Engineering Structures 79 (2014) 290–296

Contents lists available at ScienceDirect

Engineering Structures

journal homepage: www.elsevier.com/locate/engstruct

Review article

A chimney's seismic assessment by a tuned mass damper

Nicola Longarini [a,*], Marco Zucca [b]

[a] Rome, via Clitunno 22 00198, Italy
[b] Cagliari, via XXIX Novembre 6 09123, Italy

ARTICLE INFO

Article history:
Received 25 November 2013
Revised 15 May 2014
Accepted 16 May 2014
Available online 3 September 2014

Keywords:
Chimney
Seismic
TMD
Numerical analyses
Masonry

ABSTRACT

The paper concerns a tuned mass dumper (TMD) design to improve the seismic response of an historical chimney located in an important Italian hydraulic plant. The chimney, built at the beginning of XX century, has about 50 m total height and its structure is completely in masonry.

To understand the chimney's dynamic response and evaluate the TMD characteristics (in terms of optimum mass, stiffness and damping values) to improve the seismic response, some numerical analysis are carried out by Finite Elements Models (FEM) represented two configurations, respectively: the "chimney" (Type A) and "chimney with TMD" (Type B). Both of the configurations are investigated by two different kind of FEMs: a FEM-Model 1 characterized by beam elements and a FEM-Model 2 characterized by solid elements.

In the FEMs, observing the Italian Buildings Code, the local earthquake has been applied by a spectrum-compatible accelerograms by performing a "time history" analysis. The mechanical characteristics of the masonry (elastic modulus and compressive strength) implemented in the FEMs has been already determined by a set of experimental tests.

Finally, optimizing the TMD characteristics, the seismic improvements in terms of base shear, compressive/tensile stresses and top displacements are shown.

Contents

1. Characteristics of the structure

The historical chimney is characterized by an inner and an outer cylindrical skins (thickness, $t = 27$ cm) linked themselves by a no. 8 meridians and no. 11 parallels structure (shown in Fig. 1). The chimney's height is about 50 m and the thickness of the skins, meridians and parallels is 0.27 m. The chimney is a part of an important hydraulic plant in Italy, built at the beginning of the XX century and currently in use.

The mechanic characteristics of the masonry (Modulus of elasticity $E = 12{,}185$ MPa, ultimate compression strength value $f_d = 4.96$ MPa) are deduced from the surveys carried out by flat jacks tests in some positions of the chimney's masonry. Applying the Italian Structures Regulations [1,2] and [3] – "D.M. 2008-Norme Tecniche per le Costruzioni" (DM2008) and "Circolare no. 617/2009" (C2009) – the mentioned f_d value decreases to $f_{dc,rid} = (f_d/c_1)$

* Corresponding author.
E-mail addresses: nicola.longarini@libero.it (N. Longarini), m.zucca@aol.com (M. Zucca).

http://dx.doi.org/10.1016/j.engstruct.2014.05.020

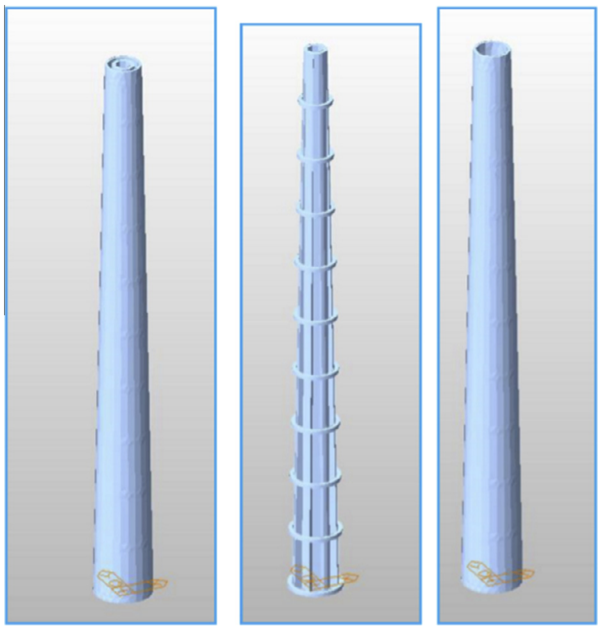

Fig. 1. Structure of the chimney (inner and outer skins, meridians and parallels system).

$\cdot c_2 = 3.55$ MPa: either for the coefficient $c_1 = 1.2$ which considers the tests number on the structure (Section C.8.A.1.A.4 in C2009), either for the coefficient $c_2 = 0.86$ which considers the geometrical slenderness and the chimney's vertical loads eccentricity (Section 4.5.6.2. and Table 4.5.III in DM2008).

To define the TMD's characteristics [4], the type A configuration (only chimney) is analyzed by the implementation of FEM-Model 1, where all of the finite elements are beam elements; moreover, the structural seismic improvements are evaluated by inserting the TMD in the FEM, so considering the type B configuration (chimney and TMD).

The flowcharts to observed in parallel are shown in the following Fig. 2 (see Fig. 3).

2. FEM-Model 1 analysis

2.1. Type A

All of the beam elements in the FEM-Model 1 are tapered (from the base to the top) and the base boundary condition is a perfect join. The loads combination on the structure are the summation of dead loads and the seismic actions by the application of seven spectrum-compatible accelerograms (like its mentioned in the Italian structures regulation) shown in the next Fig. 4.

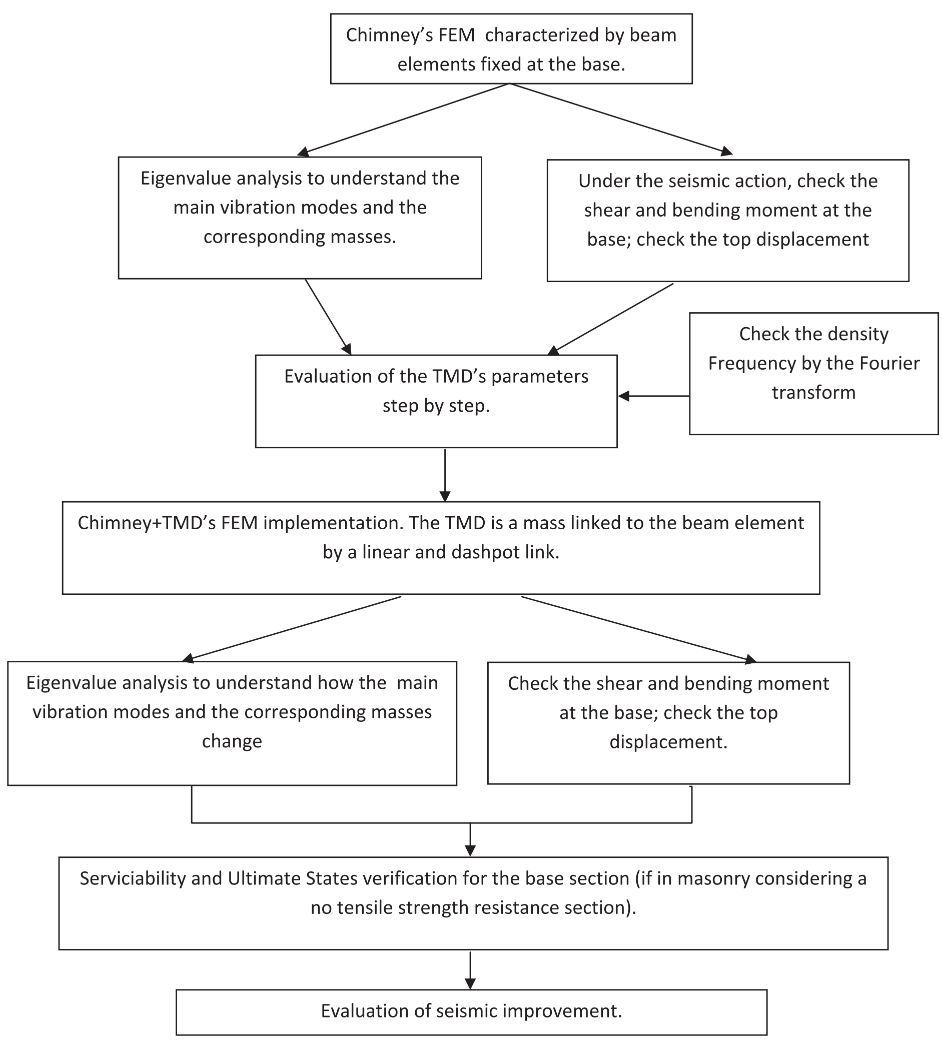

Fig. 2. Flowchart of tuned mass dumper (TMD) design.