Structural implications in Fiumara d'Arte Pyramid

Marcello Arici[1]; Michele Fabio Granata[2]; Salvatore Serio[3]

Summary

Fiumara d'arte is an open-air museum of sculpture and contemporary art. Among the artworks of Fiumara d'arte, the Pyramid is the last one in order of time. It is a monumental sculpture made of COR-TEN steel, by the artist Mauro Staccioli and it is located on one specific point of the 38th parallel of latitude.
After describing the Pyramid and discussing about its architectural, artistic and environmental values, the structural implications in its design and construction are explained and discussed. Structural solutions and the general behaviour are also addressed, together with structural analysis results.

Keywords

Pyramid, 3D truss, steel, artwork

Theme

design – construction – architectural and structural items

1. Introduction

Fiumara d'arte is an open-air museum of sculpture and contemporary art. It lies along the ancient bed of the Alaesus river (today Tusa stream), a path from the sea to the hinterland across a vast region bordered by Nebrodi and Madonie, the northern mountains of Sicily lying along the Tyrrhenian Sea. The park of Fiumara is one of the most interesting examples of land art in Italy, born from the will and obstinacy of its founder, Antonio Presti.

The Pyramid, a monumental sculpture made of COR-TEN steel by the artist Mauro Staccioli, is located on a precise point of the 38th parallel of latitude, from which the sculpture takes its name. The Pyramid was opened the 21st of March, 2010, the day of the spring equinox, which makes it a metaphor of the equilibrium between the opposite forces of day and night. Since then, the sculpture of Staccioli has become one of the attraction points of Fiumara d'arte park, enriching the heritage of ten monumental sculptures, made of concrete or steel, set in special and significant locations of the region. Art Works such as "La materia poteva non esserci" ("Matter could not be there") by Pietro Consagra, "Monumento per un poeta morto. La finestra sul mare" ("Monument for a died poet. A window on the sea") by Tano Festa, "Il labirinto di Arianna" ("Arianna labyrinth") by Italo Lanfredini, "Energia mediterranea" ("Mediterranean energy") by Antonio Di Palma, are some examples of these land art works.

The Pyramid, like the other sculptures of Fiumara d'arte, enters the landscape and extracts from it its own symbolic force. At the same time, all these art works change the spatial coordinates of their environment, both modifying the human perception process and becoming themselves landscape, a place of thinking dedicated to art.

The perimeter walls of the hollow Pyramid are made of hundreds of COR-TEN sheets with a maximum height of 27 meters, constrained to a plain alveolar steel structure.

At sunset, the sunrays make red the brown colour of steel, and the sunlight goes inside the structure through a vertical cut on the west edge. "Cosmic sonorities" spread when the steel structure, heated by the strong Sicilian sun, grows cold explicating its interior movements.

[1] Dr. Eng., Professor at University of Palermo, DICA. Italy. arici@unipa.it
[2] Dr. Eng., PhD, Assistant Professor at University of Palermo, DICA. Italy. granata@unipa.it
[3] Dr. Eng., Structural Engineer. Italy. serio.ing@libero.it

Just like the architectural works, where the structure complies through its static and technological role with the aesthetic and functional architectural theme, the monumental works of Fiumara d'arte allow making real and tangible the artist thought. Particularly in the case of the Pyramid, the will of its author was to build a "laic hermitage which invites Man to an awakening of his conscience, a place to be universal and particular at the same time, where Man can stay thinking about the sense of life: a question without answer but a tangible question."

The structure of the Pyramid is a 3D frame, obtained by three 2D frames with profiles made of S450 steel, with a rhombic structure. The external skin is made of COR-TEN sheets, 1 cm thick, fixed on the framed structure. Foundations are organized in a closed horizontal frame with reinforced concrete beams, inserted into the ground for a depth of two meters.

The global stability has been verified with reference to the dominant wind, blowing from the river valley beneath, and also to seismic excitation and to the serious thermal gradients due to the day-night temperature excursion.

Figure 1 shows a render of the Pyramid and the hill on which is set. It has been used also for the study of possible wind paths from above and below.
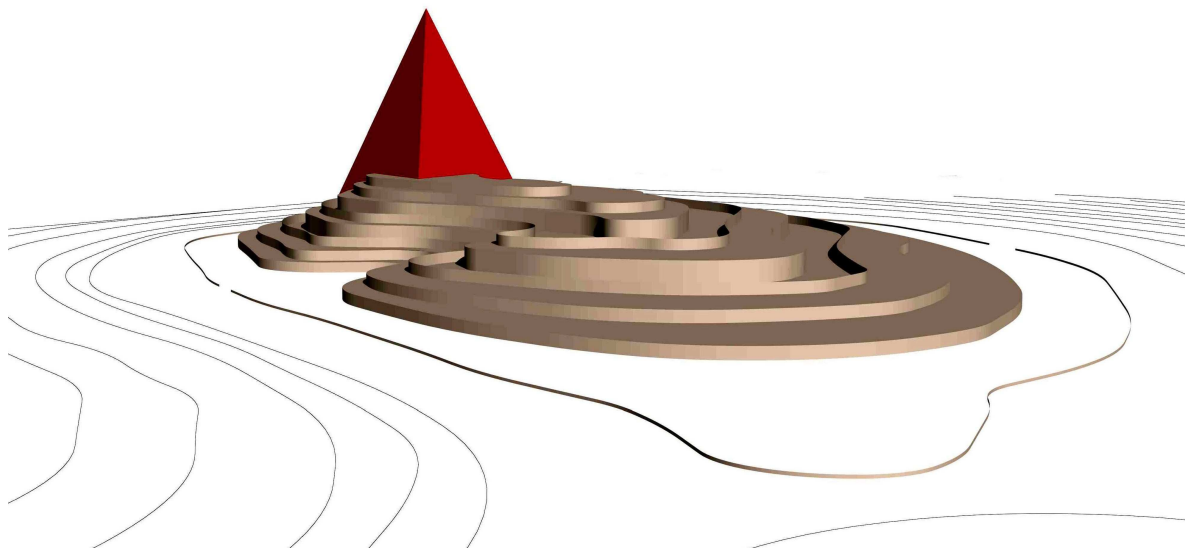

Figure 1: 3D render of Pyramid and land model

2. Architectural values and artistic meanings

The Pyramid – 38th parallel is located over a hill in the municipality of Motta d'Affermo, Sicily. The meaning of this artwork is the perfect synthesis of the universal co-existence of opposites. The triangular shape, as said by its author, is a picture with three tips, every vertex representing Art, Religion and Philosophy. Also Sicily has a geographic shape of triangle. This perfect figure is then an invitation to think about the Man destiny, a continuous fight between immanence and transcendence, between matter and spirituality. In the author's will the Pyramid represents an occasion to recover the sense of beauty, searching for the real justice.

About this sense of beauty the Pyramid is set in front of the Eolian Islands, particularly it refers to Stromboli volcano, with its energy and its triangular shape, again. The Pyramid looks at the sea and the background is given by the archaeological rests of the ancient city of Halaesa. The point is also one of the 38th parallel, the same that separates North Corea from South Corea. It is a sort of balancing: in that part of the world, the 38th parallel has a symbolic meaning of division, in this one instead it has a symbolic meaning of union, serenity, beauty.
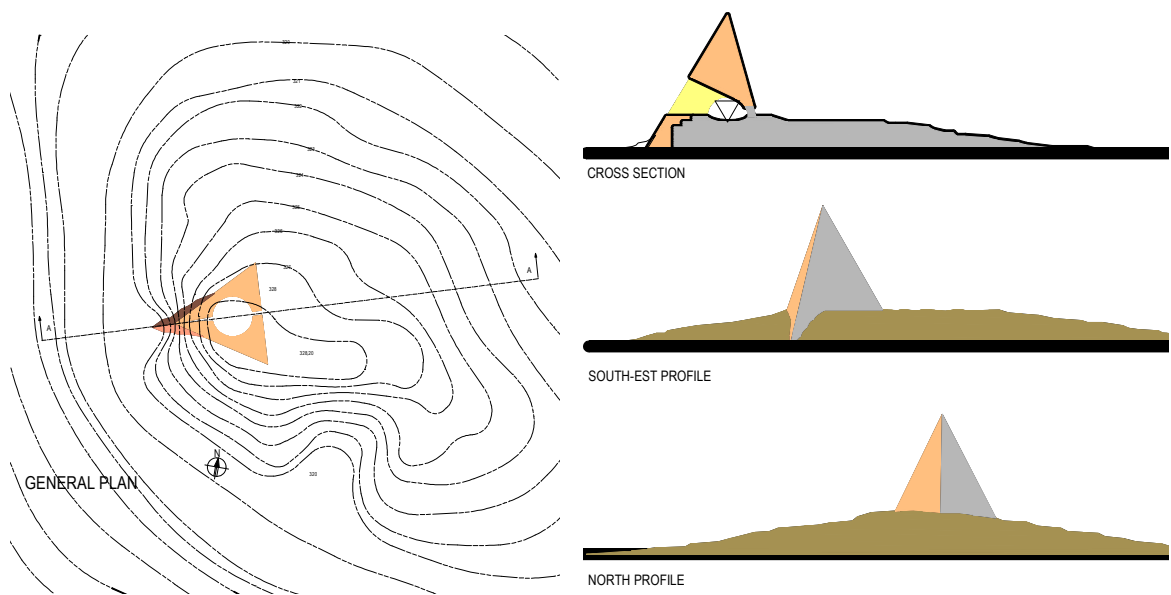
Figure 2: General views of the project

At the centre of the hollow tetrahedron, ferrous stones are located in form of spiral. In this way the artist materializes the two opposite forces: the horizontality which signs the life-death cycle through the spiral shape and the verticality of the sky-earth axis, which bears at the centre of the spiral and pass through the highest Pyramid vertex. So, the Pyramid has inside the same red ferrous earth of the hill on which is set. Every year, on the 21st of June, in coincidence with the summer solstice, the Pyramid is opened to public. People can enter it through the narrow cut of the west edge, to see the brown colour of light inside, in the day in which daylight hours are more than dark ones.

Figure 2 shows the Pyramid geometry and some profiles, while figure 3 emphasizes the brown colour of COR-TEN sheets with respect to the environment in which the Pyramid is set.

Figure 3: The Pyramid on the hill.

Figure 4 shows the cut on the edge, from which daylight enters the tetrahedron. It has been built by doubling the edge framed structure inside, separating the alveolar structure, that is continuous in the other edges.
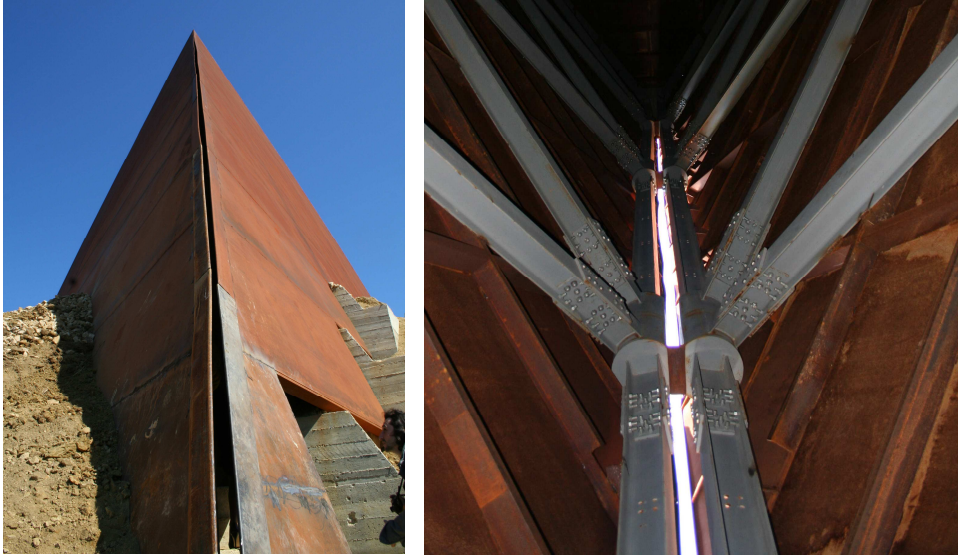
Figure 4: View of the corner chink from outside and from inside.

3. Structural features

The artwork is a Pyramid with an equilateral triangular base and 20 m of side length. It is 20.00 m high with a longer edge below at the west corner, arriving to a maximum height of 27 m. Foundations have been realized as a perimetral frame of reinforced concrete beams. Beams are on different levels in the longer corner, in order to compensate the different ground altitudes. The alveolar steel structure is composed of HEA 160 profiles. The skin is composed of COR-TEN sheets 1 cm thick, joined by welding and fixed on the 3D reticular structure.

Analysis has been performed through a 3D finite element model and actions have been modelled as static loads applied at structural joints. A dynamic modal analysis have been performed in order to consider earthquake and modal shapes.
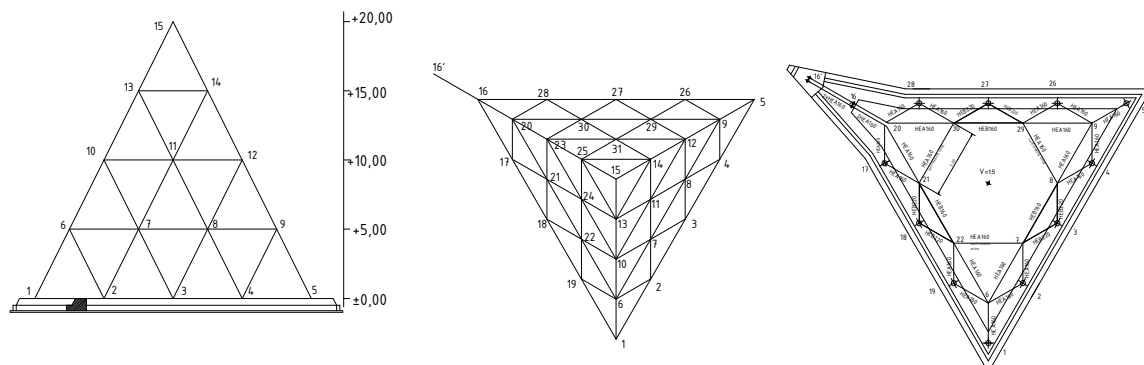

Figure 5: Alveolar steel structure.

Figure 5 describes the alveolar steel structure made of HE profiles.

Materials used are: steel profiles and COR-TEN sheets of steel type S450, concrete f_{ck}= 25 MPa. Steel bars for reinforcements are of B450C kind.

The structure has been subjected to wind actions as pressure and depression on the steel skin.

Normal wind pressure: 2.986 kN/m^2;

Wind pressure in the corner bisector direction: 3.434 kN/m^2;

Tangent wind to steel skin: 0.04 kN/m^2.

Moreover earthquake with PGA = 0.25 g has been considered. Regarding earthquake the Pyramid has been modelled as a rigid cellular 3D frame and modal analysis with 20 mode shapes has been performed. Internal

forces and displacements due to earthquake have been always less significant then those deriving from wind excitation. Analysis has been performed in accordance with Italian code [1] and Eurocodes [2,3]. Figure 6 shows some details of frames joints to ground.
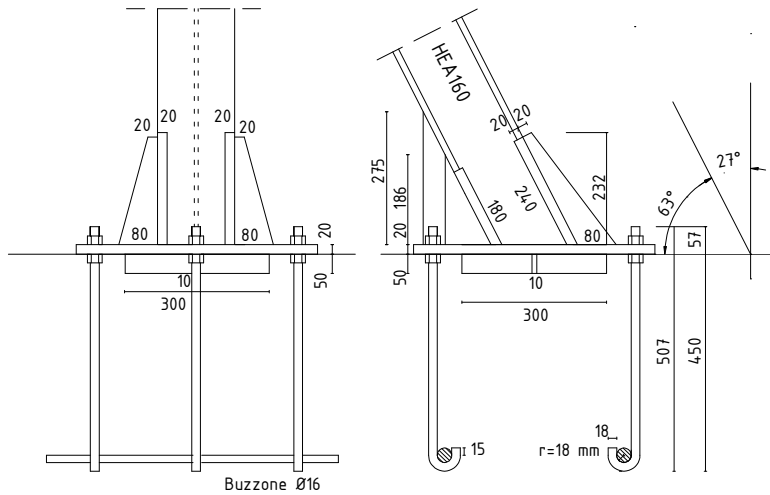

Figure 6: Detail of ground connection.

About thermal loads a temperature gradient from outside to inside of ± 25°C has been considered, due to the strong sun of Sicily.

The FE model has 4200 degrees of freedom with HE profiles organized in a 3D framed structure with beam elements (rigid connections), while sheets have been modeled as 2D shell elements. Modal analysis confirms the big stiffness of the structure, being the first 20 periods between 0.4÷0.6 s, all related to the in-plane and out-of-plane deformations of skin sheets. Figure 7a shows the general view of the FE model, while figure 7b shows the maximum of normal stresses for COR-TEN sheets subjected to wind excitation.
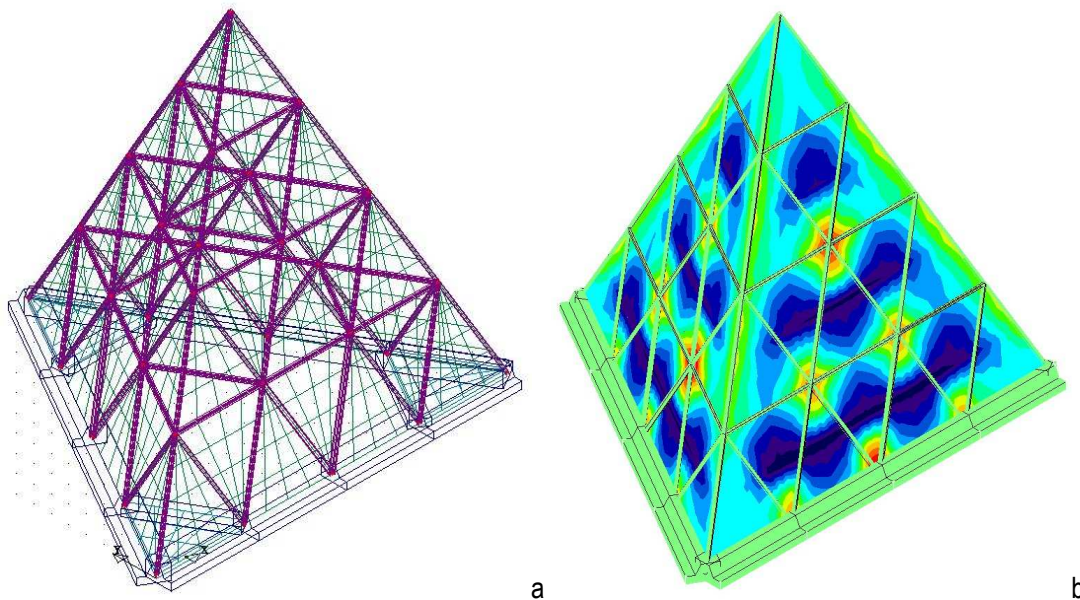

a   b

Figure 7: a) General view of FE model. b) Maximum normal stresses of COR-TEN sheets.

Project numbers are the following ones:
Altitude on the sea level: 320 mt.
Ground: clay with tracks of sand.
Static live load: 1.3 kN/m^2
Concrete (f_{ck}= 25 MPa): 150 m^3

Reinforcement steel: 10.000 kg
Profile steel for 3D alveolar structure: 20.000 kg
Lateral surface (skin steel area): 700 m^2
COR-TEN sheets: 21.000 kg
Figures 8 and 9 show instead some views of the internal structure and of construction phases.

Figure 8: Inside view. Framed alveolar steel structure.

Figure 9: Construction works. 3D steel alveolar structure assembling. COR-TEN sheets assembling. View from above.

4. Conclusions

The design of a steel Pyramid in the Fiumara d'arte land art park has been presented. The project is part of a large artwork program in Sicily. The architectural values have been discussed and the structural implications have been shown with reference to geometry, steel 3D truss structure and COR-TEN sheets. Considerations about wind and thermal actions have been discussed and structural analysis results have been presented.

References

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