International Journal on Recent and Innovation Trends in Computing and Communication
Volume: 5 Issue: 6

ISSN: 2321-8169
426 – 431

Feasibility and Stability of Steel Girder Bridge on Basis of Corrosion

Reshma Biswakarma
M.Tech Student, Civil Engg. Department,
Indo Global Coleges, Abhipur,
Chandigarh India
e-mail: Sapkotareshma27@gmail.com

Er. Manjit Kaur
Assistant Profesor,Civil Engg, Department
Indo Global Coleges, Abhipur,
Chandigarh India
e-mail: manjitscience@rediffmail.com

Abstract— This study is focused on evaluating of a composite steel girder bridge structural. The reliability indices have been calculated for a specified bridge in Nebraska State which had corroded girders. The problem of corrosion was dealing with as outcome of a long time exposure where the environmental impacts take place. The increasing number of deteriorating infrastructures (bridges) needs more attention from the designer's aspect. In parallel action, the evaluation procedure and rehabilitation process are becoming important topics in bridge field. The steel girder bridges are the typical structures in the highways system. The targeted steel girder bridge has been evaluated in this research through ultimate and service limit states. According to results, the designed live load capacity may be influenced; it is simply depend on the size of the affected area and corrosion rate. The corrosion penetration was determined according to (Park, 1999) data for the steel girder.

Keywords*-component; Steel Girder Bridge, Corrosion, Stress &Physical Analysis.*

*****

I. Introduction

The profound changes in civil engineering over the last few decades were reflected by ideas of uncertainty recognized in civil engineering today. The recent advancement in statistical modeling has been provided by civil engineering by an increased power of making decisions under different degrees of uncertainty. Confidence should be placed in the ability of engineer emphasize any existing information when it is required because it is impossible to get sufficient statistical data for any existing problem. The estimation of structural reliability would be related to specify failure modes because it is impossible to examine all failure modes for structures, therefore representative failure scenarios should be chosen.

In designing structures, civil engineers use a probabilistic evaluation for reliability instead of using their desirable performance under applied loads during construction and service.

II. Objectives

1. Critical linkage between the design and preservation communities by correlating the element-level behavior to the system-level response under the effect of different damage scenarios.
2. The numerical modeling approach implemented in the proposed framework also has the potential to explore the implication of advances in material, design methodologies
3. Construction practices on the long-term performance of bridge superstructures.

III. Methodology used

Step1: Numerical Modeling and Analysis

- Intact Element-Level Validation
- Intact System-Level Validation
- Damaged Element-Level Validation
- System-Level Damage Integration

Step2: System Performance and Safety Assessment

- Member Failure
- Ultimate Limit State
- Functionality Limit State
- Damaged Condition Limit State

Step3: Evaluation of Results, Conclusions and Recommendation

IV. Problem Formation

Despite successful implementation of these methods, the lack of a rational understanding of the system-level behavior of in-service structures, especially in the presence of damage and deterioration, makes resolving this problem even more complicated. This constraint, coupled with limited resources and the vast network of existing structures in service, highlights the need to develop systematic strategies to help engineers better understand the system performance and estimate the remaining service life of these structures, while facilitating and supporting maintenance/preservation decision making process. Project aims to present a performance-based numerical modeling framework that can be used to evaluate the behavior and identify the failure characteristics of in-

ISSN: 2321-8169
426 – 431

service bridge superstructures under the impact of common deteriorating mechanisms. Representative numerical models, ranging from basic levels of intact bridge components to more complicated levels of bridge systems with both intact and damaged configurations, were generated based on available experimental data in literature. Critical to this investigation is the strategy to leverage simulation techniques and appropriately integrate the effects of existing deteriorating conditions into the measure of system performance. Upon validation of the proposed simulation approach, the methodology was implemented to study the performance parameters, including ultimate capacity, redundancy, and operational safety, of representative in-service composite steel girder and pre stressed concrete girder bridges under the of various damage conditions. It is expected that the developed framework will provide a first step for establishing a critical linkage between

Design, maintenance, and rehabilitation of highway bridges, which are uncoupled in current practices.

V. SYSTEM ANALYSIS

The bridge design depends on the prime load combination of dead load, live load, environmental load and other specific loads. The dead load components contain the deck (slab) weight, wearing service weight and barriers weight. Live load is divided into two components, static and dynamic. The moving truck represents the live load value such as HS20-44 from AASHTO-LRFD design code. In addition, the dynamic impact (IM) is added to live load as design requirements. The environmental loads included temperature, wind and earthquake. The last ones are the specific loads, which include collision and emergency braking. The development of load models using the available statistical data were demonstrated by Nowak (1995-2013). Nowak used the reliability theory to develop the design of bridges. The load components have been treated as random variables. Different components of load and resistance have a relation that has been modeled as probabilistic data.

In this study, the major loads of the considered bridge were modeled, and the load combination represents the highway bridge loads simultaneously. Practically these loads are dead load, live load and dynamic load. All other load components will not be considered in this study, as it requires a special area of research.

VI. RESULT & ANALYSIS

The steel girder bridges inadequacies require more investigation to improve the design and the material selection. One of the important disadvantages in steel bridges is time dependent corrosion. Thus, the structure component encounters increasing traffic and capacity loss. As corrosion damage will degrade the cross section of composite steel girder. The impact of corrosion on the internal forces (shear and moment) depends on the location of cross section, which means corrosion will be measured separately according to difference in damage between the two locations, the support and mid span. However, when corrosion has the same volume, it will consider one cross section for analyzing.

In this study, the corrosion deterioration mostly appeared at girder supports. However, the mid span cross section will be less affected. It seems that the bridge has a deck leak at the cross section where the abutment is contacting the bridge. In this chapter, linear analysis has been applied to the girder cross section to evaluate the reduction capacity in the moment (bending), the shear, and the bearing.

(a) Girder Deterioration Model

The corrosion model should not be the same in every place, the situation of one bridge site is different from another so, the corrosion pattern will be different also. The typical corrosion model of steel girder has been introduced by Kayser in 1988. Figures 5.1 and 5.2 represent the corrosion model of them at the support (shear section) and mid span (moment section) respectively.

The corrosion penetration of steel has been estimated then, its effect on the cross section of steel girder at support and mid span has been calculated. Moreover, the load carrying capacity for bending moment and shear in girder is calculated by assuming that the two models have been represented a real application relatively.

In this study, the models have been used to calculating the effected properties of corroded steel girder adopted from (Kayser, 1988). On the other hand, (Park 1999) developed the models mathematically by adding deferent dimensions criteria to calculate the affected area. Then, the models have been divided into three types of model depending on the corrosion pattern.

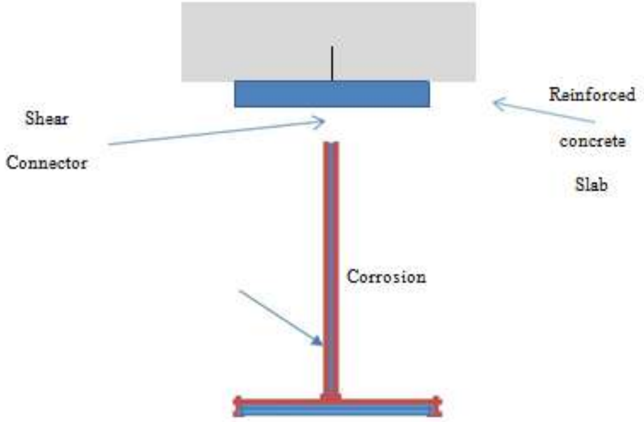


Figure 4.1: Composite Steel Girder Corrosion Model of Cross Section at Supports.

ISSN: 2321-8169
426 – 431

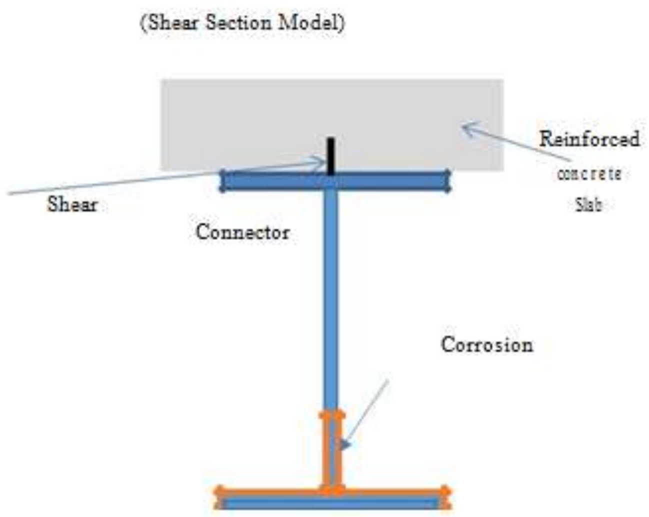


Figure 4.2: Composite Steel Girder Corrosion Model of Cross Section at Mid Span. (Moment Section Model).

(b) Bridge 1 Specifications

The data of bridge has been received from Hawarda (NHPL) as in the following:

- Simple Span Bridge with 50 ft builds in 1989.
- 8 girders of W 27x94 A36 steel.
- Composite deck, 6.5 in thickness and fc=12000 psi.
- 1.5 in Hunch above girder.
- 2 in wearing surface.

(c) Bridge 2 Specifications

The data of bridge has been received from bihar (above river soon) NHPL Department of Roads as in the following:

- Simple Span Bridge with 50 ft builds in 1993.
- 8 girders of W 30x104 A46 steel.
- Composite deck, 6.5 in thickness and fc=6000 psi.
- 2 in Hunch above girder.
- 4 in wearing surface.

d)Reduced Cross Section

Due to corrosion penetration in the steel girder bridge the dimensions of cross section will decrease following the loss of material at specific location. This will reduce the area of cross section as a function of dimensions. In addition, moment of inertia will be reduced as it a function of area. Girder load carrying capacity will be decreased depends on the type of corrosion (low, Medium, and High). The corrosion level as low, medium, and high has a distinguished differently accords to the Figures 5.3 and 5.4, which are shown the reduction in cross section with deferent corrosion level. Also, a big difference in area reduction between supports cross section (shear section) and mid span cross section (moment section). This is according to the difference of the considered corrosion models as clarified in Figures 5.1 and 5.2.

(e) Shear Capacity

The resistant to shear load capacity may be effected by corrosion, as the resistance to shear in girder primary performed by the web part. The design of web is according to the theory of elastic non-buckling stress. Therefore, the thinner steel girder web is not preferable to avoid the slenderness. The application to examine the slender web is highly recommended. To check the web panel at supports (shear critical section), the plate buckling theory should be investigated. The section of the web should be modeled according to that theory. Figures 5.5 through 5.7 have shown the percentage of the remaining shear capacity with different levels of corrosion.

(f) Bearing capacity

The steel girder resistance to loading forces may decrease due to corroded web section, which directly above the supports. The corrosion has an impact of bearing since the web section will be reduced and there is no presence of stiffeners to support the web to resist the bearing reaction. The installation of stiffeners is needed if the nominal shear load is more than 0.75 of the shear capacity design (AASHATO-LRFD). Therefore, for most cases when installing a new girder, it has enough carrying capacity to resist shear forces. However, due to deterioration caused by corrosion, the stiffener option may be mandatory to be installed. The evaluation of bearing capacity in this study has been done by plate theory calculation as the web section at supports resist the stresses of bearing. This section has been modeled according to the plate theory assumptions. The length of web bearing assumed to be as the width of flange that is approximately dominated for most design cases. Some researches add the flange thickness and the web fillet also. In this study, the bridge under investigation has been designed without bearing stiffeners. The following Figures 5.8 through 5.10 show the bearing capacity reduction versus the web section loss.

(g) Moment Capacity and Bending Stiffness

The design limit state of simply supported composite steel bridge girder in bending assumes three criteria of failure as in the following:

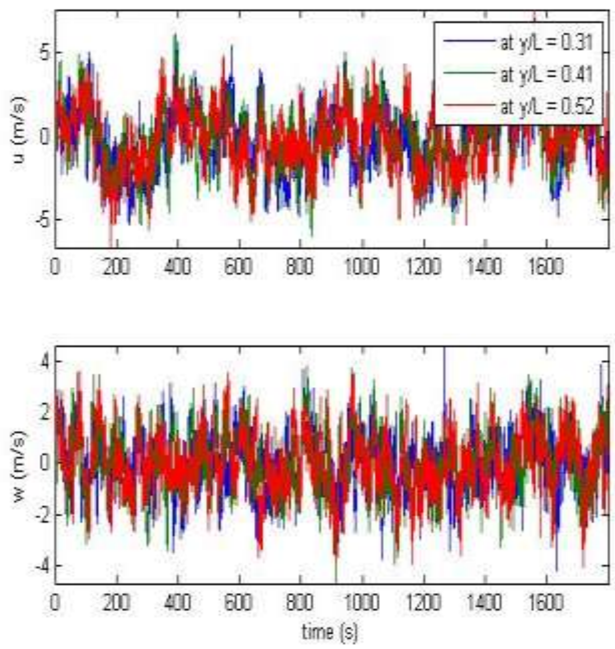
ISSN: 2321-8169
426 – 431

1- The stress exceeds yielding of steel failure.
2- Damage of concrete.
3- Getting out of slab for shear connectors.

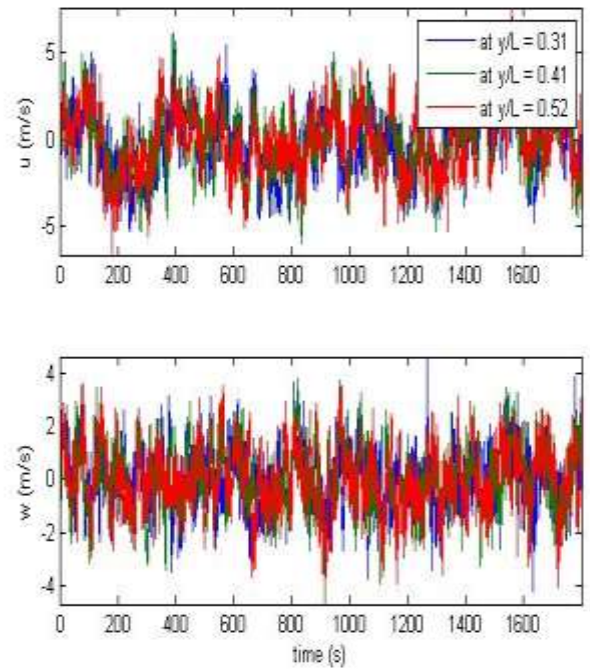
According to the standard bridge design of composite steel girder, the steel is approaching the yielding limit before the concrete starts to smash, which is caused by the failure of concrete that takes place at average strain scale of 0.00325 also, the ductile property in failure of steel has to consider. On other hand, getting out of slab for shear connectors is rare(no significant history).

Therefore, the type of failure will be steel yielding when reaching the ultimate capacity. The bending stress has been evaluated for the steel girder of composite section. The steel girder analytical model has been constructed with slab as a composite section behavior. The slab section needs to be converted as a steel component and required to find the effective width of the slab segment over the girder. The AASHTO-LRFD code provides three formulas for effective width of slab segment and the lower value will dominate. In addition, from the structure point of view, the assumption of plane section before bending remains plane after bending. The bending capacity has been calculated versus flange loss and the bending stiffness (EI) has been estimated in this study. The Figures 5.11 through 5.16 show the reduction in bending behavior.

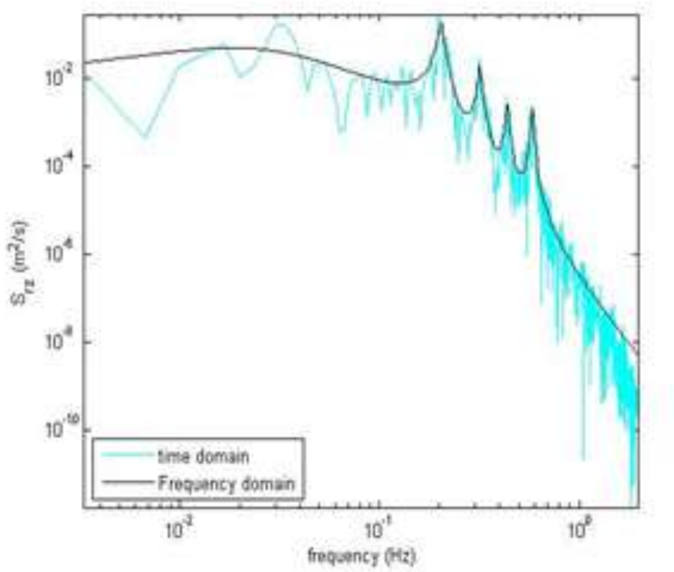
Graph 4.10: Reduction in Moment Capacity with Flange Loss for Low Corrosion for Bridge2.



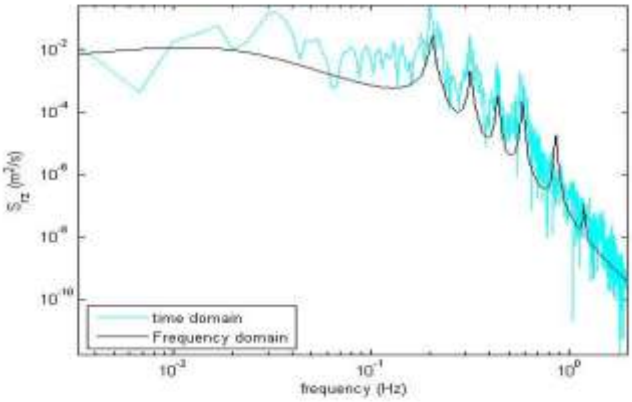
Graph 4.11: Reduction in Moment Capacity w ith Flange Loss for Medium Corrosion
For bridge1.



Graph 4.12: Reduction in Moment Capacity with Flange Loss for Medium Corrosion
For bridge2.



Graph 4.13: Reduction in Moment Capacity with Flange Loss for High Corrosion For bridge1.



(h) Evaluation of the Bridge

The HS rating factor of AASHTO-LRFD code has been applied to evaluate the bridge for low, medium and high corrosion using HS20-44 truck as live load vehicle. The bridge is a simple span of 50 ft. The girder type is A36 steel with cross section of W27x94 with 5 girders in the bridge cross section. The concrete slab thickness is 6.5 inches. The capacity was determined based on the pervious composite steel girder corrosion model that was used for moment and shear behavior calculations (for composite section). Figures 5.17 and 5.18 represent the obtained results.

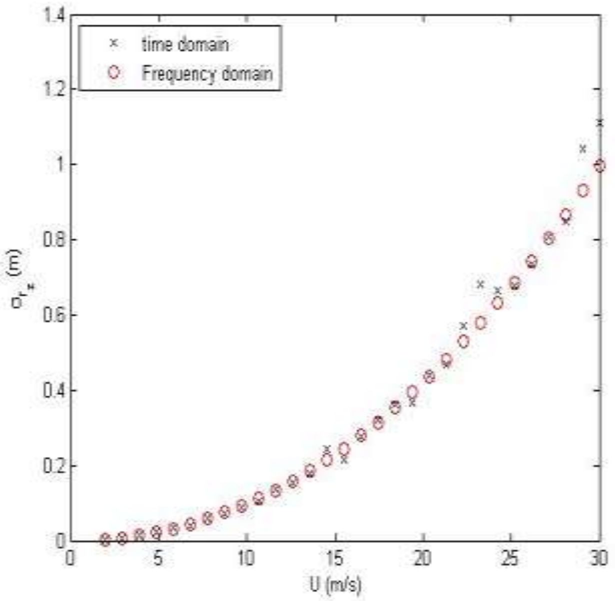


Figure 4.18: HS Rating Factor versus Years of Exposure of Moment for bridge1.

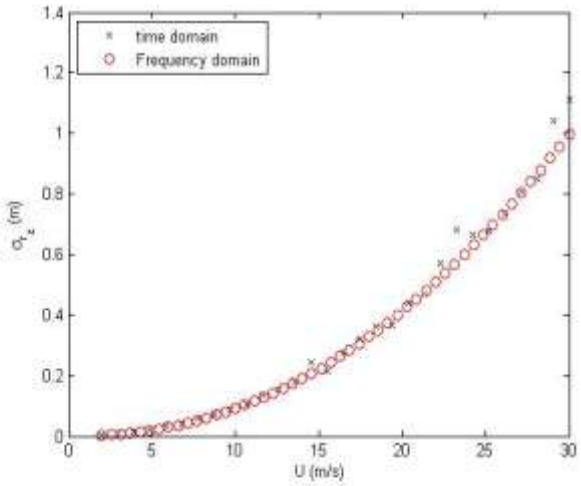


Figure 4.19: HS Rating Factor versus Years of Exposure of Moment for bridge2.

VII. CONCLUSION

The main conclusions of this research are outlined as follows:

- This research showed that the reliability can be considered as a rational measure of performance for structures in the bridge design and for the evaluation of an existing bridge.
- MATLAB software girder simulation presented the large stresses affecting the lower flange of the steel girder Therefore, using the steel plate is an economic way for the design and maintenance.
- The reliability analysis procedure was demonstrated on a corroded composite steel girder of a specified bridge in bridge.

VIII. FUTURE WORK

- Further work related to corrosion with reliability analyses, the system reliability of bridges can be considered instead of component reliability analysis.
- In addition, as an advantage of this analysis the live cycle cost needs to be considered.

For evaluating the effect of corrosion accurately, the non-destructive testing method of bridges should be recommended in this analysis

REFERENCES

[1] AASHTO LRFD Bridge Design Specifications (2012). “American Association of State Highway and Transportation Officials”, Washington, D.C. ACI 318-12 (2012). “Building Code Requirements for Structural Concrete,” American Concrete Institute, Farmington Hills, Michigan.

[2] AISC 325-11B (2011). “ Steel Construction Manual, Fourteenth Edition,” American Institute of Steel Construction, Chicago, IL

ISSN: 2321-8169
426 – 431

[3] Allen, T.M., Nowak, A.S. and R.J. Bathurst (2005) . “Calibration to Determine Load and Resistance Factors for Geotechnical and Structural Design”. TRB Circular E-C079, Transportation Research Board, Washington, D.C

[4] Anderson B. J., Townsend F. C. and Rahelison L. (2007).”Load Testing and Settlement Prediction of Shallow Foundation.” J. Geotech. Geoenv. Eng., vol. 133, No.12, 1494-1502.

[5] Ang, A.H-S. and Tang W.H., (2007). “Probability Concepts in Engineering”, John Wiley & Sons, Inc.

[6] ASCE 7-02 (2002), “Minimum Design Loads for Buildings and Other Structures”, SEI/ASCE 7-02, American Society of Civil Engineers, Reston, VA, 2002, 376 pp.

[7] Albrecht, P., and Naeemi, A.H. (1984), “Performance of weathering steel in bridges,” National Cooperative Highways Research Program, Report 272, TRB, Washington, DC.

[8] ASCE “2013 report card for America’s infrastructure” Reston, VA. www.asce.org/reportcard, 2013.

[9] Ayyub, B.M. and McCuen, R.H. (1997). “Probability, Statistics, & Reliability for Engineers”, CRC Press, New York.

[10] Benjamin, J. R., and Cornell, C. A. (1970). “Probability, Decision, and Statistics for Civil Engineers”, McGraw-Hill, New York.

[11] Cornell C.A. (1967). “Bounds on the Reliability Structural Systems”, Journal of the Structural Division, ASCE. Vol. 93, pp. 193-200.

[12] Cornell C.A. (1969). “A Probability Based Structural Code”, ACI Journal , Vol. 66, pp. 974-985.

[13] Czarnecki Arture (2006). “System Reliability Models of Corroded Steel Girder Bridges“, Ph. D. Dissertation, University of Michigan.

[14] Ditlevsen O. and Madsen H.O. (1996). “Structural Reliability Methods”, John Wiley & Sons Inc., New York.

[15] Ellingwood, B., Galambos, T.V., MacGregor, J.G. and Cornell, C.A., (1980) “Development of a Probability Based Load Criterion for American National Standard A58”, NBS Special Report 577, U.S. Department of Commerce, National Bureau of Standards.

[16] Kayser R. Jack, (1988) “The Effects of Corrosion on the Reliability of Steel Girder

[17] Bridges”, Ph. D. Dissertation, University of Michigan.

[18] Nowak, A.S., (1995). "Calibration of LRFD Bridge Code", ASCE Journal of tructural Engineering, Vol. 121, No. 8, pp. 1245-1251.

[19] Nowak, A.S., (1999). "Calibration of LRFD Bridge Design Code", NCHRP Report 368, Transportation Research Board, Washington, D.C

[20] Nowak, A.S. and Szerszen, M.M., “Calibration of Design Code for Buildings (ACI 318) Part 1: Statistical Models for Resistance”, ACI Structural Journal, Vol. 100, No. 3, 2003, pp. 377-382.

[21] Nowak, A.S. and Collins, K.R. (2013). “Reliability of Structures”, McGraw-Hill, NewYork.

[22] Park , Chan-Hee (1999). “Time Dependent Reliability Models for Steel Girder Bridges“, Ph. D. Dissertation, University of Michigan.

[23] Thoft-Christensen, P. and Baker, M.J. (1982). “Structural Reliability Theory and Its Applications”. Springer-Verlag.