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Fluid dynamic interaction between train and noise barriers on High-Speed-Lines

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Abstract

Noise barriers are lineside structures next to the railway track, subject to vibrations due to fluid-dynamic excitation induced by the train passage in High-Speed-Lines (HSLs). The train, travelling along the railway track, is immersed in a fluid, which increases its resistance as the speed of the train increases; the generated pressure field, with sinusoidal trend, is orthogonal to the barrier and excites its dynamic response, testing strength and fatigue resistance. This phenomenon becomes particularly significant for the HSLs trains, travelling at 300 kph speed, and should be evaluated to ensure the transport safety. The aim of the study is to focus on the dynamic response of existing noise barriers, with special regard to fatigue aspects, and proposes the introduction of special devices, Tuned-Mass-Dampers (TMDs), to place on the top of each column in order to reduce structural vibrations. The noise barrier is modeled as a generalized single-degree-of-freedom (SDOF) system. The pressure field induced by the train passage is modeled by a dynamic action function of the barrier height and geometry, of the railway geometry and the train speed. Two case studies are illustrated with columns 4 and 5 m high and concrete noise panels. The design of the auxiliary system, the TMD, is carried out as first tentative solution for reducing the structural vibrations and dynamic analysis on the barriers with and without the TMD shows the effectiveness of the control system to reduce the amplitude of motion and the number of cycles of vibration.

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Keywords: noise barriers; fluid-dynamic interaction; dynamic analysis; tuned-mass-damper system.

1. Introduction

The vibration induced on the trackside structures generated by aerodynamic pressure produced by the train transit represents a topic worthy of attention [1-3]. The noise barriers, due to the repeated passage of the train along High-Speed-Lines (HSLs), undergo cyclic loading and can be affected by fatigue phenomena. This aspect is intended to

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raise importance in the future for increased train running speeds which imply higher pressure fields. Until the last decade, only few European countries focused on this aspect; all the evaluations were done in absence of national codes or specific requirements considering the dynamic effects induced by the train passage. Italferr, the engineering company of the Italian State Railways, has carried out several theoretical and experimental studies on the HSLs along with their increasing spread in Italy [4].

Tuned-Mass-Dampers (TMDs) are acknowledged systems that produce passive vibration mitigation. They can be linear [5] or nonlinear [6], conventional or non-conventional [7] and can include innovative control elements to improve their performances [8].

The aim of this study is to focus on the fluid-dynamics interaction between existing noise barriers and train on HSLs and to develop possible solutions to mitigate the effects produced on such structures. The paper illustrates dynamic analysis of noise barriers, modeled as a generalized single-degree of freedom (SDOF) system, subject to the aerodynamic pressure field induced by the train passage. A first tentative solution for reducing the noise barriers vibrations is proposed with the design of a TMD to place on the top of each barrier column.

2. Noise barriers on high-speed lines: description and critical aspects

In Italy, the current HSLs barriers are often the result of older structures designed and, for years, built along the ordinary lines generally characterized by speeds not exceeding 200 kph. These types of barriers are composed by HE steel profiles columns, spaced each 3 m, adequately constrained to the base through anchor bolts, Fig. 1 (a). Between the flanges of the profiles, noise panels are inserted. These panels are usually made of metal (aluminum, stainless steel or galvanized steel) or concrete, or transparent material (glass or PMMA), also in mixed combination, according to environmental aspects and costs.

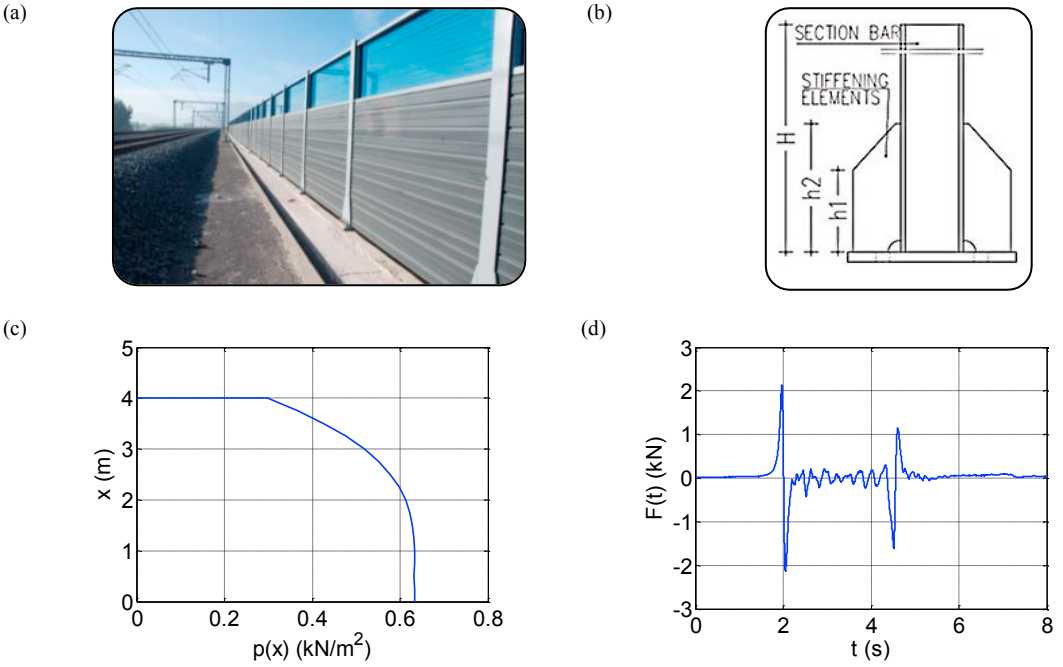

Fig. 1 (a) Noise barriers along Italian HSLs, (b) Geometrical features of the column, (c) Aerodynamic pressure along the barrier height (H= 4 m, s= 350 kph, d=4,3 m, i= 3 m) (d) Measured time history of the input to the SDOF system for a train speed s=350 kph.

The experimental trends obtained during testing campaigns on the noise barriers confirmed their dynamic interaction with the train passage. The input pressure dynamic signal is characterized by two main not symmetrical impulses corresponding to the entrance and exit of the train connected by oscillations of minor amplitude, Fig.1(d). Moreover, the signal: *i*) is roughly sinusoidal; *ii*) the number of sinusoids between the first wave (head locomotive)