

THE LEANING TOWER OF PISA

The Tower of Pisa has been called one of the world's seven wonders.

The Tower of Pisa is the bell tower of the Cathedral. Its construction began in the august of 1173 and continued (with two long interruptions) for about two hundred years, in full fidelity to the original project, whose architect is still uncertain (Bonanno Pisano). In the past it was widely believed that the inclination of the Tower was part of the project ever since its beginning, but now we know that it is not so. The Tower was designed to be "vertical" and started to incline during its construction. Both because of its inclination, and its beauty, from 1173 up to the present the Tower has been the object of very special attention.

During its construction efforts were made to halt the incipient inclination through the use of special construction devices; later columns and other damaged parts were substituted in more than one occasion; today, interventions are being carried out within the sub-soil in order to significantly reduce the inclination and to make sure that Tower will have a long life. In all this story it is possible to find a meaningful constant, the "genetic code" of the Tower: its continual interaction with the soil on which it was built. Today's (1999) works for the safeguard and the conservation of the Tower with very advanced methodologies are designed to fully respect this constant.

The Tower, with its great height, was a visual fulcrum, visible from all areas of the Piazza, and, probably, from the river Arno. In this way the Tower assumed the function of both connection between the city and the piazza, sited in a decentralised area of the urban nucleus, and beacon: a reference point and look-out and, ultimately, an authoritative symbol of the civic and religious pride of the Pisan community.

The Building

The building as it stands today is the result of a series of building works and restoration attempts executed over the centuries with the primary aim of reducing the risk of collapse resulting from the inclination. It is formed by a cylindrical body of masonry encircled by arcades with arches and columns resting upon the base, followed by a belfry.

The central body of the structure is composed of a hollow cylinder, formed by an external wall facing of shaped ashlar in white and grey San Giuliano limestone, an inner wall facing also of worked limestone and, between these two wall facings, an annular masonry area. Within this masonry area is a spiral stair, which, with 293 steps, climbs up to the sixth arcade, where the internal well terminates in a vault with a central aperture for the passage of light, allowing access to the belfry above and, in the lower intermediate areas, to the various arcades.

The problem of the inclination

The problem of the inclination of the Tower is the aspect which, over the centuries, has most fascinated and aroused the curiosity of visitors, art enthusiasts and scholars, rendering the building world famous. This is also due to the fact that, to this day, the reasons behind the inclination of the Tower are in many ways mysteries. Experts have debated at length, in particular in the XIX century, over whether or not the inclination came about as a result of problems of statics which emerged during the construction of the Tower: in other words, whether the inclination was the result of an unforeseen and inevitable progressive subsidence of the ground, or whether it constituted an effect consciously desired by the architect.

In the course of the XX century the increasingly accurate measurements of the Tower, alongside the investigations conducted with various instruments into the subsoil and archival and historical research have allowed for the emergence of some certainties (though these too cannot be considered definitive). For example, it now seems certain that the Tower was originally conceived as a straight building, but that it began to give way during the early phases of construction.

This was caused by the particular morphological characteristics of the ground underneath, composed of various strata formed of deposits and clayish material, interlayered, at about a metre of depth, by strata of subterranean waters. This conclusion has been reached by observing the composition of the ground and the corrections made to each floor of the Tower. Given the sporadic documentary evidence which we possess, it would appear certain that the oscillation of the building over the centuries was minimal, it having probably settled into a certain equilibrium with the subsoil. This is confirmed by the accurate survey undertaken in 1817 by two English scholars, Cresy and Taylor.

A few years later, in 1838, events caused a brusque acceleration of the oscillating movement of the Tower, leading to the need for resolute conservation operations. In this date, in fact, on the basis of exigencies of historical and aesthetic nature, it was decided to free the base of the Tower from the blanket of earth with which it had been covered for centuries. This operation, which led the Tower to lose the equilibrium which it had acquired, also included the dismantling of the buildings and structures nearby and, above all, the drying of the stagnant waters which perennially encircled the entrance. Subsequent measurements recorded an increase in the inclination of about 20 centimetres, while in the 267 years between the surveys of Giorgio Vasari in 1550 and Cresy and Taylor in 1817, the inclination had increased by a mere 5 centimetres.

After the works of 1838 the acceleration of the inclination continued for some years, after which it decreased to about a millimetre per year. Over the XX century, increases in knowledge and improvements in technical instruments, together with the involvement of conservation and government authorities, have promoted studies, research and even conservation interventions. Since 1988 the Tower has been closed to the public and a committee of experts is working to evaluate every danger likely to worsen the inclination of the Tower and to develop definitive measures to block, and hopefully to invert, the inexorable inclination of the monument towards the ground.

The measurements of the Tower

The Tower is 58.36 metres high from the foundation and 55 from the ground. Its weight has been calculated at 14,453 tonnes. The centre of gravity is 22.6 metres above the foundation, which has an exterior dimension of 19.58 metres, with a central aperture of 4.5 metres. The area of the annular foundation is thus 285m², and the average pressure on the ground is 497 kPa. The present inclination is about 55j - i.e. about 10%; the value corresponding to the eccentricity on the loads on the foundation is 2.3 metres.

Did you know that the Leaning Tower of Pisa has never really been straight?

Soon after building started in 1173, the foundation of the Pisa tower settled unevenly. Construction was stopped, and was continued only a 100 year later. It then became visibly clear that the Tower of Pisa is leaning, tilting to the south.

Since regular measuring of the tower began in 1911, the top of the tower has moved 1,2 millimetres (0,05 Inch) per year. Today the top of the Tower of Pisa is some 5,3m (17,4 ft) off-centre.

After the bell tower of the Cathedral of Pavia collapsed in 1989, the

Consorzio Progetto Torre di Pisa (Tower of Pisa Project Consortium)

commissioned engineers to stabilise the Leaning Tower. Because the Tower tilted in different directions in its first years, it is

slightly curved, like a banana. Engineers are working on the footing of

the Tower rather than the structure, hoping to ease the top back about 20 cm (about 8 inches). But it means that the 800-year old tower

will remain leaning.