Stability Analysis of Gwangan Bridge considering Aerial Shell firework festival

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ABSTRACT

In this thesis, we analysed the displacement and dynamic characteristics of the bridge due to the repulsive force generated by the aerial shell from the deck of the bridge during the firework festival. The time history analysis was performed by setting the triangular shape impact load function during the repulsive force generated by the aerial shell during the firework festival. From a total of 7 types, 871 shots were considered as the impact load function of the time history analysis. The loading time of the time history load was matched with the actual launch point of the aerial shell. The analysis results were verified by comparing the measured data from GNSS, laser deflection system, inclinometer, accelerometer and structural analysis results at the corresponding points.

KEYWORDS: fireworks festival, aerial shell, time history analysis, acceleration response

1. INTRODUCTION

Fireworks festivals have been held on bridges all over the world, and the Kentucky Derby Festival has been held annually since 1990 in Louisville, North Kentucky, USA.
The festival hosts a fireworks festival on the top of the George Rogers Clark Memorial Bridge across the Ohio River (Kleber, 2001). In 2014, the fireworks festival was held at the Forth Bridge in Scotland and the Clifton Suspension Bridge in England.
The Busan Fireworks Festival has been held every year since 2005. Around one million visitors visit the Gwangan Grand Bridge every year to watch the festival.

In this paper, during the 9th Busan Fireworks Festival, Time history analysis was performed by considering the repulsive force generated as an impact load function from the aerial shell fired from the top of the bridge,

2. MAIN

2.1 Fireworks Festival Outline

The 9th Busan Firework Festival, which will be discussed in this paper, was held from 7 pm to 10 pm on October 26, 2013, and a total of 991 aerial shells were launched from the first lane of the land side of the Gwangan Bridge. The fireworks festival outline and the amount of Aerial shells are shown in Table 1 and Table 2.

Table 1. Event contents of the fireworks festival

Time	Event contents
19:40~20:00	Suspension bridge was closed
20:00~20:50	Fireworks festival(Shot aerial shells)
20:50~21:30	Site cleaning
21:30~	Suspension bridge was opened

Table 2. Classification according to aerial shell size

Size	3inch	4inch	5inch	6inch	8inch	10inch	12inch	16inch	Total
Count	120	130	190	270	65	85	117	14	991

2.2 Time history analysis

Time history analysis was performed considering the repulsive force applied to the bridge due to the aerial shell during the fireworks festival. The analysis execution time was set to 50 minutes (3000 seconds), and the damping ratio of the total bridge was set to 0.02.

There are 8 different types of aerial shells (3inch, 3inch, 5inch, 6inch, 8inch, 10inch, 12inch,16inch) and among these, excluding the most smallest repulsive force with 3inch, 871 shots were taken into consideration as the impact load function of the time history analysis. The impact load function over time is set as a triangular function and structural analysis was performed assuming the load duration to be 0.01 seconds.

The figure below shows the 12inch aerial shell load function when the load duration is 0.01 second.

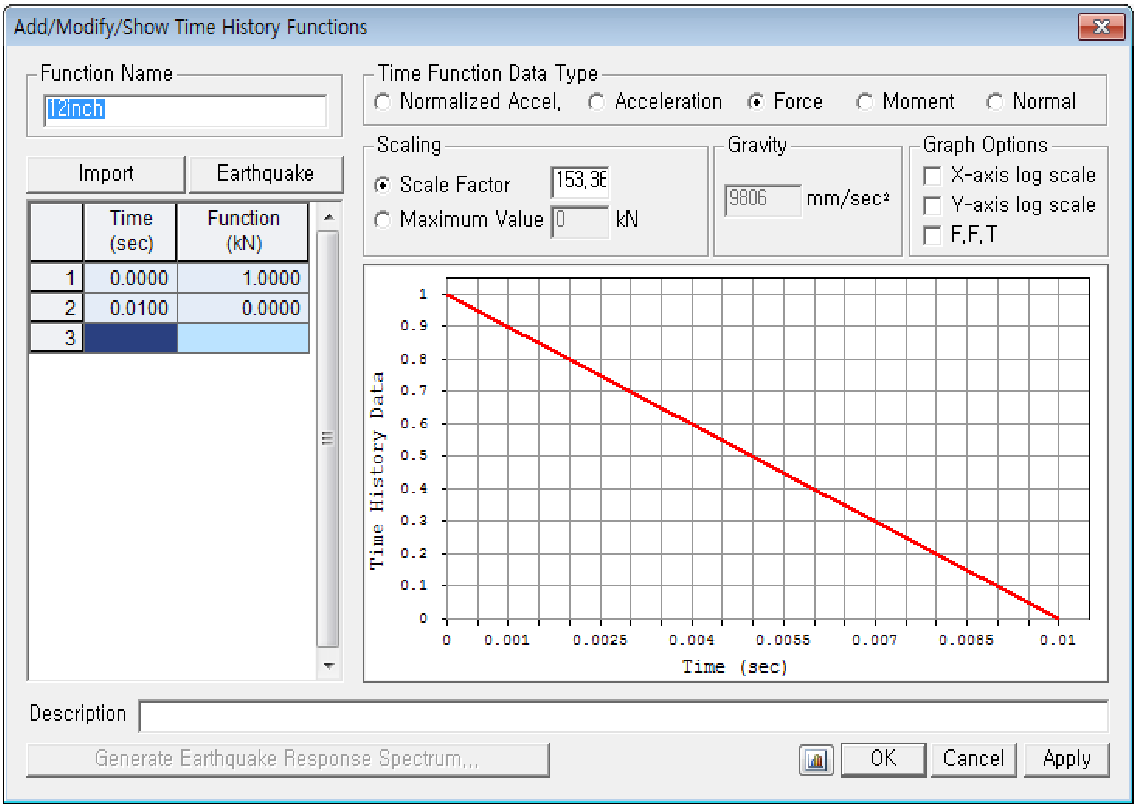

Figure 1. Load case of the 12inch aerial shell

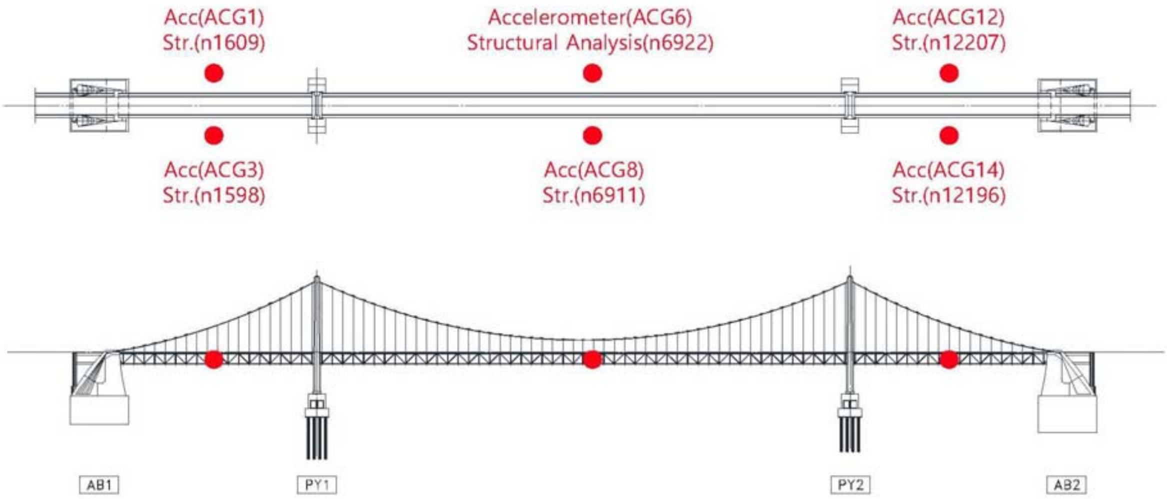

Figure 2. Acceleration measurement positions

We compared the accelerations derived from the structural analysis with the accelerometer signals installed on the bridge. Here, ACG1, ACG3, ACG6, ACG8, ACG12 and ACG14 are accelerometer data, and n1598, n1609, n6911, n6922, n12196 and n12207 are structural analysis data.

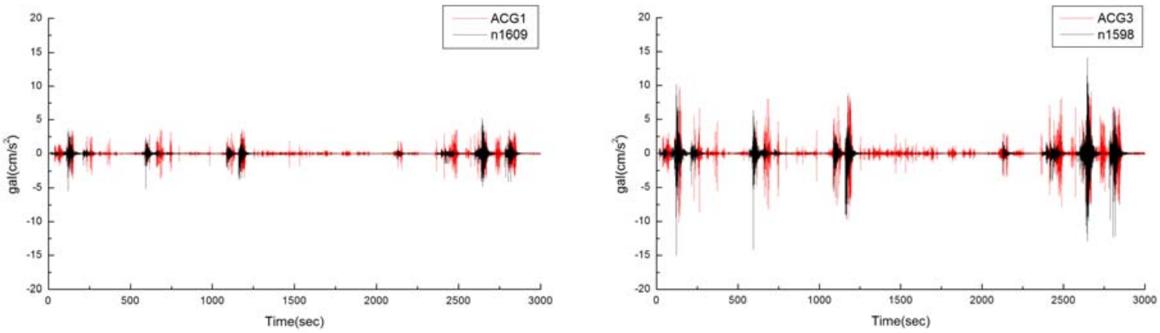

Figure 3. Acceleration data comparison at the side span near the PY1

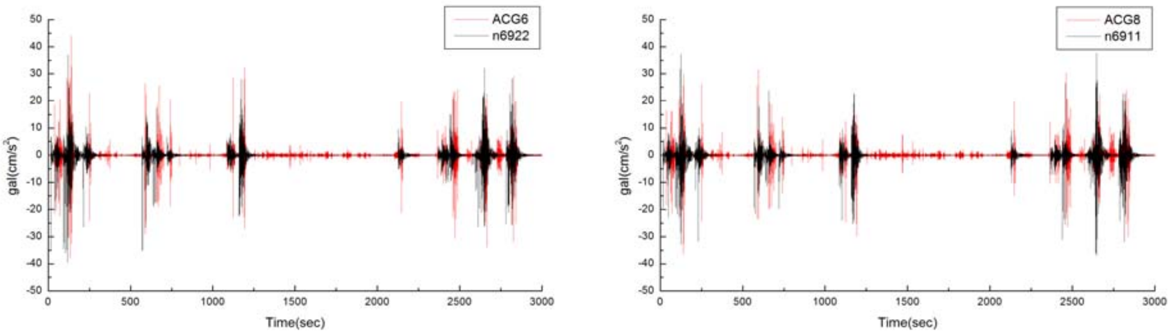

Figure 4. Acceleration data comparison at the middle span

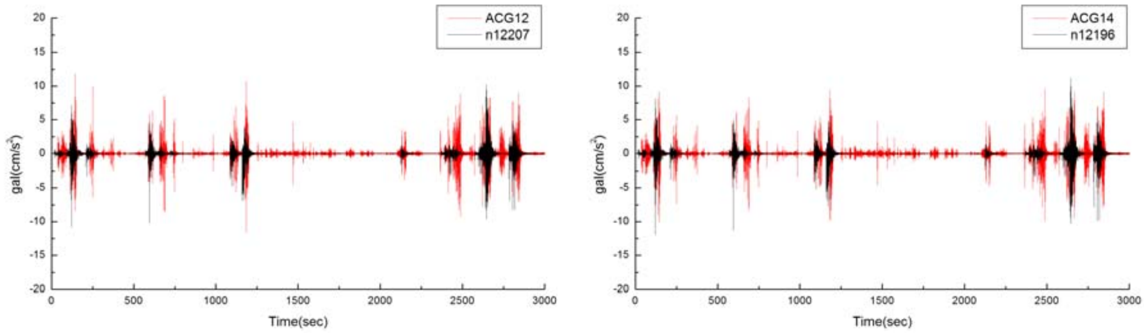

Figure 5. Acceleration data comparison at the side span near the PY2

3. CONCLUSIONS

If firing an aerial shell on top plate of the bridge, and by predicting the weight of the aerial shell and burst height in advance, we are able to predict the maximum acceleration and the natural frequency by using the time history analysis. It will be possible to review the bridge safety in advance by predicting the effects of the fireworks festival on bridges

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