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# INVERSE DYNAMICAL PROBLEMS AND DAMAGE IDENTIFICATION IN STEEL-CONCRETE COMPOSITE BEAMS

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## ABSTRACT

Steel-concrete composite system is widely used in bridge construction and also for long-span building floors [1]. The global structural behavior is achieved by shear connectors placed between the concrete slab and the steel beams. Assessment of the connection integrity is obviously of primary importance for evaluating the safety of the system. In ageing bridges, for example, the condition of the connectors may not be good due to the occurrence of corrosion or fatigue phenomena or to unexpected overloading. Failure or even damage of the shear connectors will significantly reduce the composite action and, therefore, reduce the bridge load-carrying capacity. Since the inaccessibility of the connection makes inspection difficult, it is of practical importance to develop non-destructive techniques in order to assess the integrity of the connection [2], [3].

Within the large class of methods of non-destructive testing, dynamic techniques based on modal analysis have received great attention in the engineering community in last decades, see, for example, [4], [5]. One attempt to detect damage in steel-concrete composite beams via dynamic methods has been originally developed in [6]-[8]. In those papers, a series of composite beams were studied dynamically in laboratory, both in undamaged and damaged state. Natural frequencies and vibration modes were used to calibrate a mechanical model of the system and to localize the damage in the connection. The analysis concerned with *severe levels of damage*, corresponding to the extreme case where concrete surrounding a damaged connector is thoroughly degraded and the connection is fully plasticized. For these levels of damage, the mechanical model proposed in [8] was able to accurately describe the dynamic behavior measured during the experiments and was successfully used for damage detection purposes.

The main goal of this paper is to fill the gap concerning the mechanical modelling and damage identification for composite beams with partially damaged connection, that is for *intermediate levels of damage*. This aspect is of large importance when non-destructive dynamic methods are employed to detect possible damage in structures. In fact, one of the main difficulties connected with the use of such methods lies in the small sensitivity of the dynamic parameters to damage. This is an intrinsic feature of structural diagnostics based on dynamic data and represents a source of important indeterminacy, such as the strong dependence of the results of identification on the experimental errors and on the accuracy

of the mechanical model that is chosen to interpret measurements. Application of dynamic techniques to steel-concrete composite beams, in addition, makes the problem more complicated, owing to the uncertainty about the mechanical behavior of the connection and damage modelling.

In this paper an Euler-Bernoulli model with a *shearing-type model* of the connection is proposed to describe the dynamic behavior of steel-concrete composite beams in undamaged configuration and with small levels of damage in the connection. In the experiments, described in detail in [9], the damage was simulated by means of a crack of increasing depth produced on one end connector. The mechanical model has been calibrated on the basis of dynamic tests carried out on several specimens. Analytical values of modal parameters, such as natural frequencies and mode shapes, show a good agreement with measurements and a uniform degree of accuracy for all the damage configurations was also observed. The accuracy in reproducing the experimental data has been further improved by introducing a Timoshenko-like model for the composite system, see also [10] for an application to undamaged beams. The two analytical models have been used to detect damage by means of a variational-type method based on frequency shift measurements only. Good indication, both for damage location and severity, has been obtained when the first few flexural frequencies are included in identification.

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