



Prediction of Maximum Load Capacity of a Plain Concrete Arch Bridge Based on Limited Test Results

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ABSTRACT

Field testing of an old railway bridge at the 23rd km of Tehran–Qom railway showed important characteristics of the bridge such as initial stiffness, yield strength, nonlinear response, cracking pattern and the governing mechanisms of structural behavior. Nevertheless, due to the practical limitations of field testing, the ultimate load capacity of the bridge had not been determined. In this article, an attempt is made to use the limited test results to predict the maximum strength and nonlinear response of the bridge. Therefore, while the finite element method is used, the pattern of cracks is modeled. The load–deflection curve is determined and compared with the test results. The numerical results are calibrated with test data such that they are extended to better prediction respect to the limited test data. Consequently, the load–deflection curve up to the maximum strength, formation of four hinges in the bridge arch and the collapse mechanism of the bridge are predicted.

KEYWORDS

Plain Concrete Arch Bridge, Finite Element Modeling, Application of Track Pattern, Nonlinear Analysis, Estimation of Maximum Load.

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1- INTRODUCTION

Assessment of the remaining strength of arch bridges is one of the remarkable fields for engineers and researchers. In this assessment, the behavior of the structure in modeling should be considered. However, their complicated behavior leads to use the field testing as an important requirement.

In this paper, maximum load capacity of a plain concrete arch bridge is predicted based on the limited test results. The 70 years old railway bridge, located at the 23rd km of Tehran–Qom railway, has previously been tested and important characteristics such as initial stiffness, yield strength, nonlinear response, cracking pattern and governing mechanisms of structural behavior of the bridge have been recorded. Nevertheless, due to the practical and field limitations, ultimate load capacity had not been determined. In this study, prediction of the maximum strength and nonlinear response of the bridge using finite element analysis is performed. Numerical results are calibrated with the experimental data. Consequently, the numerical results are extended to the better prediction with respect to the limited experimental data.

2- METHODOLOGY

In this article, finite element method is used, pattern of cracks is modeled and the load–deflection curve is calibrated with the limited test results. So, the load–deflection curve up to the maximum strength is predicted.

The main contributions of the methodology are as follows.

- Case study of an important type of old bridges (i.e. plain concrete arch railway bridge).
- Numerical modeling based on the limited test results.
- Applying crack patterns to the numerical model for the calibration of the finite element analysis, in addition to the load test results.

3- CONCLUSIONS

This article provides numerical results to predict the maximum load capacity of a two span of 20 m plain concrete arch bridge which is located in the 23rd km of Tehran-Qom railway. The operational field loading accomplished on the bridge shows important characteristics such as initial stiffness, yield strength, nonlinear response ultimate until 7280 kN load, cracking pattern, and collapse mechanism of the bridge. However, due to the practical field limitations, ultimate load capacity had not been tested. This article attempts to reach the maximum strength and nonlinear response of the bridge using the limited test results. For this aim, the finite element method is used, and the pattern of cracks is modeled. Comparison of load-displacement curves obtained from numerical and experimental data demonstrates that the curves match each other in every stage as shown in Figure 1, therefore, the maximum strength is quantified as 13760 kN. This study also predicts the failure mechanism of the bridge that is shown in Figure 2.

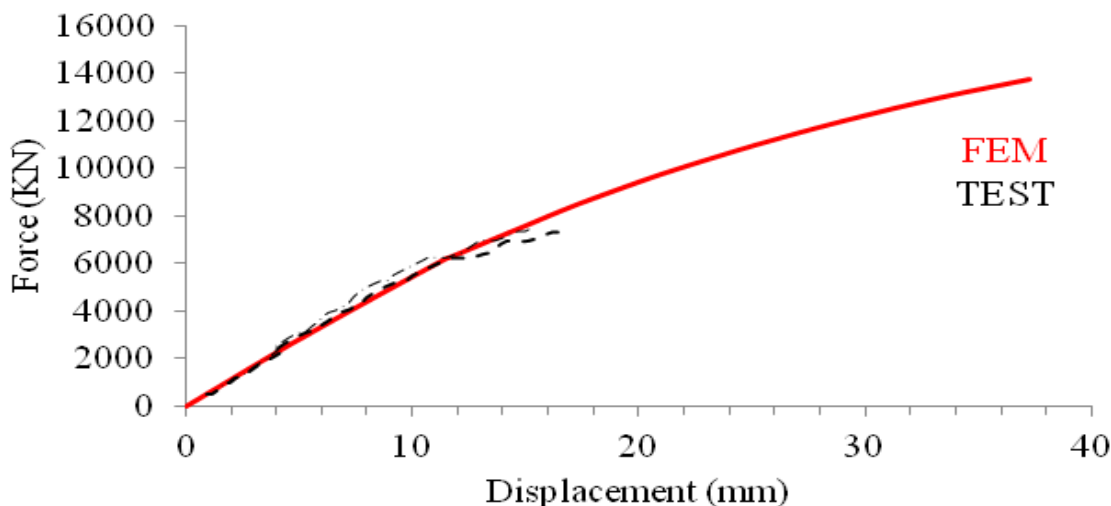


FIG 1. VERTICAL DISPLACEMENT OF BRIDGE 23 KM, AT THE BRIDGE CROWN, UNDER ESTIMATED ULTIMATE STATIC LOAD

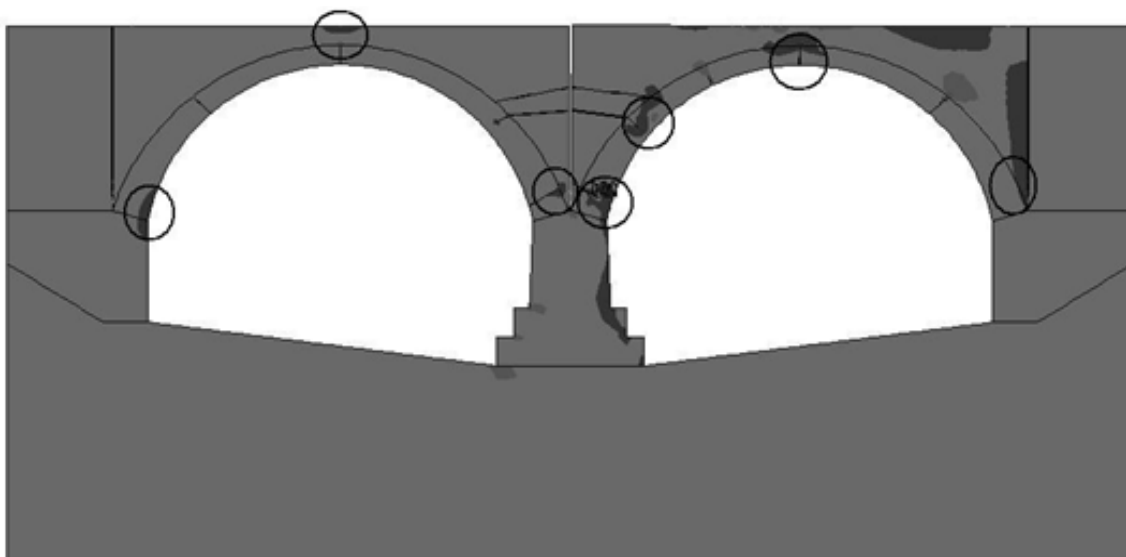


FIG 2. STRESS DISTRIBUTION AND COLLAPSE MECHANISM UNDER ULTIMATE CONDITIONS

4- REFERENCES

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