge number in the space provided and then clicking on the GO button. If the bridge number is not in the database a screen for inputting new information will appear as described in section III.2.B.i. If the bridge is already in the database the Manage Case History and Bridge Structure Information screen shown below will appear. If the user is not familiar with the list of existing bridges he/she may click on the box next to “Display List of Existing Bridges in BIRD”. This produces the listing of all bridges in the database as described above. By clicking one of the “Select” buttons the user will again see the Case History and Bridge Structure Information screen. If the user is an ADMINISTATOR the listing of bridges will also contain “Delete” buttons. By clicking on a “Delete” button an ADMINISTRATOR can completely remove all documents for that bridge from the database. Alternatively, the user again has the option to use the HOME or LOGOUT buttons.



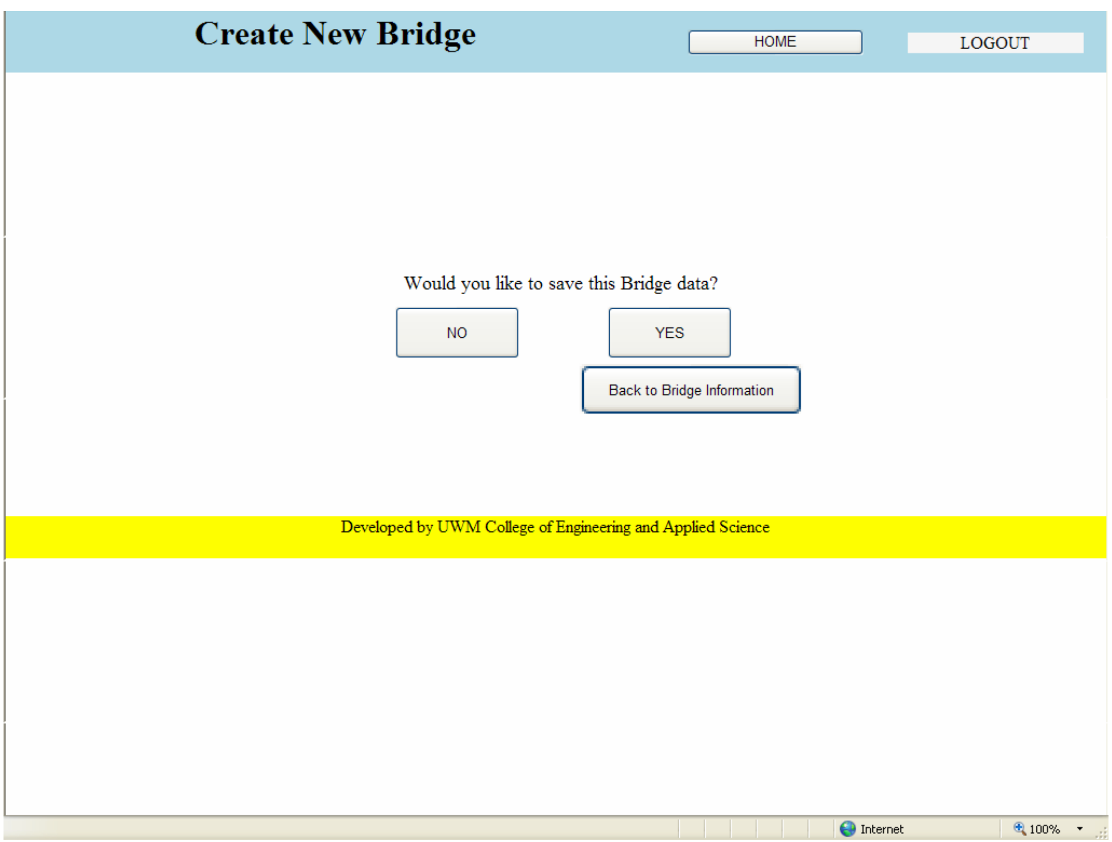
The user now has the option to manage Case History Documents or Bridge Structure Information. The choices for managing Case History Documents are discussed in section III.2.B.ii. The choices for managing Bridge Structure Information are discussed in section III.2.B.iii.

III.2.B.i Create a New Case History and Bridge Structure Information Element

If a MANAGER or an ADMINISTRATOR inputs a new bridge number in the "Manage Case History Documents and Bridge Structure Information" screen the user will be required to initiate a Bridge Structure Information document. To enter data for a Bridge Structure Information document the user will progress through a series of "Create New Bridge" screens. These are:

1. Basic Bridge Information.
2. Abutment Data (Cardinal).
3. Abutment Data (Non Cardinal).
4. Bridge Geometric Data.
5. Bridge Capacity.
6. Bridge Construction.
7. Bridge Misc.
8. Bridge Hydraulic Data.
9. Information Processing.

On each of the first eight screens the user inputs the requested data. The data can be obtained by reference to the "Bridge Inventory" and "Inspection" records located in the WisDOT HIS files. On pages 1 – 8 a NEXT button will take the user to the next screen after completion of data input on that page. On pages 2 – 8 a BACK button will take the user to the previous screen. Also, on each screen the user will have the option of using the HOME or LOGOUT buttons. The last screen (# 9) of the "Create New Bridge" series is shown below.



In this screen the user has the option of saving the new bridge data, not saving it (canceling the process) or returning to the first “Create New Bridge” screen. If the user clicks on the NO button the “Main Information Screen” (see section III.2) will appear. If the user clicks on the YES button the second document screen described in section III.2.B is presented. If the user clicks on the “Back to Bridge Information” button page 1 of the “Create New Bridge” sequence reappears. Lastly, the user can click on HOME or LOGOUT if desired.

III.2.B.ii Manage Case History Documents

If a MANAGER or ADMINISTRATOR wishes to manage Case History Documents they can proceed with three options. These are to "Get EXISTING Case History Document', "Add NEW/UPDATED Case History Document", or "View Case History Document Archive".

When the user clicks on the "Get EXISTING Case History Document" button the usual Microsoft WORD File Download screen will appear. The user can now proceed in the same manner as discussed in section III.2.A when "viewing" a case history document. The user can edit the WORD documents in the usual manner. The process flow diagram that is inserted into the case history is a JPEG file and cannot be modified. If a change in the diagram is required the user will need to contact the system administrator to make suitable arrangements for diagram editing. The user should edit and store the modified document at an offline site.

When the user clicks on the "Add NEW/UPDATED Case History Document" button an overlay screen will appear. This screen is also titled as "Add NEW/UPDATED Case History Document" and contains instructions for uploading the new or revised case history document. Three buttons are provided; "Browse", "Upload", and "Close". To add a case history document to the database the user performs the following actions.

1. Click Browse
2. Browse to Case History Document
3. Highlight the document and Click Open
4. Click Upload
5. Wait for response
6. Close

After completing these steps a new case history document will be loaded as revision 1, an updated case history document will be loaded with the revision number increase by one and the previous version is added to the database archive.

If desired, the user may view all previous versions of the case history document that are archived in the database. When the user clicks on the "View Case History Document Archive" button an overlay screen titled "Case History Archive" appears. This screen contains a listing of all archived versions of the case history document for the specified bridge. Included in the listing are the version number, the date archived, the document name, and the document type for each revision. By clicking on the appropriate "Select" tab the user can view the appropriate version of the document. If the user is an ADMINISTRATOR a "Delete" tab also appears. By clicking on the "Delete" tab all unwanted versions in the archive are permanently removed from the database. By clicking on the CLOSE button the user is returned to the screen for managing case history or bridge structure information documents.

III.2.B.iii Manage Bridge Structure Information

If a MANAGER or ADMINISTRATOR wishes to manage Bridge Structure Information they can proceed with two options. These are “View Bridge Structure Information” and “Edit Bridge Structure Information”.

When the user clicks on the “View Bridge Structure Information” button the usual Microsoft WORD File Download screen will appear. The user can now proceed in the same manner as discussed in section III.2.A for viewing case history or bridge information files.

When the user clicks on the “Edit Bridge Structure Information” button a screen titled “Edit Bridge Information” will appear. The series of screens under “Edit Bridge Information” are similar to those that were used to create a new bridge database element. (See section III.2.B.i.) In this case the screens will already contain existing information on the structure and at the bottom of each screen there is a button labeled “Go to Submit page”. By clicking on this button the user is taken to the final screen in the series and can either submit the changes, reedit the document, or cancel the process. If the changes are submitted the previous Bridge Structure Information document is permanently modified. There is no archive for these documents.

III.2.C Administrative Activities

Only an ADMINISTRATOR can perform activities that modify the database processes. Several of these activities have already been mentioned in previous sections of this manual.

In section III.2 it was noted that an ADMINISTRATOR would see the SETTINGS button on Main Information Screen. After clicking on this button a screen appears with “Create New User” and “Delete Existing Users” areas. To create a new user the administrator inputs the user name, a password, confirms the password, inputs the users E-mail address, and then includes a security question and the appropriate security answer. Clicking on the “Create User” button adds the user to the roster. The other area lists all of the usernames and E-mail addresses with a “Delete” tab. Clicking on the “Delete” tab and confirming the desire to delete permanently removes the user from the roster.

In section III.2.B the process for an ADMINISTRATOR to delete all documents for a specific bridge from the database. In section III.2.B.ii the process for deleting entries in a case history archive for a specific bridge are discussed.

Appendix 7.4: Implementation Plan

WisDOT Research

Wisco

0

Wisconsin Department of Transportation

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Pat Casey, Communications Consultant

53.0

Implementation of Research Results

Project Information	
Project Title: Bridge Integrated Analysis and Decision Support System: Case Histories	**Project ID:** 0092-04-15 **Today's Date:** 08/15/07
Technical Oversight Committee (WHRP or COR): WHRP Structures TOC	**TOC Chair and Phone number:** Scot Becker
Project Start Date: 09/01/2004	**Approved Contract Amount:** $100,000
Project End Date: 08/31/2007	**Final Project Expenditures:** $100,000
Reference Final Report Draft Dated: August 2007	
Principal Investigator: Al Ghorbanpoor **Organization:** University of Wisconsin-Milwaukee	**Phone:** 414-229-4962 **E-Mail:** algh@uwm.edu

This research resulted in sixteen case histories of bridge incidents for Wisconsin bridges. The new database of bridge incident case histories may be accessed through web and searches may be made using keywords. The results of this research study are intended to be used in a follow up study to develop a decision support system to aid bridge engineers to take appropriate actions in emergency cases involving bridges. As such, no implementation plan is presented here.

Technical Oversight Committee Recommendations	
1. Check one of the two choices below **☐ Yes. We recommend changes to current practice based on <u>some or all</u> of the results of this report. The research was sound, and the report's conclusions appear to offer an advance over current practice.** **☐ No. We do not recommend changes to current practice at this time. This approach does not appear fruitful OR future study is needed OR our objectives have changed, etc.**	
2. If implementation <u>is not recommended</u>, we suggest the following actions instead:	
3. If implementation <u>is recommended,</u> we suggest the following <u>specific</u> changes to current practice, detailed on the <u>attached work plan and timeline</u> (check applicable items): **☐ Standard Specifications** **☐ Quality Management Program (QMP) Specifications** **☐ Facilities Development Manual (FDM)** **☐ Highway Maintenance Manual** **☐ Training, outreach** **☐ Other (describe):**	
4. Approval of this implementation plan by the Technical Oversight Committee (chair on behalf of entire committee):	**Signature:** **Date:**
5. Approval of this implementation plan by the Council on Research (for COR approved projects):	**Signature(s):** **Date:**
6. Referral for development of detailed work plan and timeline to (check one):	**☐ WisDOT/Industry Technical Committee on:** ____ **☐ Other WisDOT policy body:** ____
7. Approval of work plan and timeline by the WisDOT Bureau Director(s) responsible for the policies described in item #3 above:	**Signature(s):** **Date**
8. Acceptance by a project manager of the responsibility for completing these implementation efforts according to the attached work plan and timeline:	**Signature:** **Date:**

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Implementation Work Plan	
1. Project Title:	**2. Prepared by:**
1. Scope and objectives of implementation, including specific changes to WisDOT procedures.	
2. Estimated cost (if any) to implement.	
4. Expected benefits and how they will be measured (dollar savings, time savings, other).	
5. Possible pitfalls and how they will be avoided.	

Implementation Timeline (Gantt Chart)												
Tasks/Person Responsible												

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