EXPERIMENTAL ANALYSIS BY ACOUSTIC EMISSION ON FULL-SCALE PC DECK BEAMS AFTER 50 YEARS OF SERVICE

Giuseppe Lacidogna[1*], Pierclaudio Savino[1], Oscar Borla[1], and Francesco Tondolo[1]
[1]*Department of Structural, Geotechnical and Building Engineering, Politecnico di Torino,*
Corso Duca degli Abruzzi 24, 10129 Torino, Italy
** Presenting Author email: giuseppe.lacidogna@polito.it*

Abstract
The AE technique is highly adopted for the structural integrity assessment of materials as well as large-sized structures (buildings, bridges, etc.) due to its ability to offer information on their stability conditions. This paper presents a loading test on a prestressed concrete (PC) full-scale beam. It was taken from a bridge built in Turin (Italy) in 1970 and dismantled in 2018 for urban redevelopment works. The efficacy of the AE technique for determining the progression of damage is confirmed by the observed relations between the measured strain and the recorded AE activity.

1. Introduction

In order to support the safety assessment and residual lifetime evaluation of existing bridges, it was launched the BRIDGE|50 research project, which includes a wide experimental campaign aimed to investigate the residual structural performance of a decommissioned 50-years-old PC bridge [1]. This was a 80-span double deck road viaduct, built in Turin in 1970 and dismantled in 2018 for urban redevelopment works. The deck was formed by ten inner I-beams and two box beams linked by two intermediate transverse beams and a top cast-in-situ RC slab. The deck girders were simply supported over each span having a variable length ranging from 16 to 24 m, for a total length of the viaduct of about 1.4 km. Contextually to the dismantling of the viaduct, a group of 29 precast PC beams, including 25 I-beams and 4 box beams, and 2 pier caps were collected from the deconstruction and stored in a testing site (Fig. 1a).

2. Experimental tests

The research project includes conventional and innovative experimental techniques to determine the structural performance up to failure. Multiple load tests were planned, considering tests under service loading up to collapse, and different types of bending and shear failures induced using an experimental equipment specifically designed to this purpose (Fig. 1b). Several methods are used for the detailed assessment of the structural condition in its current state and after defined damage level, namely dynamic ultrasonic, and Acoustic Emission (AE) tests. The results will be used to evaluate the impact of defects and material deterioration on the residual capacity of aged structural elements at the end of their service lives.

(a)   (b)

Fig. 1 – (a) Aerial view of the testing site; (b) Reaction steel frame.

3. Results

The experimental campaign carried out with the aid of the AEs was conducted through three- and four-point bending tests which replicate the simply supported beams scheme with hinge and roller according to the in-service static scheme. The loading system consists of two couples of hydraulic jacks having a maximum capacity of 1200 kN (Fig. 1b). Each couple of actuators act on a steel transverse beam which transfers the load to the PC beam under test. The PC beam (B4-SP/P47) considered herein as an example to evaluate the residual strength capacity has a total length of 19.4 m and an I-shaped cross section of 600x900 mm^2, with a 0.14 m thick upper slab. The beam is reinforced by 17 prestressing strands in the bottom slab and 3 prestressing strands in the upper part, having a nominal diameter of 12.7 mm. The three-point loading test consisted of two loading phases performed with a loading rate of about 4.0 kN/min. During the first phase the beam was loaded up to 40.0 kN; while in the second phase it was loaded up to failure recorded at 288 kN. The load-time diagram for the two loading cycles and the load-displacement diagram are reported in Fig.2a. The load level refers to a single actuator and should be multiplied by 4 to obtain the total applied load. Eight AE wide-band piezoelectric sensors (S1-S8), sensitive between 50 kHz and 1 MHz, were applied on one side in the middle section of the beam to evaluate the AE parameters during the test (Fig.2b). The AE sources localization (microcracks) are represented by red dots in Fig. 2b. To get a picture of the damage evolution, the AE data were analyzed, starting from 2250 seconds from the test beginning, in terms of cumulative signals, their rate, evolution of signal frequencies, amplitudes and duration in time (microseconds) (see Fig. 3). Furthermore, the speed with which the damage evolved was estimated by the β_t coefficient, which represents the time-scaling exponent characterizing the time evolution of the damage process. While, the critical distribution of the cracks and their tendency to cluster along fracture surfaces was described by the *b*-value evolution, which tends to reach 1.0 a few seconds before the beam collapses [2]. Other three- and four-point bending tests have been conducted or will be carried out on similar beams in order to evaluate the different collapse modes and to check the differences in terms of the AE parameters.

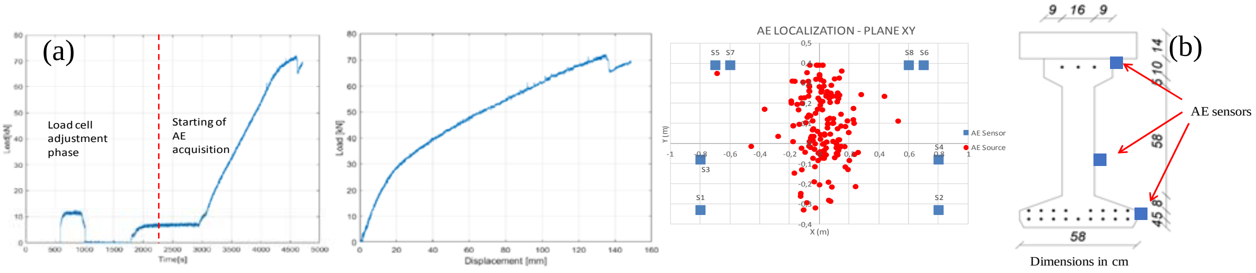

Fig. 2 – (a) Load vs time and displacement diagrams; (b) Crack sources and applied AE sensors.

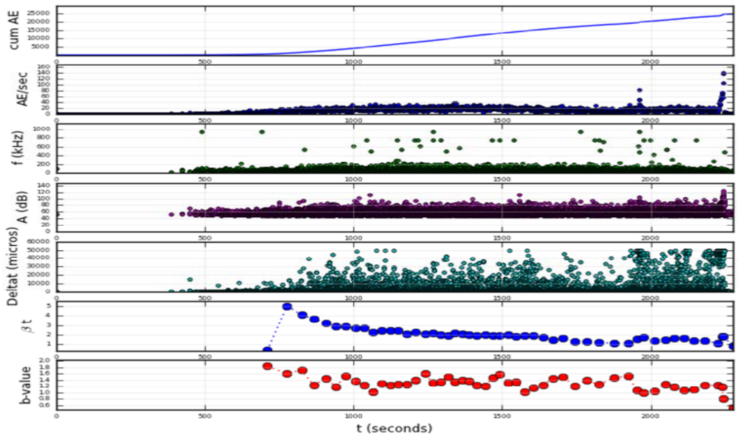

Fig. 3 – Acoustic Emission results

4. Conclusions

The experimental program of the research project on full-scale PC deck beams after 50 years of service has been presented. Moreover, the large scale loading system and the used equipment have been described. In this framework, a first experimental study using the AE technique, via a three-point bending test, has shown that this technique can be effectively applied in situ to discriminate between the main rupture mechanisms and the residual capacity of aged structural elements.

References

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