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WIND TUNNEL TESTS AND NUMERICAL SIMULATIONS ON THE NEW TRAIN STATION AND HIGHWAY TOLLGATE IN REGGIO EMILIA

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1 INTRODUCTION

Two different experimental and numerical campaigns conduced in the Boundary Layer Wind Tunnel of the CRIACIV are presented.

The first one deals with the wind tunnel tests carried out on the new high speed train station in Reggio Emilia, Italy. For this structure pressure coefficients for the wind action have been measured; moreover, the internal pressures due to the passage of the high speed trains have been estimated.

The second campaigns deals with the cable-supported roofing of the new highway tollgate. Steady aerodynamic coefficients have been identified in the wind tunnel for several angles of attack and for three different configurations; then, time-domain buffeting simulations of the whole tollgate have been carried out by using a commercial nonlinear finite element code and by generating multi-correlated turbulent velocity wind field.

Some of the results are presented in the paper.

2 HIGH SPEED TRAIN STATION OF REGGIO EMILIA

The structure of the station is made of 13 steel portals that repeat in a total length of 400 m in full-scale. The steel portals are 20 cm thick and have a mutual distance of 100 cm, between them there are glass walls. In order to evaluate the action of the wind on the covering of the station a 1:50 scale model has been reproduced and pressure tabs have been positioned on the steel portals and on the glasses on the top side and on the lateral sides (Fig. 1). For every position two coaxial pressure tabs have been placed with the purpose of receiving the net value of the pressure (extrados-intrados). Sixteen directions of the incoming wind have been simulated by rotating the model into the measuring section. The extreme values of the c_p have been calculated through a Gumbel analysis; this data were necessary in the design process because of the particular shape of the structure not referable to any standard model available in Codes.

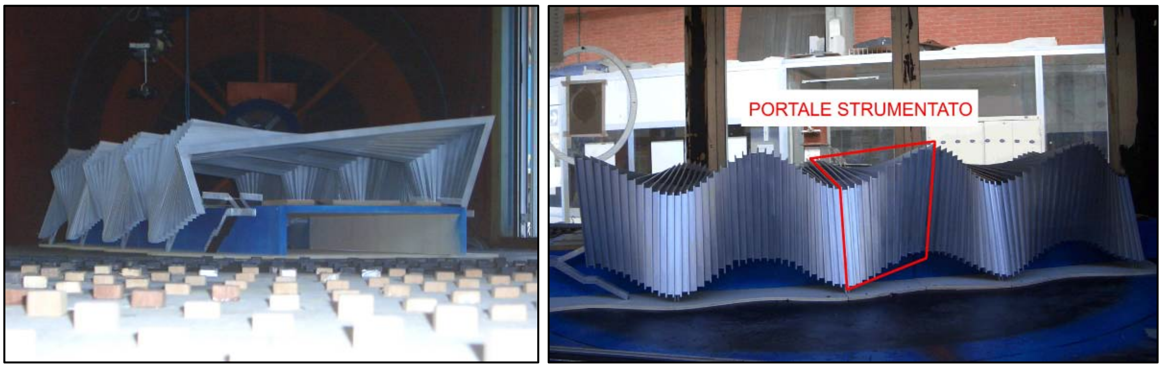

Figure 1: Model of Reggio Emilia high speed station

2.1 Pressure fluctuation induced by a moving high speed train

Because of the thickness of the steel elements and the brittleness of the glass walls this particular geometry results very sensitive not only to the action of the wind but also to any pressure fluctuation. In the two central trucks of the station trains will run through at a velocity of over 300 km/h, causing an overpressure on the structure and on the adjacent noise-barriers as well. To estimate the value of this action is not easy since there are only few of such measurement available in literature and refers always to specific cases.

During this experimental campaign a scaled-model test has been conduced, in witch the pressure fluctuations induced by the passing through of a train-model have been measured (see Fig. 2). The train model has been launched at a velocity of about 26 m/s through an elastic propulsion system, the velocity has been recorded by two lasers positioned at a known mutual distance that revealed the passage of the train. Because of the uncertainness due to scaling problems (maintenance of Reynolds number) the set-up of the test has been validated through a comparison between measurement in real scale found in literature and a similar test conduced in scale 1:50 [1-4].

The obtained results show as the passing through of the train causes an overpressure followed by a depression. The effects generated by the train both on the superior part of the structure and on the glasses are very low. In these positions the values recorded are near the range of the sensitivity of the pressure transducer. On the noise barrier instead the fluctuation of pressure is evident. From the tests it has emerged that in order to have a good agreement with the reference values it is necessary to modify the shape of the train model. The maintenance of the geometric staircase can cause errors because the Reynolds number is not maintained. This study is to be considered a first attempt to resolve this kind of problems; the aspects regarding the correct scaling of the phenomena has to be further deepened.

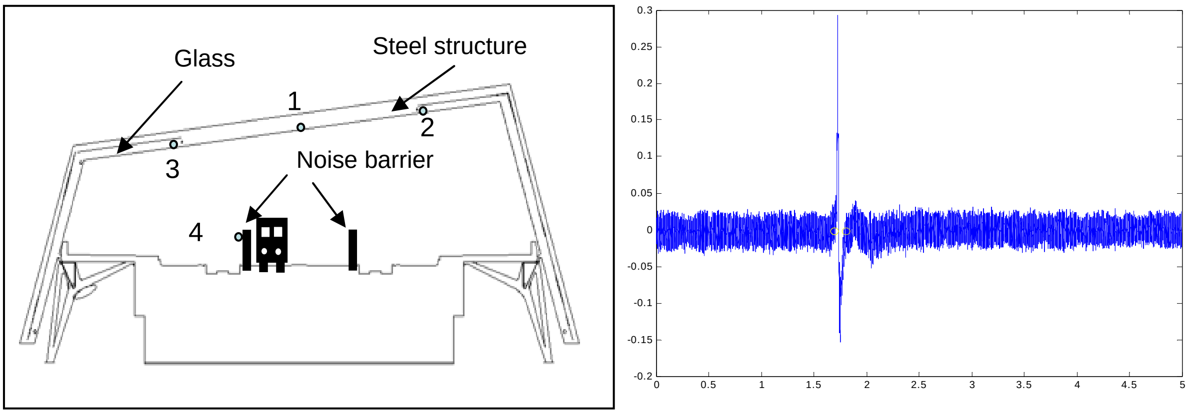

Figure 2: (a) Pressure taps position; (b) Record of the pressure on the noise barrier adjacent to the truck

3 TOLL-GATE

Recently, a wind tunnel test campaign on a section model of the new roof for the Reggio Emilia motorway payment station has been carried out. Wind tunnel test were necessary in order to investigate the force coefficients for such a structure mainly in presence of the sub-structures which drastically modify the wind flow around the roof profile. The model, in scale 1:40, has been analyzed under three different configurations: (1) Height above ground higher than the actual one without any other structure; (2) Correct height above ground but no sub-structures for the ticket payment; (3) Same as 2 but with the substructures for the ticket payment.

3.1 Main test results

During the wind tunnel tests, drag, lift and moment coefficient have been measured in function of the attack wind angle. These coefficients have been obtained by rotating the roof model around its own axis between -10° and +10°, assuming the following intermediate configurations: -10°, -7.5°, -5°, -3°, -2°, -1°, 0°, 1°, 2°, 3°, 5°, 7.5°, 10°.

The most important result concerns the lift moment and, with reference to the Fig. 3b, we can note that for the third configuration, the presence of the payment substructures, drastically modify the wind flow under the roof, leading to a big increment of the vertical force coefficient for the null angle. It is also interesting to note that actually the rotations of the roof structure under turbulent wind seem to be small enough to force the assumption of the lift coefficient relative to the null angle of rotation.

3.2 Dynamic analyses

The results obtained in the wind tunnel, have been used in order to load the numerical model of the whole structure (Fig. 3a). In particular three sets of quasi-steady forces, simulating the global drag, lift and torsional moment, have been applied on the model following the scheme of Fig. 3a. Forces have been generated, starting from a simulation of the turbulent wind velocity components, by means of an ARMA filter algorithm [5-6]. The time histories length was assumed to be of 10 minutes, according with the most used international codes, for the evaluation of the statistical properties of the response (maxima and minima of the displacement function). Fig. 3c shows the vertical component of the displacement for the central point of the roof structure. For the statistical evaluation of the response, the complete time history has been subdivided in 20 time windows. Hence the 20 values obtained have been placed on a Gumbel chart and the design value has been considered to be the one corresponding to the exceedance probability of 22%.

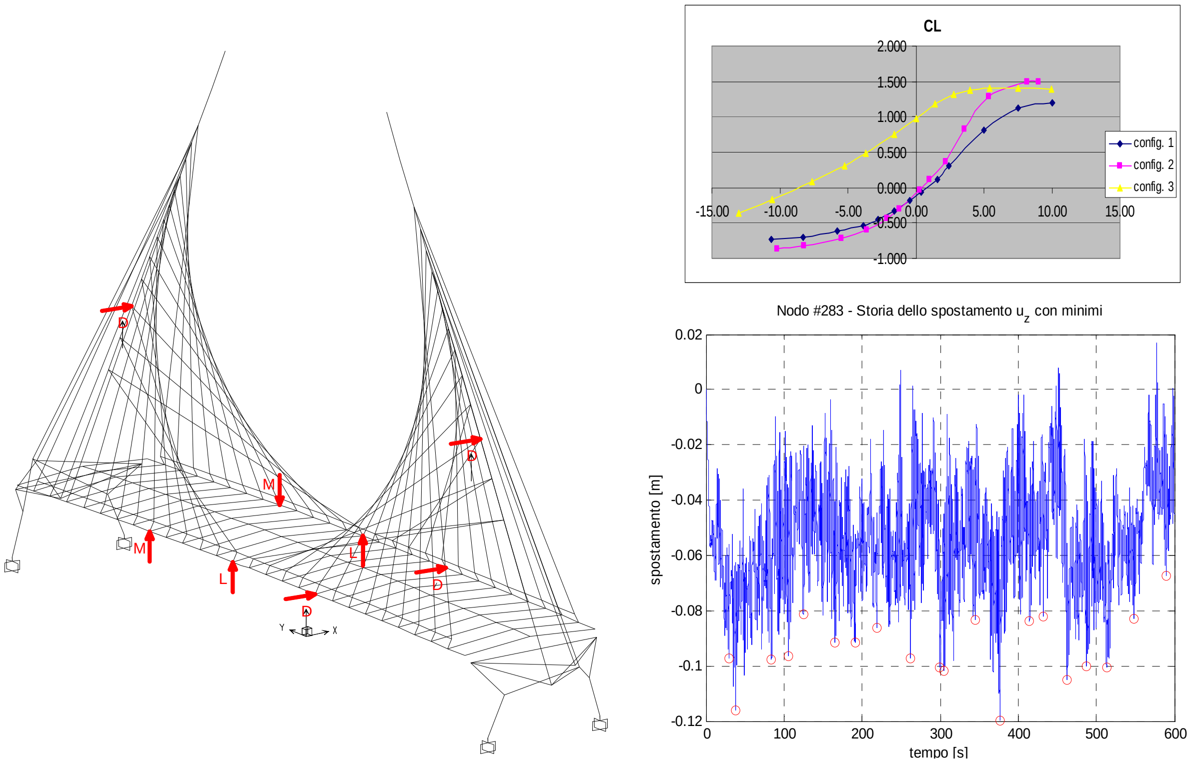

Figure 3: (a) FE model of the tollgate; (b) Lift coefficient for the three assumed configurations; (c) vertical displacement of the central point of the roof

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