

POLITECNICO DI TORINO
FIRST SCHOOL OF ARCHITECTURE
Master of Science in Architecture
Honors theses

Medieval towers of the city of Alba. Assessment of the damage of tall buildings made of masonry

by Alice Destefanis

Tutor: Simonetta Lucia Pagliolico

Co-tutors: Silvia Beltramo and Giuseppe Lacidogna,

My thesis suggests a methodology for the evaluation of the consistence and the damage of tall structures, what the medieval towers are. For this reason I have chosen as methodic the interpretative scheme of the conservative restauration proposed by Mario Dalla Costa.

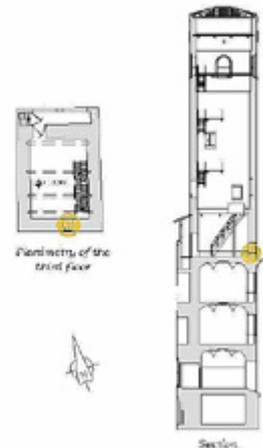
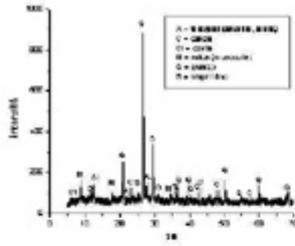
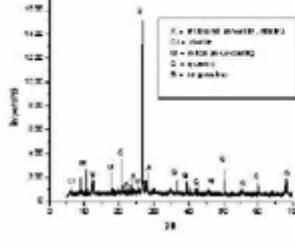


The aid of tests directly performed in situ and in the laboratory has allowed me to exhaustively analyze the material nature and the structural stability of my case-study, what the monumental complex of the medieval towers in Alba (CN) is.

This study articulates in five parts, in accord with the methodology individualized by Dalla Costa.

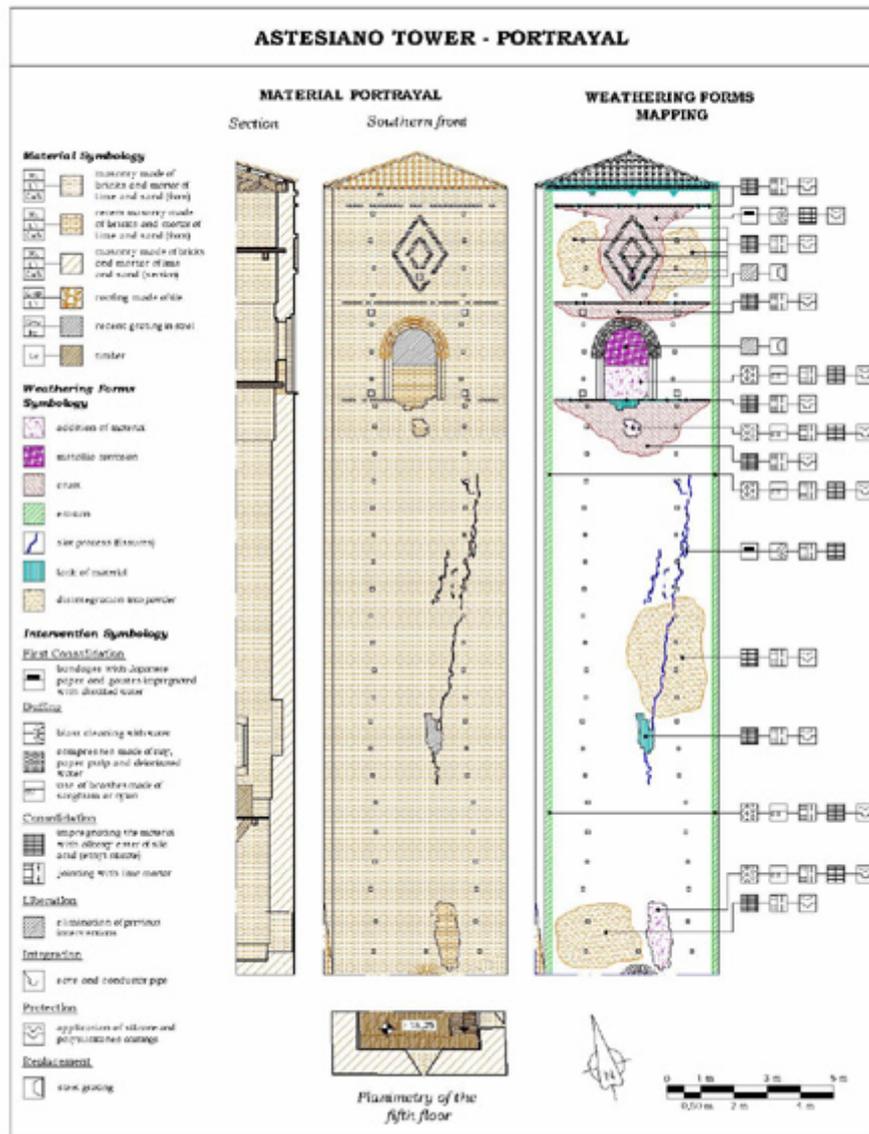
1. Historical investigation, where the architectural tower type with the committees and the habits are analyzed, as they brought to build such structures. A comparison has been performed between the towers of Alba and other structures, rising on the territory of the south-western part of Piedmont, so that to compensate the lack of historical information about the city of Alba.
2. Investigation on the consistence of the three towers, integrally preserved in their height within Alba: such investigation has primarily considered the geometric and materials aspects.
3. Analysis of the cortical degrade and relative proposals of intervention, using the symbols codified by the document NORMAL 1/88 and the approach proposed by Mario Dalla Costa.
4. Structural investigation: this section has been divided in two parts, the first one regarding the monitoring performed on each of the three towers while the second concerns an energetic approach to the problem of the safety of tall structures.
5. Critical synthesis of the results gotten by the preceding sections.

The towers Astesiano, Bonino and Sineo constitute the object of the study here introduced: they are placed inside the historical center of Alba, on the ancient *cardo* and *decumano maximi* of Roman period. They have been built between the end of the XII and the beginning of the XIII century, on the occasion of the familiar struggles that upset the city in municipal period. The towers are made of bricks, while the foundations were built in stone. Inside the walls there is a special kind of masonry, that is called "a sacco". The towers are characterized by quadrangular plans and their side dimensions vary between 4,80 meters of Bonino tower and 6,50 meters of Astesiano tower. Their heights range from 35,00 meters of Bonino tower to 38,50 meters of Sineo tower.

ASTESIANO TOWER - SAMPLE VI POINTING LIME MORTAR WITH SILICEOUS AGGREGATE Sampling altitude: +14,15 meters	
<p>DESCRIPTION: under a brick fragment several pieces of mortar, partially integer, have been sampled. The sampling was easy, as the pieces of mortar were already taken off from the brick below. A dissolution test with hydrochloric acid has been carried out and it showed the presence of lime binder and an insoluble siliceous aggregate.</p>	 <p style="text-align: center;">Planimetry of the third floor</p> <p style="text-align: center;">Section</p>
 <p>Before the sampling</p>	 <p>After the sampling</p>
<p>Date: 26th July 2006</p> <p>Object: powder diffraction analysis</p> <p>Used equipment: diffractometer Philips PW 1710 X - CuKα - 40 kV - 20 mA, speed 0,002$^\circ$ per 0,4 s</p> <p>Sample description: mortar between bricks</p> <p>Sample preparation: the sample has been handily crushed in an agate mortar and sieved to a grain size lower than 0,104 mm (150 mesh).</p>	 <p style="text-align: center;">Comments</p> <p>Mortar: binder: lime; aggregate: silica sand (quartz, feldspars, mica, serpentine, chlorite)</p> <p>Weathering forms: gypsum</p>
<p>Date: 26th July 2006</p> <p>Object: powder diffraction analysis</p> <p>Used equipment: diffractometer Philips PW 1710 X - CuKα - 40 kV - 20 mA, speed 0,002$^\circ$ per 0,4 s</p> <p>Sample description: aggregate of the mortar VI</p> <p>Sample preparation: the sample has been handily crushed in an agate mortar and sieved to a grain size lower than 0,104 mm (150 mesh).</p>	 <p style="text-align: center;">Comments</p> <p>aggregate: silica sand (quartz, feldspars, mica, serpentine, chlorite)</p>

After several surveys and the preparation of photographic cards of the investigated objects I have prepared the geometric reliefs, where I have pointed out the materials of which the tower are constituted. In the laboratory some materials samples have been analyzed, withdrawn by the inside of the structures, using the Diffractometry X-rays. The chemical composition of the samples has been valued with the cortical degrade, operating on the towers. Subsequently the reliefs have been adjoined pointing out the material superficial degrade with the relative location and extension; then for every type of cortical damage I have defined and study the relative proposals of intervention.

I have finally analyzed the structures of the three towers studying the results obtained by monitoring continuously the towers from the winter 2002 to the spring 2003.



Several non destructive tests have been carried out on the three towers:

- flat-jack test;
- endoscopic technique;
- thermographic technique;
- acoustic emission technique.

During the period of monitoring some numerical models have been prepared to calculate the three structures with the ended elements approach. Combining the gotten results an approach has been formulated that, appraising the critical number of acoustic emissions that conducts to the breakup of the masonry, allows to foresee the safety of damaged buildings of great dimensions.

For further information, e-mail:

Alice Destefanis: alidestefanis@yahoo.it