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The Bartolomeo Ammannati's Fountain: an artifact in progress

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Abstract

Artifacts are not only fundamental evidences of our history and culture, but they are even entities having a proper "life". The present research focuses on Bartolomeo Ammannati's Juno Fountain (1555) – a Late-Renaissance masterpiece whose eventful story made it moving around from its planned site, the "Sala Grande" in Florentine Palazzo Vecchio, to Pratolino Park, then to Boboli Garden. Finally, current fragments re-assembling and museography staging under the vaults of the National Museum of Bargello court in Florence has been set up a few years ago on the 5th centenary of Ammannati's birthdate – after careful historical research about the many vicissitudes of the Fountain. Although there isn't any location change expected for this Ammannati's artwork, investigations and researches are going on. Namely, the seismic performance of the reconstructed Fountain is to be checked with reference to the seismic hazard of the site, as provided by the Italian Code classification. To this objective, the previously done laser scanning which allowed a three-dimensional digital modeling to help re-assembling the Fountain, has been now adopted to perform the structural analysis. Consequently, a structural evaluation to check the setting's seismic behavior is currently under process. The research, developed by joining different knowledges and fields, is an example of the importance of a multidisciplinary approach for preserving artifacts and museums' collections.

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Keywords: Juno fountain, rigid block analysis, sculptures by Ammannati, Bargello Museum, seismic assessment of artifacts.

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1. History of the fountain

1.1. Brief description

The Juno Fountain is a sculptural group currently exhibited at the National Museum of Bargello (see Figure 1), in Florence. The Fountain presents an articulated composition, which originality is determined by the architectural arrangement of the statues. The Juno statue was placed at the top of a rainbow and was accompanied by two peacocks. In the current staging, these three statues are copies; the originals are displayed beside the rearrangement. The feminine statue alludes to both the goodness and to the duchess Eleonora di Toledo, who had these animals as emblems. The rainbow is born from the two sources of water: Arno, represented as a powerful man, and Spring of Parnasus, imagined as a gentle feminine figure. Under the arch, and figuratively inside the water, Cerere presses her breasts, embodying the life and the richness. In the current arrangement, two statues, Fiorenza and Prudenza, are placed laterally to the group. According to the original project, these two pieces, with others, should have been positioned in the niches of the South wall of Sala Grande.

Fig. 1,2,3. Views of the current reconstruction of the Ammannati's Fountain.

1.2 The original project.

The initial project goes back to the middle of the XVI Century, when Florence was an important center for art and architecture. Cosimo I de' Medici was the patron and promoter of such achievement. At first, the fabbriche medicee (Medici's yards) focused on the center of the power: Palazzo Vecchio, the Uffizi, and Palazzo Pitti. With the moving of the Duke residence to Palazzo Pitti, Palazzo Vecchio became a sort of headquarters of the Ducato, with its new suitable spaces and offices (Uffizi). The goal of the Duke was to transform the Medieval palace in a modern site: a place of representation, where to welcome (and impress) foreign hosts. The first works interested the Throne room, Baccio Bandinelli and Giuliano di Baccio d'Agnolo, coordinated by Del Tasso, designed the new asset and started refurbishing it from the North wall. When Vasari succeeded to Del Tasso as the yard director, the works inside the Sala Grande stopped for ten years, until the wedding of Francesco I in 1555. Bartolomeo Ammannati, introduced by Vasari, became the designer of the South wall of the Sala Grande. In continuity with Bandinelli's work, Ammannati designed the architectural arrangement and started sculpting the statues for the fountain. The project foresaw a rich architectural display with a fountain in the middle, surrounded by statues in marble and bronze (Cerri, 2014). In 1560, the plans for the Sala changed (Ferretti, 2011) and the new project (the Salone dei Cinquecento) did not include Ammannati's design. As consequence, the fountain works stopped.

1.3 The Fountain's journeys

The project interruption turned uncertain the future of the fountain. Documents testify the presence of its marbles in Medici's gardens and villas through time. Some papers (Zikos, 2011) indicate the presence of some statues inside Ammannati's bottega (atelier), while Borghini (Borghini, 1584) recognized the statues of Arno and Parnasus at Pratolino Villa: it can be assumed that Ammannati finished the back of the statues when they were set up in the Pratolino's garden. In 1588, the sculptures moved to Palazzo Pitti. Ammannati himself was the person in charge of the arrangement of the artwork in the courtyard. In 1635, the Artichoke Fountain (Fontana del Carciofo) took its place, and, once again, the Juno's Fountain changed location. The group of sculptures was dismantled, and the pieces were scattered between the Casino di San Marco and the Boboli gardens. As well as the concept design for the South wall of Sala Grande, also the vicissitudes of fountain's story are not well documented.

1.4 The final arrangement

During the XX century, the statues were somehow brought together and placed under the vaults of the courtyard of the National Museum of the Bargello. The current set up is the result of an interdisciplinary study that involved the curators of the museum and the University of Florence (Pirazzoli, 2011) in occasion of the temporary exhibition: "L'acqua, la Pietra, il Fuoco. Bartolomeo Ammannati scultore" (Paolozzi Strozzi and Zikos, 2011), made in 2011 to celebrate the 5th centenary of the birth of Ammannati. The final set up has taken advantage of the studies made by Heikamp (Heikamp, 1978), which lead to a reconstructive proposal for the group of sculptures. Years later, regular studies combined to 3D technologies helped to find a likely solution, actually close to Heikamp's suggestion.

1.5 The current developments

Now, the location of the Fountain is not going to change. Nevertheless, investigations concerning this piece-of-art are still in progress, involving different issues and techniques. The current concerning is the safety of the Fountain with regards to the seismic risk. The assessment of the seismic response of the Fountain has been checked by modeling each statue and representing the seismic excitation through the elastic spectra provided by the Italian Technical Code (2008) for the site hazard. The response of the statues has been found with reference to a simplified representation of their response, i.e. by assuming a rigid block behavior.

2. The sculptures in detail

2.1 The 3D laser scanner survey

A reliable and detailed geometrical representation is a crucial step of the seismic assessment of artifacts; the recent developments in the digital survey procedures (Pascale and Lolli, 2013) have improved the quality of the achieved results. In the current work, the geometrical description of the sculptures has been made by means of a 3D laser scanner survey. The survey work was done using a Cam/2 Faro Photon unit, based on phase shift measurement technology. To complete some parts of the back of the statues of Cerere, Arbia and Arno it was used a Nextengine unit, with a higher accuracy, but most of all, with the correct size to enter in the narrow space between the statues and the wall.

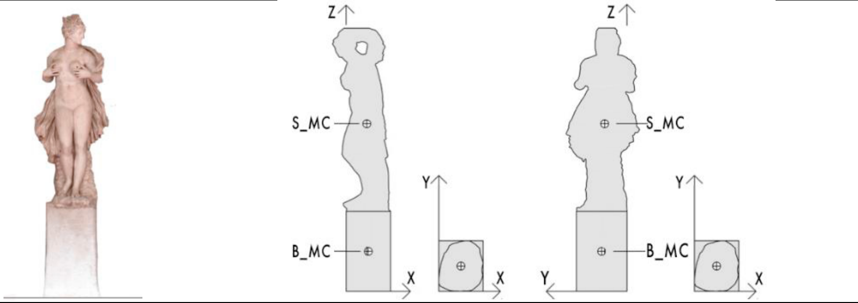
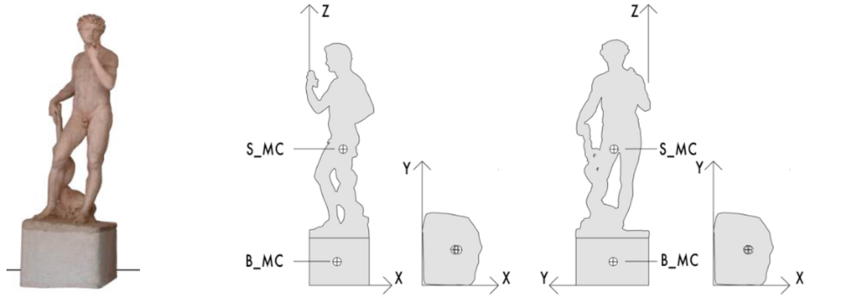
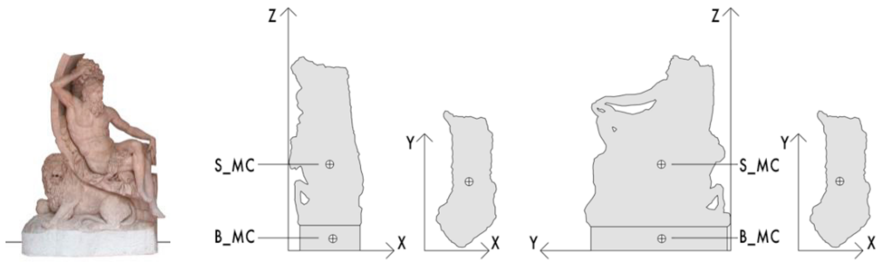
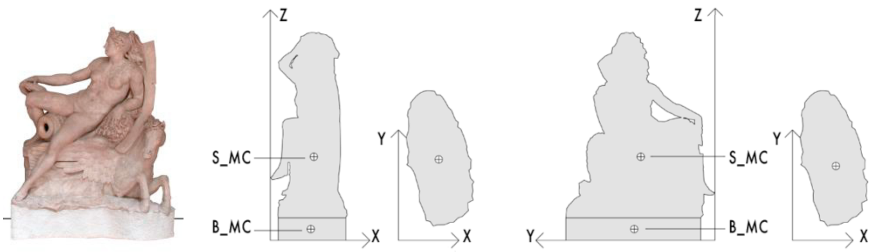
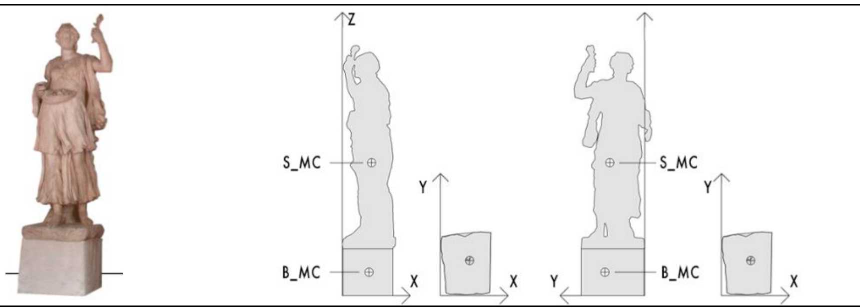
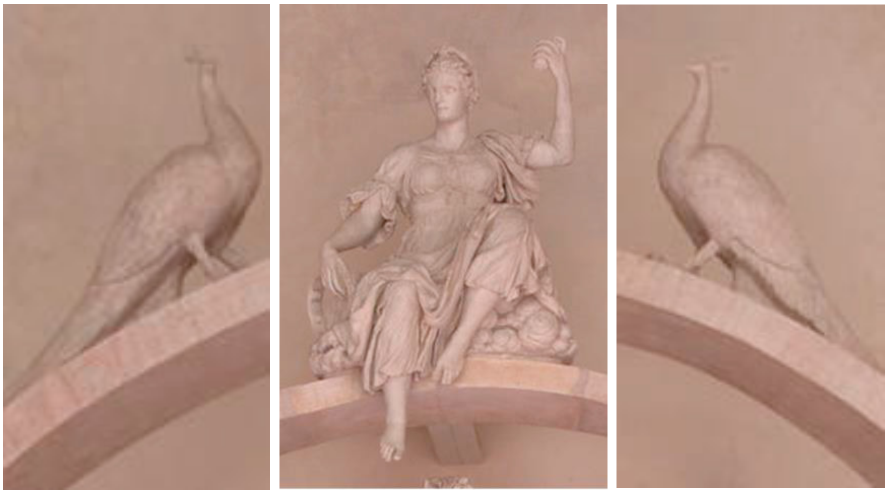
Cerere		**Statue** Mass (W_s) = 970 kg Height (H_s) = 230 cm Footprint = 63.0x55.7 cm S_MC (x,y,z)=26.2,28.0,211.7 cm **Basament** Mass (W_b) = 616 kg Height (H_b)= 101 cm Footprint = 64x56 cm B_MC(x,y,z)=26.1,32.0,50.5 cm
Prudence		**Statue** Mass (W_s) = 729 kg Height (H_s) = 232 cm Footprint = 85x71 cm S_MC (x,y,z)=39.9,41.0,161.3 cm **Basement** Mass (W_b) = 497 kg Total height (H_b) = 56 cm Footprint = 85x71 cm B_MC (x,y,z)=42.0,42.0,28.0 cm
Arno		**Statue** Mass (W_s) = 3349 kg Height (H_s) = 230 cm Footprint = 180x80 cm S_MC (x,y,z)=58.1,99.0,111.3 cm **Basement** Mass (W_b) = 586 kg Height (H_b) = 30 cm Footprint = 180x80 cm B_MC (x,y,z)=53.9,107.7,15.0 cm
Arbia		**Statue** Mass (W_s) = 3197 kg Height (H_s) = 213cm Footprint = 170x75 cm S_MC (x,y,z)=25.1,87.1,108.4 cm **Basement** Mass (W_b)= 434 kg Total height (H_b) = 30 cm Footprint = 170x75 cm B_MC (x,y,z)=56.0,86.7,15.0 cm
Fiorenza		**Statue** Mass (W_s) = 953 kg Height (H_s) = 240 cm Footprint = 74 x 60 cm S_MC (x,y,z)=35.1,41.8,158.9 cm **Basement** Mass (W_b) = 385 kg Height (H_b) = 56 cm Footprint = 74 x 60 cm B_MC (x,y,z)=32.0,47.8;28.0 cm

Figure 4. Description of the original sculptures of the Juno Fountain

All the scans were later aligned on morphological similarities, creating a pointcloud with all the information about shape and detailed characteristics of each statue. This has been the starting point to study the “new” setting of this group of statues, verifying Heikamp’s proposal and reconstructing with an accurate “inverse design” process all the main missing parts of the fountain.

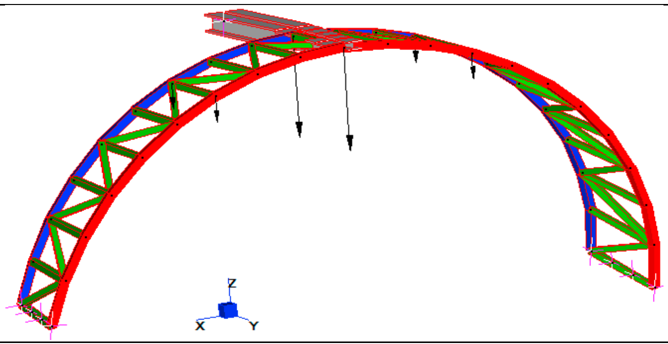
2.2 The data adopted in the analysis

In this work a simplified analysis, based on the evaluation of the limit horizontal load which activates the sculptures overturning, has been performed. Therefore, the main quantities required to perform the analysis are the geometry, the mass and the center position of each sculpture. In Figure 4 the main information describing the marble original sculptures, object of the seismic analysis, has been shown, whilst Figures 5 and 6 refer to the other components of the Fountain complex.



The copies have been made by the studio *Techne* (Florence), with the partnership of *Fonderia Artistica Marinelli* (Florence). A specific preparation, consisting of a preliminary restoration and cleaning, has been made on the original sculptures in order to optimize the molding procedure. The molding has been performed through a special survey based on elastomer lectures. The copies are made in gypsum, and their external layer has been reinforced through glass and vegetal fibers. The structure of Juno has been made by an alveolar aluminum panels, which have been used for the connection to the arch.

Figure 5. Description of the other components (*Spring of Parnesus, Peakoks*) of the Juno Fountain.



The arch design of the current staging has been made by a team coordinated by G. Pirazzoli, (2011) after the information collected for the Fountain exhibition (2012), while the structure has been calculated through the software Straus (Engisoft, 2013). The arch, executed by Opera Laboratori Fiorentini – Civita Group, consists of a core of steel truss, covered by marble-painted wood. The arch structure is sustained by the courtyard wall through a steel support (two double T profiles), resulting completely independent by the original sculptures.

Figure 6. Arch structure in the Juno Fountain arrangement.

3. The seismic analysis

3.1 The simplified overturning rigid block analysis

The seismic assessment of sculptures can be pursued through several analytical approaches, differing to each other for their computational effort, theoretic consistency and approximation level. In this work an approximated method, based on the equilibrium of the rigid body (Parisi and Augenti, 2013) has been applied. This approach assumes that the rigid overturning of the sculpture is the first which occurs in case of earthquakes. In the analysis, each sculpture has been modeled as a single rigid block, neglecting the possible interface between the basement and the upper sculpture, such as the vertical component of the earthquake. The maximum seismic acceleration which each sculpture can sustain is found by imposing the equilibrium between the overturning moment demand, MD, and the corresponding capacity, MC. The overturning demand is defined as the product of the horizontal force, supposed to be applied to the statue centroid, and its distance to the turning point, whilst the capacity is defined as the product of the sculpture weight and the distance between its centroid the basement side (Parisi and Augenti, 2013), according to the following simplified equations:

$$M_C = Wd \quad (1)$$

$$M_D = F_{HS}h \quad (2)$$

where W is the weight of the sculpture, d is the horizontal distance between the system centroid and the basement side along the considered direction, F_{HS} is the horizontal component of seismic force applied to the statue and h is the vertical distance between the statue centroid and the overturning point.

3.2 The obtained results

For sake of brevity, only the results referred to sculpture Cerere are shown in this section. The overturning analysis has been performed in both directions (*X* and *Y*), by considering two different situations: the overturning of the statue around the most conservative contact point between statue and basement, and the overturning of the complex "statue + basement" around the most conservative contact point between the basement and the floor (soil). Figure 7 shows the structural schemes considered for the analysis in the two directions. The quantities involved in the analysis can be easily derived by *W_s*, *W_b*, *S_MC* and *B_MC*, specified in Figure 4.

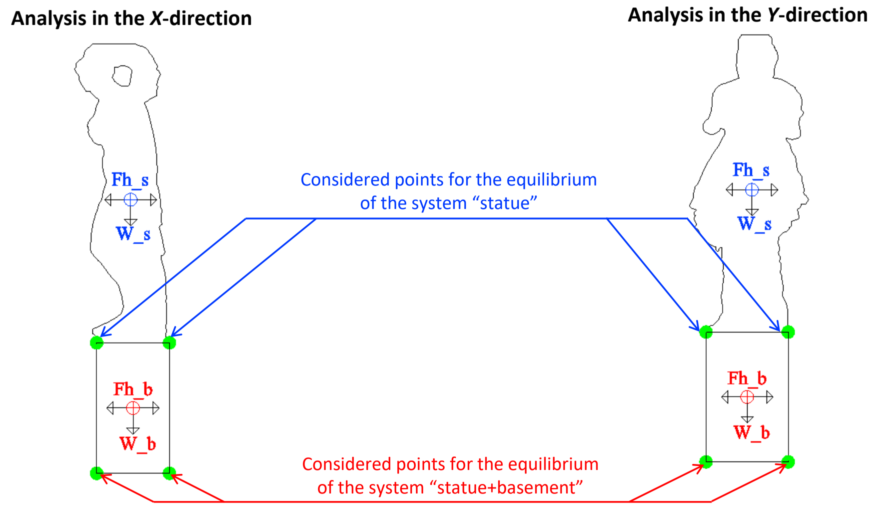


Figure 7. Assumed structural schemes for the overturning analysis of Cerere.

For each case of analysis, the quantity d has been assumed as the minimum (most conservative) distance between the considered mass center and the two sides of the support. The equilibrium between demand and capacity overturning moment provides a limit value, F_{HS}, for the horizontal acceleration. The values of F_{HS} have been compared to the spectra provided for the site by the Italian Technical Code (8), by assuming a Fundamental Period equal to 0 sec (since the sculptures have been assumed as perfectly rigid), a nominal life equal to 50 years, a Coefficient of Use (c_U) ranging between 1.0 and 2.0, and values of the amplification factor (F_0) found according to the Code provisions (see Table 1). As a result of the simplified analysis, the amplification factors have been found for each considered Return Period, according to the following expression (NTC, 2008):

$$f_a = \frac{a_0 \times q_a}{A_g \times S \times CF} \tag{3}$$

where a_0 is acceleration corresponding to the overturning mechanism, q_a is the behavior factor assumed equal to 2 and CF is the confidence factor assumed equal to 1. The coefficient expressing the soil features, S, is found as the product of S_S (stratigraphic amplification factor, defined as a function of F_0 and A_g, listed in Table 1) and S_T (topographic amplification factor, assumed equal to 1). In Figure 8 the values found for the Vulnerability Factor (I_v), defined as $1/f_a$, have been shown for the five soil-classes considered by the Italian Code. At the current time, the soil of the Bargello museum has not been checked, and a reliable classification it's hard to achieve. Please note that the seismic vulnerability is usually considered to be low for I_v below 0.5, medium for I_v ranging between 0.5 and 1.0 and high for I_v over the unity. The examined sculpture, therefore, results to have a seismic vulnerability low or medium-high depending on the assumptions made for the soil.

Table 1. Parameters assumed for the analysis.

Return Period (years)	Nominal life (years)	Limit State	c_U	Ag (g)	F_0
75	50	Damage Limitation	1.5	0.0649	2.594
101	50	Damage Limitation	2.0	0.0722	2.591
475	50	Life Safety	1.0	0.1313	2.413
712	50	Life Safety	1.5	0.1506	2.399
949	50	Life Safety	2.0	0.1659	2.389
1462	50	Collapse prevention	1.5	0.1890	2.399
1950	50	Collapse prevention	2.0	0.2060	2.407

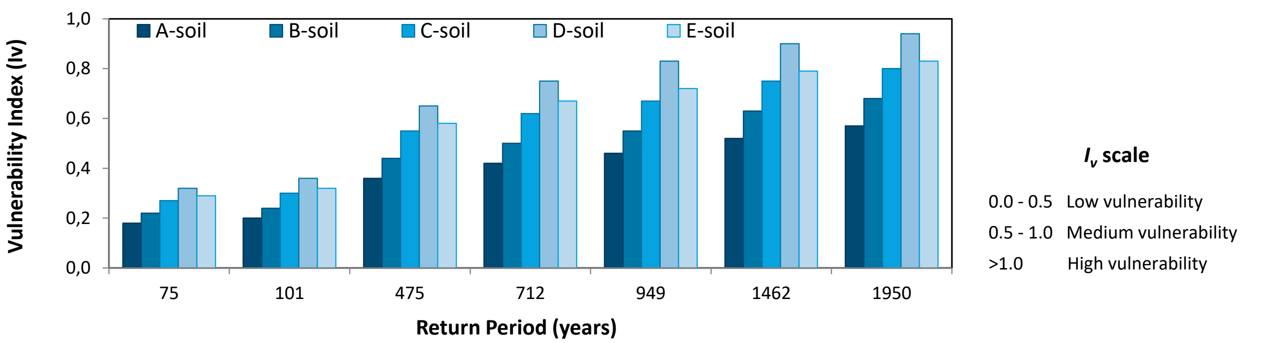


Figure 8. Parameters assumed for the spectra setting.

4. Conclusions

In this paper, the Ammannati's Juno Fountain has been presented in its main features, history, and staging. The main records concerning the Fountain have been collected and briefly resumed. A special attention has been paid to the seismic assessment of the sculptural complex, by performing a simplified analysis based on the overturning limit condition of the sculptures. The analysis has taken advantage by a preliminary laser scanner survey, which lead to a precise and detailed geometrical representation of each sculpture. For sake of brevity, only the results found for Cerere, which is the main – and slenderer – sculpture of the complex, have been presented. The equilibrium between demand and capacity overturning moments had led to determine the maximum horizontal acceleration acceptable for the statue. Finally, the comparison between such acceleration and the seismic hazard of the site had provided a range of possible vulnerability index related to different considered limit states. The vulnerability index never exceeds the unity, resulting however in the alert range for the higher Return Periods, especially for some soil assumptions. The univocal quantification of the seismic performance of the sculptures would require a more detailed knowledge of the soil site, currently under observation, and the adoption of more refined analytical model to represent their seismic response.

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