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Numerical Investigation on the Seismic Response of a Steel Girder Bridges using Stainless Steel

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Abstract - *Steel structures, especially steel girder bridge, are subjected to corrosion in outdoor environments not only in Japan but also all over the world. For Bridges constructed by Conventional Carbon Steel (CCS), the deteriorate mechanism of the materials specifically the corrosion and aging of the secondary steel members is of great importance and major concern. Another important concern is the seismic load path in the transverse direction of a Steel Bridge. However, various methods have been proposed in the past as a seismic design and retrofit strategy for Steel Girder Bridges. In this study, stainless steel implement to secondary members such as sway or lateral bracing in the transverse direction as an alternative to the CCS bridges.*

***Key Words*: Steel Girder Bridge, Conventional Carbon Steel, Stainless Steel, Secondary Member, Corrosion, Seismic Load.**

1. INTRODUCTION

Steel girder bridge is one of the most common infrastructures in the civil engineering aspects that greatly elevate the economic prosperity and social life of a country. The local governments administrate 68% of the steel bridges used in Japan. During recent years, steel bridges constructed by CCS where the durability of load bearing steel members is of great importance and major concern. It causes deterioration of the structure and induces high maintenance & repair costs. As a result, it is degraded functionally. This is due to the fact that maintenance constitutes a substantial part of the overall cost of the bridge. Therefore, Bridge Engineers, as well as Owners are concerned about the durability of load bearing steel members, cost and liability caused by corrosion and aging. So, the largest part of the total cost for CCS bridges is associated with the maintenance and renovation of the protective layers. For reducing the cost of maintenance and other issues, non-corrosive reinforcement like stainless steel may be replaced as an alternative to the CCS. Commonly, stainless steel has not been used for load bearing structures due to the higher initial cost of stainless steel. In addition, the construction industry is unfamiliar with stainless steel as a structural material. Stainless steels have been increasingly used in bridge construction since the year 2000. Actually it is highly corrosion resistant and attractive, while having good strength, toughness and fatigue properties in combination with the low maintenance requirements over the CCS. Although a lot of research conducted about the material properties of stainless steel and its application to structural members, a few types of research has been found about the application of stainless steel in steel bridge system. Therefore, this study clarifies the practicability of the girder bridge especially secondary members replaced by the stainless-steel is evaluated by comparing to CCS bridges with respect to the failure loads, failure modes, enhancement of load carrying capacity and the energy absorption capacity of stainless-steel sections by numerical investigation.

2. METHODOLOGY

In the current research, the transverse seismic performance of a plate girder superstructure is investigated using a three-span model of a Steel Girder Bridge. In this context, this study considers the limited application of stainless steel (SUS304 and SUS316) to the steel bridge at the secondary member corroded or damage bracings in the transverse direction. Then, it performs a series of Linear and Nonlinear Static Analysis (NSA), Eigenvalue Analysis (EA) and Nonlinear Pushover Analysis (NPA) by Finite Element (FE) models using the DIANAIE 10.3.

3. DEVELOPMENT OF NUMERICAL MODELLING

The present study includes the transverse seismic performance of a plate girder superstructure using the three-span model of a steel girder bridge.

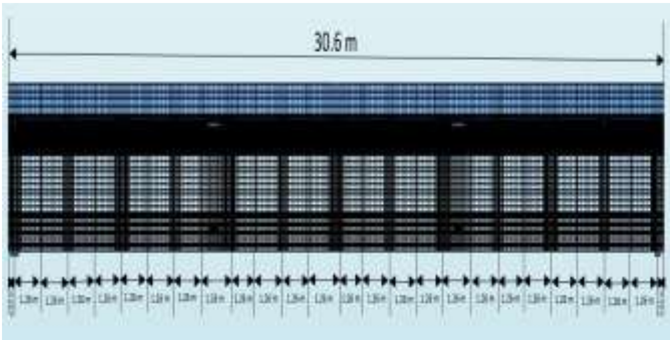

Fig-1: Longitudinal view of Steel Girder Bridge

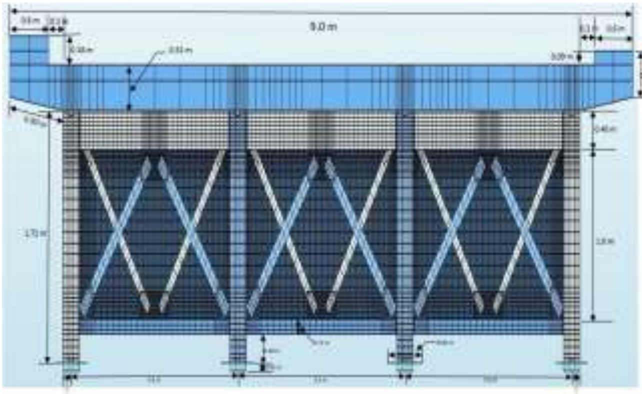

Fig-2: Transverse view of Steel Girder Bridge

The length of the model is 30.6 m long and each span is 2.6m, with the cross-sectional properties shown in (Fig-1 ~ Fig-2). The spacing of the vertical stiffeners is considered in the longitudinal direction as 1.26 m shown in Fig. 1. Also, a transverse main girder in the center part of the bridge and the diagonal bracing in the bottom level to connect the main girder with other parts are taken into a concern.

4. LITERATURE REVIEW

The focus of this research lies on the use of stainless steel to evaluate the performance of steel girder bridge. Compared to other more established materials, such as concrete and carbon steel, the construction sector is somewhat unfamiliar with the best utilization of stainless steel. Since stainless steel is poorly used as construction material, the full potential of stainless steel remains largely unexplored. In addition, practical guidance in codes and guidelines for the proper use of stainless steel is limited and dispersed. To ensure a viable alternative for structural engineering, it is to understand the use of stainless steel properly. Thus a steel girder bridge, where the secondary members of CCS replaced by the stainless steel, has been chosen to present important aspects of stainless-steel pertaining to bridge construction in a condensed form. This study is to create a solid foundation of the current knowledge about stainless steel as a construction material. As mentioned above, stainless steel has many desirable aspects in comparison with structural carbon steel.

In this research bridge analysis specifies the procedures and parameters used to simulate the seismic demand on the bridge structure in the form of imposed static and dynamic forces or displacements. The study provides an adequate and detailed methodology that allows the bridge researcher to conduct modal, gravity load, pushover, response spectra, time history analysis, and definition of additional parameters required for the different nonlinear analysis types. The guided documents represent ample recommendations for linear and nonlinear analysis of steel girder bridge structures appropriate for any structural analysis program, as well as specific details on the use of DIANAIE for such procedures. Additionally, a general review and definitions related to structural dynamics, applicable to both linear and nonlinear analysis, are presented throughout. The emphasis of the present research document is the implementation of nonlinear analysis procedures used primarily for the estimation of the demand on a bridge structure. The design engineer must determine the appropriate methods and level of refinement to analyze each bridge structure on a case-by-case basis. Moreover, the existing literatures and findings in steel girder bridge are based on the very small and simple structures to investigate damages and service life. On the other hand, current steel girder bridge is a large complex structure to eliminate the misunderstandings.

5. ANALYTICAL RESULTS

Results from NSA show that bridges with stainless steel can carry loads more than 80% prior to failure. On the contrary, the damaged steels don't reflect on the natural frequency and mode shaping. However, energy absorption capacity in the hysteresis loops (Chart-1) of the stainless-steel bridge model is approximately 70% higher in response to the cyclic force displacement incremental loading.

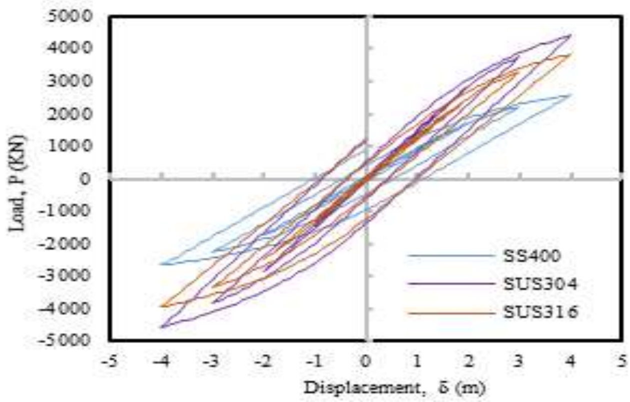

Chart-1: Hysteresis Loops of Load vs. Displacement (NPA)

5. CONCLUSION

It can be concluded from the numerical investigations that stainless steel has substantial effects as an alternative to carbon steel in the transverse sway members of the Steel Girder Bridges to increase durability, to control damage and to extend the service life.

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