Non-destructive and effective bridge monitoring through fast-falling weight deflectometer

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Abstract

Recent collapses due to hydrogeological soil instability caused by extreme climate events recall the attention on a large-scale monitoring of the road infrastructures, particularly bridges and viaducts. Several studies focus the attention on both hydraulic and structural issues. In-depth systematic investigations do not suit this purpose because of time and cost investments usually carried out from local authorities. Increasing needs of available fast, low cost and reliable methods to investigate the performance of the road and bridges pushed towards new applications. The use of Fast-Falling Weight Deflectometer, conceived for airport pavements, is here applied as a non-destructive test to evaluate the stiffness of the deck and embankment of a bridge. The-Fast Falling Weight Deflectometer can produce a broadband, constant and replicable dynamic force, providing data in real time. An experimental campaign is here described on a case study of single span bridge.

Keywords: bridge vulnerability, infrastructure monitoring, concrete degradation, aging, Fast Falling Weight Deflectometer, structural response, non-destructive test, health monitoring, aging effect.

1 Introduction

Depending on the construction period and on the technology, the aging of road infrastructures can produce critical situations. Recurrent damaged scenarios for bridges and viaduct are very spread: the evaluations of the public or private stakeholders play a strategic role in the economic activities. One of the most frequent causes of bridge collapses is the erosion of the embankment [1, 2] related to extreme climatic events [3–5]. The viaduct or overpass collapses (see the examples in Fig.1, 2, 3 occurred in Italy during 2016 and 2017) are frequently related to structural issue due to brittle behaviour of the supports or of the r.c. components. In Italy the collapse of the Morandi bridge (14th August 2018) caused 43 victims and 500 inhabitants had to evacuate. This tragic event attracted the international attention and forced a significant impulse on the monitoring of the road infrastructures: specific Guide-Lines have been published by the Italian Ministry of Infrastructures and Transportations [6] to address monitoring procedures.

As the following pictures (Figure 1 - Figure 4) shows, the vulnerability induced by aging, improper maintenance and ambient degradation are crucial aspects to be consider. Two recurrent mechanisms of collapse are explained: a brittle shear failure of the supports are depicted in Figure 1, Figure 2 and Figure 3, while Figure 4 represents the failure of the precast element of a prestressed r.c. beam.

Several methods are tuned to investigate bridge vulnerability with the aim to foresee possible collapses [7–9]. Particularly the collapse of r.c. bridges reveals as the fatigue, corrosion of the reinforcement and aging are crucial elements to considers [10, 11]. The visual inspections are simple, low cost and widespread strategy but not sufficient to point out the approaching collapse phenomena [12–14]. From the other side, the monitoring through identification of dynamic

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