

POLYTECHNIC OF TORINO  
FACULTY OF ARCHITECTURE 1  
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*Honors theses*

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**Evaluation of the structural conditions of masonry towers**

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Ancient masonry towers are an important part of the artistic and historical heritage of our country. They belong to the Italian landscape, they witness our past and our workmanship in masonry tall buildings.

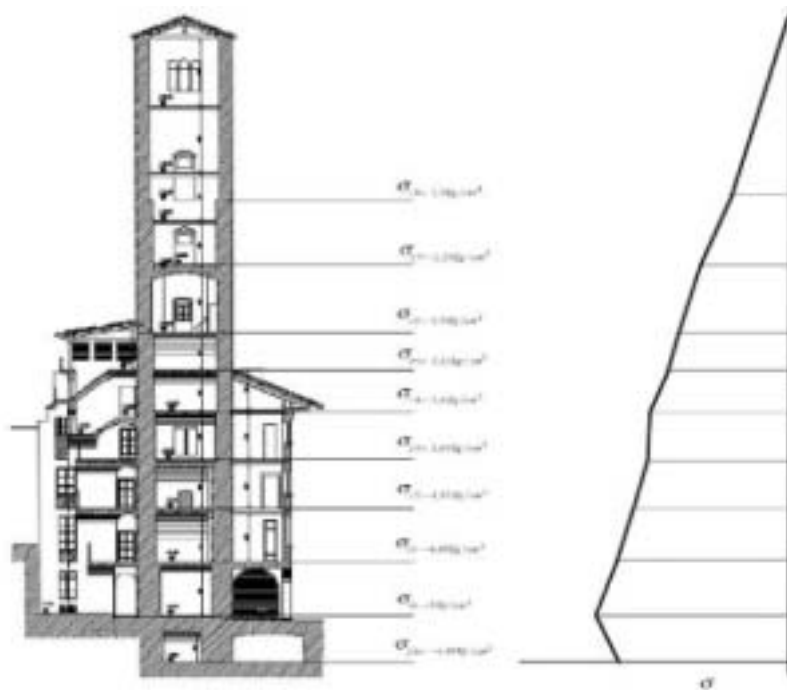
The main topics of this thesis are the problems related to the analysis, diagnosis and interpretation of the most important damage phenomena which occur in this kind of buildings, with a special concern for the medieval towers of Alba (Cuneo).



*View of the city centre of Alba: from the left, Astesiano, Sineo and Bonino towers*

The protection of ancient masonry towers is mostly related to the static behaviour of the structure, because of the huge vertical development of the façades. As a matter of fact, the static behaviour of the structure is one of the main causes which yielded the deterioration or even the sudden collapse of several masonry towers, such as the Civic Tower of Pavia and the bell-tower of S. Marco in Venice. The shape of the towers implies a high position of the centre of gravity; the subsidence of the foundations, the horizontal stresses such as the wind and the earthquake are a risk for the steadiness of the towers. Moreover, the huge development of the façades and the small surface of the plan may cause very high stresses, which are even more dangerous if the brickwork is ancient or deteriorated.

There are a lot of static problems related not only to the geometry of the structure, but also to the brickwork itself. The brick masonry is fragile, with a very low tensile stress resistance, especially if the brickwork is ancient or deteriorated: this may cause irreversible static damage, partial or total collapse without any visible warning signal. That is why we need to project the analysis and the monitoring of this kind of structures with innovative techniques, such as the acoustic emission technique.

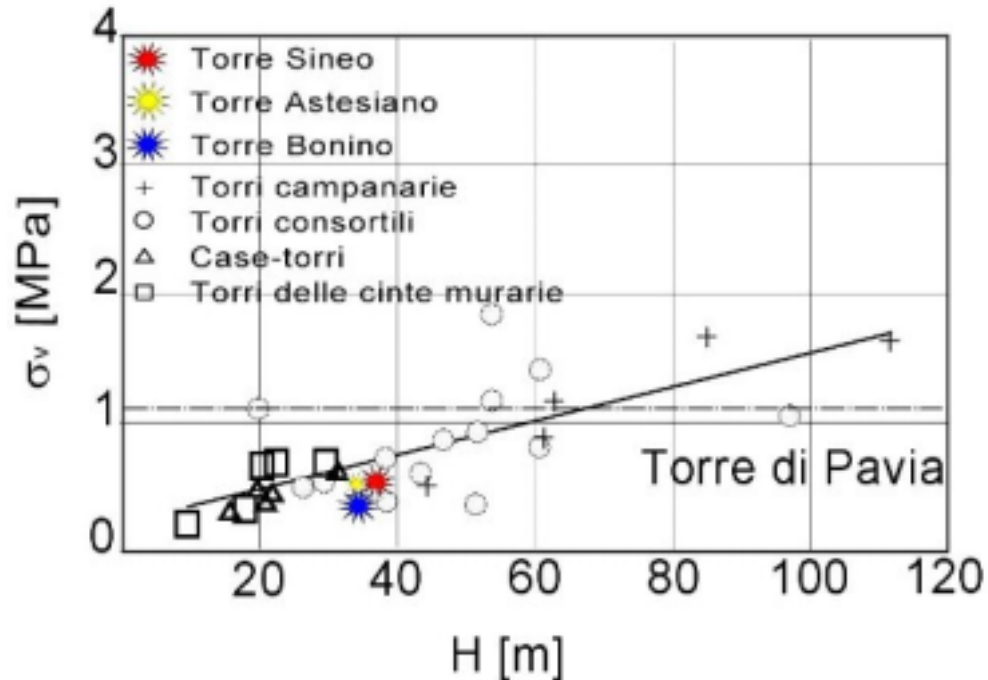


*Trend of the compression stress values in the Sineo tower: typical performance of the  $\sigma$  for tall buildings, with very high stress values at the basis*

The writing is composed of three main sections: in the first one there is a brief historical analysis of the kinds of towers which can be found in Italy (bell-towers, fortifications, civic towers, etc.); in the second section there is a dissertation about the static behaviour of brick masonry, with a particular concern for the aging of the material due to chemical and physical causes; finally, the third section is about the monitoring techniques for the analysis and diagnosis of the brickwork damage, such as thermography, traditional structural calculus, flat jack tests and acoustic emission technique.

Within this overall framework, particular attention was paid to the medieval towers of Alba (Sineo, Astesiano and Bonino towers), which have been analysed and monitored.

This study showed finally the real need of a safety factor for masonry towers. The towers of Alba have been compared with very famous examples: the civic tower of Pavia (which collapsed in 1989) and the bell-tower of the cathedral of Monza, which has showed an increasing trend of the crack pattern since 1978.



*Vertical average stress vs. the height of the towers: this diagram shows how the towers of Alba are still in a safety condition compared with the civic tower of Pavia*

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