INTERNATIONAL JOURNAL OF CONSERVATION SCIENCE

ISSN: 2067-533X Volume 13, Issue 4, October-December 2022: 1101-1116 www.ijcs.ro

A LOW-COST ISOLATION STRATEGY FOR MUSEUM ARTEFACTS

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Abstract

The safety of museum exhibitions has recently become a challenging issue due to the newly different conception of the Museum as a creative and interactive place, where people can be also close to the artefacts. The way of exhibit art objects needs accurate study to assure the simultaneous safety of both artefacts and visitors according to the current increasing safety standards. The earthquakes are the main cause of damage and even failure of art objects, especially in small museums and churches that are largely diffused all over Europe. Therefore, the low-cost protection of artefacts and visitors is key in earthquake-prone areas. In several cases art objects can be modelled as rigid bodies placed on a moving base. To capture their mechanical response, the Housner theory, developed at the beginning of the sixties, represents a valid and accurate tool. Based on this theory, this paper presents a new approach for the preservation of museum artefacts through a low-cost isolation strategy. Art objects are considered as rigid bodies placed on a shaking base and their response is modelled considering both rocking and sliding motions. This paper highlights the need for a correct optimisation of both base shape and friction coefficient in order to drive the artefact response in more stable dynamics regions. The proposed approach effectiveness is tested on a real case study, an acephalous marble statue in the Archaeological Museum of Paestum.

***Keywords**: Museum Resilience; Rocking; Artefacts protection; Nonlinear dynamics; Seismic safeguard.*

Introduction

Museum visitors have lately strongly changed their attitude [1] as the recent development of technology has made available online large part of museum collections.

Moreover, the recent pandemic crisis has enhanced this aspect. Nevertheless, visitors want to be as close as possible to the artefacts. The offer of creative and safe spaces is a key issue to be fulfilled together with the museum requirements about the ductility of their exhibition plans that can consistently change during the year [2, 3]. Thus, flexibility and sustainability of the devices should not be a secondary feature. Moreover, the design of exhibit devices needs to simultaneously satisfy safety of both artefacts and visitors, as also prescribed in current codes and

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regulations [4, 5]. This last aspect has been a concern for many years, and the literature panorama involves much research dealing with the protection of museum artefacts in seismic areas [6]. Indeeed, the damage due to ground movements is the major cause of artefacts injury, especially for fragile archaeological objects that all too often are in a poor preservation condition. Nonetheless, there are also other relevant items exposed to damage such as brittle artefacts (e.g., pottery vessels, statues or objects made of very fragile materials, such as glass). This, of course, applies to collections consisting of objects standing in a non-properly secured situation (or state), see [7]. Due to the above-mentioned factors, it is always of significant concern to develop new solutions and mechanisms, which could preserve museum objects from damage (the reader can find an exhaustive references list in [8, 9]). These are mostly restraining shelves or rings, which prevent the objects from displacements or falling over [10]. A large part of the artefacts has a narrow bottom part, which is most often the standing point, and edges are gradually expanding towards the opening. The paleolithic museums exhibit flint artefacts, especially core refits deriving from the stone age or fragile stone elements with fossil traces. In general, all these types of morphologies are prone to damage [11], and their overturn would cause injuries not only to the objects themselves but also to the nearby artefacts, to other elements of the exhibition and, importantly, even to visitors. In these cases, sliding motion could be a desired condition, taking into account the distance with the museum or showcase walls and between the objects themselves [12].

Due to the complex nature of museum exhibitions, there is the need to match proper techniques and methods of securing artefacts. Unfortunately, the actions the artefacts are usually exposed to are of different types. Beyond the ones due to climate and environmental changes, the ones related to the museum site, i.e., earthquakes, are relevant. These external action typologies are the focus of the present research, as the proposed methodology enables to model their mechanical response in such exposure conditions.

This research field is of great interest, being part of research and policy in the more general field of Cultural Heritage and has attracted several local governments and European research grants [13], since recent seismic events revealed how cultural heritage could be much vulnerable as even low-intensity loads may determine very large cultural losses.

It is necessary to preserve the museum exhibits formulating simple design rules to follow when setting up a new museum or when an old one has to be renewed. The cost of a safeguard system in fact represents a great problem. If the art object is unique and irreplaceable (the Riace Bronzes, for example) it needs a high level of protection, so that a significant economic effort is worthwhile [14]. A clear example is in fact represented by the high-cost base isolation system designed for the Bronzes. In general, large scale protective measures should be efficient, low-cost and, importantly, simple to be implemented by non-specialised workers. The exhibit devices currently available in all museums are in general not equipped with specific tools capable of decoupling the pedestal from the moving floor [15].

Additionally, in many cases museum floors are precious work of art and should be preserved themselves. In such cases, apart from their cost, the use of isolation systems is impossible as they cannot be fixed to the floor.

A simple and low-cost system should be developed for a sustainably large-scale preservation of art objects. The present paper aims at addressing this topic with a contribution towards the development of low-cost exhibit criteria complying with the safeguard of precious museum floors. The paper presents the analytical bases for the design of a low-cost passive protection of museum artifacts in case of horizontal oscillation of the floor. The requirements of the protection system here examined can be easily obtained at limited expenses and could be useful in all the contexts where low-cost tools and safeguard of the museum pavement integrity are necessary.

The protection can be realized by means of a pedestal whose bases interact respectively with the art object and the museum pavement by means of the friction coefficient only. The pedestal, that should be designed to be considered as a rigid body, can be inserted between the pavement and the art object without damage for the pavement. Its role is the reduction of the overturning risk of the above artefact by means of the friction values control. The numerical procedure here presented, modelling the dynamic behaviour of non symmetric bodies like statues, is an efficient tool for the exhibit design: mechanical parameters, mass and dimensions of the pedestal can be evaluated.

The general problem

The first program related to the seismic safeguarding of art objects is from *Agbabian et al.* [16]. It was developed in the framework of a research program sponsored by the Getty Museum in Malibu, California, USA. In that study, a wide range of objects was classified according to their shape and method of exhibiting. Analytical and experimental techniques were combined to evaluate the possible damage risk due to earthquakes. One of the problems examined concerned the safeguarding of freestanding vases and statues [17].

An artefact can be considered a rigid object placed on a shaking base that may enter a rocking motion and result in overturning [18]. Although the roots of the problem lie down in the first years of the sixties, a complete and effective solution is actually far from being found. The reference model for the rocking response of a rigid object supported on a base undergoing horizontal motions was in fact presented by [19], who first established and solved the equations of motion of the rigid body. The study was devoted to the understanding of the behaviour of tall, slender structures subjected to ground motion. Using the Housner model, only recent studies have faced the resilience of buildings contents in seismic areas, especially focusing on art objects in museums [20, 21]. Large part of them regards the examination of the motion of a single object freestanding on the museum floor. The problem becomes more complex when the behaviour of two stacked rigid bodies is examined: the highly nonlinear formulation needs some simplifying assumptions [22, 23]. In the case examined by *Spanos et al.* [24] a significant friction is considered to prevent the sliding motion. For art objects the rocking behaviour represents the limit condition. The sliding motion is in fact the only one not affecting the artefact base with impact damage, although both numerical and experimental literature are devoted mainly to examining the rocking behaviour, even in the cases in which two stacked blocks are considered [25-27]. In the seismic case, artefacts response significantly depends on both the dynamic characteristics of the objects themselves and the building in which they are arranged [28, 29]. A fundamental step towards addressing the problem envisages in fact an accurate evaluation of the artefacts' behaviour, considering the dynamic filtering effect of the building structure. In fact, the ground motion that a building is subjected to undergoes a modification of its dynamic characteristics during the propagation from the foundation up to the base of the artefact at the ith floor [30]. It must be underlined that, in many cases, the museums are within historical buildings for which isolation techniques are often not applicable.

The analytic study here proposed examines the combined behaviour of the artefact and the simple supporting device. The geometric and mechanical characteristics, such as mass, shape and friction coefficient among artefact and support base, are considered as primal parameters to be tuned in order to reduce the artefact vulnerability. Oscillations or impact with the surrounding walls in case of seismic events are accounted for. As it will be shown, the use of the present methodology allows to define a suitable placement of the artefact and also the design of the geometric and mechanical characteristics of the supporting base. The novelty of the study concerns the development of a sustainable and low-cost pedestal for non symmetric rigid bodies like statues that can be used on precious museums pavements [31].

The analytical model combines two motions: the rocking of a single slender, rigid block and the sliding of a single squat block on a moving floor. The problem has been solved for symmetric blocks in previous studies by the authors [32, 33], while in the present paper the non symmetric geometry of the slender top block (statue) is explicitly considered to better model real problems [34]. The geometrical and mechanical parameters of the double block problem are reported in Figure 1. The system has two degrees of freedom, namely the rotation θ (clockwise positive) of the statue (i.e., block 2 of Figure 1) and the centroid position of the pedestal (block 1 in figure 1), as in [35]. Because of the asymmetric geometry, the two radii R_1 and R_2 connecting the centroid G_2 of the statue with the two base impact points are different. The centroid of the pedestal whose mass is m_1 is denoted with G_1. The mass of the statue is denoted with m_2 while the total mass of the system is $M = m_1 + m_2$.

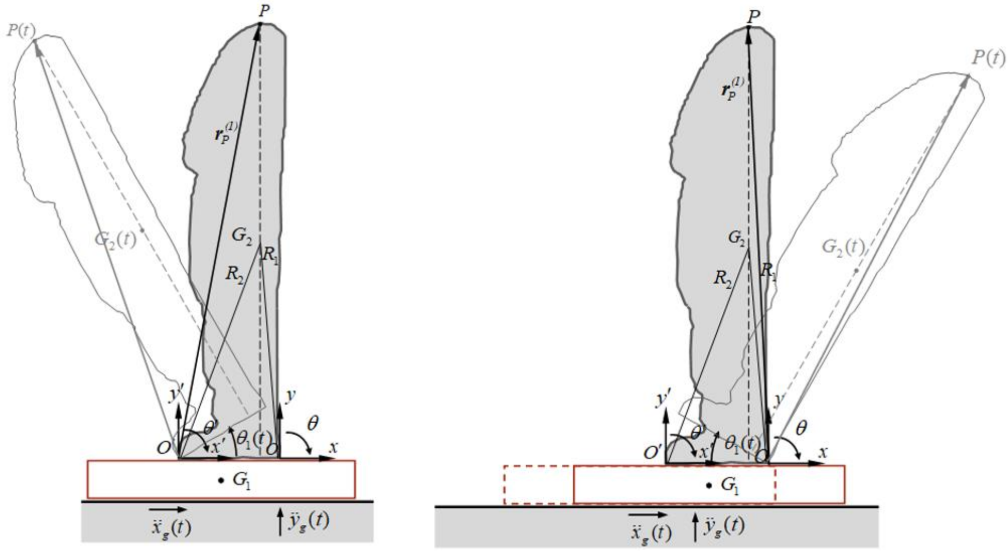

Fig. 1. Double block at rest position (left) and with upper block in rocking mode (right)

The base has horizontal sinusoidal oscillations whose acceleration is $\ddot{x}_g(t)$ where the vector $(x_g(t), y_g(t))$ denotes the base position as function of the scalar parameter t. In what follows we show how the equations of motion can be computed through the Lagrangian formulation of the problem:

$$L(t) = T(t) - V(t), (1)$$

with $T(t)$ and $V(t)$ the kinetic and potential energies of the mechanical system.

Those energies are evaluated describing the motion with respect to two distinct Cartesian reference systems $\{O, x, y\}$ and $\{O', x', y'\}$, whose origins coincide with the two impact points O and O', respectively. The position vectors of G_2 with respect to O' and O in the initial configuration are $\boldsymbol{r}_{O'G_2}$ and $\boldsymbol{r}_{OG_2}$, whose components are:

$$\boldsymbol{r}_{O'G_2} = \boldsymbol{R}_2 = \begin{bmatrix} R_2\, sin\theta \\ R_2\, cos\theta \end{bmatrix}, \boldsymbol{r}_{OG_2} = \boldsymbol{R}_1 = \begin{bmatrix} R_1\, sin\theta \\ -R_1\, cos\theta \end{bmatrix} \qquad (2)$$

The hypothesis of pure sliding motion for the pedestal implies that the vertical component of its relative motion with respect to the floor is zero. The position of the centroid G_1 can be expressed as:

$$\boldsymbol{x}_{G_1}(t) = \begin{bmatrix} x_g(t) + x_{G_1}(t) \\ y_g(t) \end{bmatrix} \qquad (3)$$

However, the position of G_2 is influenced by the non-symmetric geometry of the statue and can be computed as follows:

$$\begin{aligned} \boldsymbol{x}'_{G_1}(t) &= \boldsymbol{x}_{G_1}(t) + \boldsymbol{R} \circ \theta(t)\, \boldsymbol{r}_{O'G_2}, \theta(t) < 0 \\ \boldsymbol{x}_{G_2}(t) &= \boldsymbol{x}_{G_1}(t) + \boldsymbol{R} \circ \theta(t)\, \boldsymbol{r}_{OG_2}, \theta(t) > 0 \end{aligned} \qquad (4)$$

thus, so the current position of the control point P is:

$$O'P(t) = \boldsymbol{R} \circ \theta(t)\, \boldsymbol{r}_P^{(1)}, \theta(t) < 0$$
$$OP(t) = \boldsymbol{R} \circ \theta(t)\, \boldsymbol{r}_P^{(2)}, \theta(t) > 0 \quad (5)$$

where $\boldsymbol{R} \circ \theta(t)$ is the rotation matrix that takes the rocking motion of block 2 into account.

Thus, the total kinetic energy of the system is:

$$T(t) = T_1(t) + T_2(t), \quad (6)$$

With $T_1(t)$ and $T_2(t)$ kinetic energies of pedestal and statue, respectively:

$$T_1(t) = \frac{1}{2} m_1\, \dot{\boldsymbol{x}}_{G_1} \cdot \dot{\boldsymbol{x}}_{G_1}, T_2(t) = \frac{1}{2}\left[J_{G_2} \dot{\theta}^2(t) + m_2\, \dot{\boldsymbol{x}}'_{G_2} \cdot \dot{\boldsymbol{x}}'_{G_2}\right], \theta(t) < 0$$
$$T_1(t) = \frac{1}{2} m_1\, \dot{\boldsymbol{x}}_{G_1} \cdot \dot{\boldsymbol{x}}_{G_1}, T_2(t) = \frac{1}{2}\left[J_{G_2} \dot{\theta}^2(t) + m_2\, \dot{\boldsymbol{x}}_{G_2} \cdot \dot{\boldsymbol{x}}_{G_2}\right], \theta(t) > 0 \quad (7)$$

being J_{G_2} the centroid moment of inertia of the artefact. On the other hand, the potential energy of the system is the sum of the corresponding potential energies of statue $V_1(t)$ and pedestal $V_2(t)$:

$$V(t) = V_1(t) + V_2(t) \quad (8)$$

with $V_1(t)$ and $V_2(t)$ expressed as:

$$V_1(t) = m_1 g\, \boldsymbol{x}_{G_1} \cdot \boldsymbol{j}, V_2(t) = m_2 g\, \boldsymbol{x}'_{G_2} \cdot \boldsymbol{j}, \theta(t) < 0$$
$$V_1(t) = m_1 g\, \boldsymbol{x}_{G_1} \cdot \boldsymbol{j}, V_2(t) = m_2 g\, \boldsymbol{x}_{G_2} \cdot \boldsymbol{j}, \theta(t) > 0 \quad (9)$$

being $\boldsymbol{j}$ the unit vector of y-axis. The friction force at the base of the pedestal during the sliding movement is given by:

$$F_{x,friction} = -\mu_k\, M\, (g + \ddot{y}_g(t))\, \ddot{x}_g(t)\, sgn(\dot{x}_g(t)). \quad (10)$$

The motion is governed by two differential equations derived by the Euler-Lagrange relation:

$$\frac{\partial L(t)}{\partial t\, \partial \dot{q}_k} - \frac{\partial L(t)}{\partial q_k} = Q_k(t), k = 1, 2 \quad (11)$$

where: $q_1(t) = x_{G_1}(t)$, $q_2(t) = \theta(t)$ are the two Lagrange parameters and $Q_k(t)$ is the generalised and non conservative force dual to $q_k(t)$.

Due to the lack of symmetry, the system (10) assumes two different expressions according to the sign of $\theta(t)$, and it results:

$$J_O \ddot{\theta}(t) - m_2 R\, cos[\alpha - |\theta|]\left(\ddot{x}_{G_2}(t) + \ddot{x}_{G_1}(t)\right) + m_2 R g\, sgn(\theta(t))\, sin[\alpha - |\theta|] = 0$$
$$R = R_2 \text{ for } \theta(t) > 0, R = R_1 \text{ for } \theta(t) < 0$$
$$M\left(\ddot{x}_g(t) + \ddot{x}_{G_1}(t)\right) + sgn(\theta(t))\left\{-m_2 R\left[sin(\alpha - |\theta|)\, \dot{\theta}^2(t) - \cos(\alpha - |\theta|)\, \ddot{\theta}(t)\right] + M \mu_k g\right\} = 0$$
$$\theta(t) \neq 0$$
$$\dot{\theta}^+(t) = r \dot{\theta}^-(t), \theta(t) = 0$$

Note that the first two relations are two second order ordinary nonlinear differential equations, while the third one is the classical algebraic relation governing the kinetic energy lost during the rocking after each impact among the statue and the pedestal. The third equation involves in fact the pre-and-post-impact angular velocity of the statue during the rocking motion, defining the kinetic energy lost during the rocking after each impact through the restitution coefficient.

Therefore, the problem with the above relations is a system of algebraic-differential equations (DAEs) and the numerical solver has the structure indicated in Figure 2. Uncoupling of the two differential equations is not possible. Note that when flat block is at rest (Figure 3.a), its motion can be derived from (11) assuming $q_1(t) = x_{G_1}(t) = 0$. Particularly, it returns the following relation:

$$J_O \ddot{\theta}(t) - m_2 R\, cos[\alpha - |\theta|]\, \ddot{x}_{G_2}(t) + m_2 R g\, sgn(\theta(t))\, sin[\alpha - |\theta|] = 0 \quad (12)$$

which yields the classic rocking motion as in the Housner model (Fig. 2).

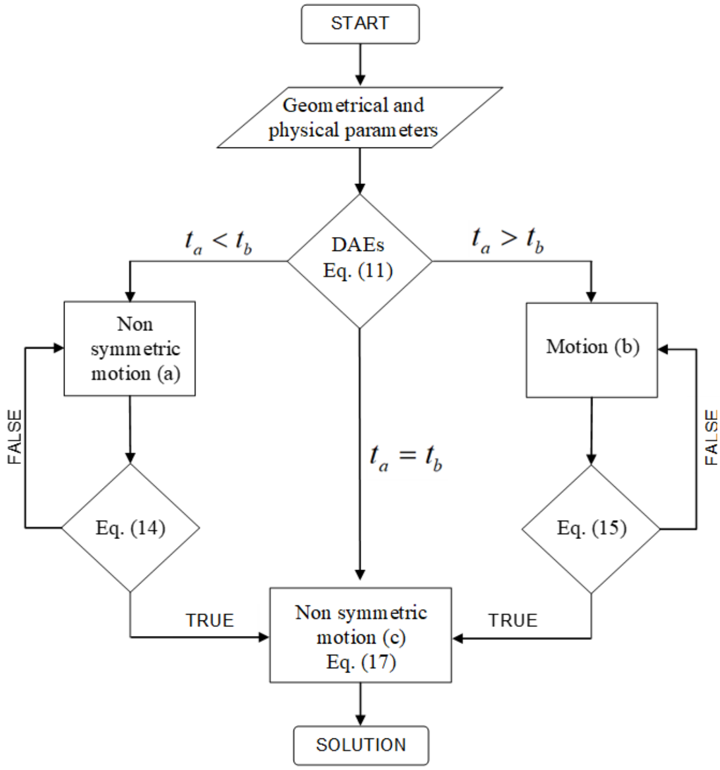

Fig. 2. Flow chart

Equation (12) describes the relative sliding motion of the two blocks (Fig. 3b), and when $q_2(t) = 0$ it returns:

$$M\left(\ddot{x}_g(t) + \ddot{x}_{G_1}(t)\right) = -sgn\left(\dot{x}_{G_1}(t)\right) M\mu_k g \tag{13}$$

which describes the sliding motion of the whole system.

As first step of the dynamic analysis, the starting typology motion as function of the ground acceleration is defined. Three possible patterns of motion have been examined (Fig. 3): a) rocking of the top block with pedestal at rest; b) sliding motion of the complex statue-pedestal as one rigid body and c) combined motion patterns: rocking of the statue and sliding of the pedestal.

Fig. 3. Possible motions

Motion (a) is activated if the two following condition holds:

$$\begin{cases} M\ddot{x}_g(t) < sgn\left(\dot{x}_g(t)\right) M\mu_k g \\ \ddot{x}_{G_2}(t)h > gb \end{cases} \tag{14}$$

while motion (b) when:

$$\begin{cases} M\ddot{x}_g(t) > sgn\left(\dot{x}_g(t)\right) M\mu_k g \\ \ddot{x}_{G_2}(t)h < gb \end{cases} \tag{15}$$

Importantly, the instant t_a such that:

$$\ddot{x}_{G_2}(t_a)h = gb. \tag{16}$$

corresponds to the change of motion from (a) to (b).

The conditions for the activation of the motion (c) are given by:

$$\begin{cases} M\ddot{x}_g(t) > sgn\left(\dot{x}_g(t)\right) M\mu_k g \\ \ddot{x}_{G_2}(t)h > gb \end{cases} \tag{17}$$

Particularly, motion (c) is activated when there is the balancement among friction and inertia force, and the corresponding instant t_b is the one solving the following equation:

$$M\ddot{x}_g(t) = sgn\left(\dot{x}_g(t_b)\right) M\mu_k g \tag{18}$$

In general, the motion (a) lasts until the ground acceleration does not overcome the static friction force, i.e., until the following relation holds:

$$M\ddot{x}_g(t) - m_2 R\ sgn\big(\theta(t)\big)\big[sin(\alpha - |\theta|)\,\dot{\theta}^2(t) - \cos(\alpha - |\theta|)\,\ddot{\theta}(t)\big] \leq sgn\big(\theta(t)\big)M\mu_k g \tag{19}$$

Conversely, the transition of motion from (a) to (c) occurs when (19) does not hold anymore.

Case study

The theory and methods above described have been implemented in a numerical routine developed with Mathematica© [36] and applied to a real case of a non symmetric statue in an Archaelogical Museum.

The National Archaeological Museum of Paestum has recently planned a new layout of the Roman collection. Some of the marble statues will be placed at the entrance of the exhibit room. In the present paper, the dynamic response of the marble statue of figure 4, left, is studied. Figure 4, right, shows its foreseen position in the museum new layout. The statue, found presumably in the Forum area, is unfortunately acephalous. The toga is the symbol of Roman citizenship given in 71 A.C. to the veterans by Emperor Vespasian together with the Paestum lands. The statue represents perhaps one of the veterans who settled in Paestum after 71 A.C. [37].

To precisely describe the statue geometry and its centre of mass a photogrammetric survey was carried out [33, 38]. Figure 5 illustrates some computational steps of the photogrammetry analysis. As the lateral slenderness plane is the most vulnerable (Fig. 5), the mechanical data have been calculated with reference to that plane and are collected in Table 1.

Because of the future position of the statue that depends on the re-organisation of the Museum, the optimal safe collocation of the artefact is strongly influenced by the type of motion [39]. Indeed, all the examined possibility of motions can lead to an impact of the statue on the back wall [40].

The analyses have been performed considering three different restitution coefficients since the quality of impact influences the artefact's possible damage. The higher the impact coefficient, the lower the damage. The restitution coefficient range has been chosen to represent possible realistic conditions. The static and the kinematic friction coefficients have been considered constant in every analysis group [27]. The mechanical and geometrical characteristics of the statue-pedestal set have been reported in Table 1 and the combinations of the examined parameters in Table 2.

Fig. 4. Picture of the marble statue (left); layout of the future position (right)

Table 1. Mechanical characteristics of the statue-pedestal set

Mechanical characteristics (Kg, m)	Weight	Centroid height	Base length	Base depth	R1	R2
Statue	707	0.774	0.72	0.43	0.777	0.853
Pedestal	250	0.10	0.80	0.60	-	-

For every variation of the restitution coefficient, and according to the current Italian Standards [41], two distinct amplitudes of the base motion have been examined:

i) the first corresponds to the life safety limit state, whose parameters are: soil type C, topographic category T1, nominal life Vn = 100 years, class of use III-Cu = 1.5, peak ground acceleration ag = 0.334g, soil coefficient S = 1.228, spectrum generator parameters F0 = 2.356, TB = 0.198sec, TC = 0.593sec, TD = 2.935sec.

ii) the second is related to the collapse safety limit state considering the following parameters: soil type C, topographic category T1, nominal life Vn = 100 years, class of use III-Cu = 1.5, peak ground acceleration ag = 0.429g, soil coefficient S = 1.104, spectrum generator parameters F0 = 2.315, TB = 0.202sec, TC = 0.605sec, TD = 3.317sec. Moreover, a huge range of frequencies have been considered, assuming that the archaeological museum structure is a low rise reinforced concrete building realised at the beginning of Fifties. In figure 6 a representation of the main geometrical parameters and displacements of the statue are reported.

The need of the pedestal has been examined with reference to two possible exhibit configurations for the statue: simply supported on the floor and placed on the pedestal. The influence of the motion parameters on these two distinct settings has been examined. Figures 7-9 report three different sets of time histories corresponding to the groups A, B, C of Table 2.

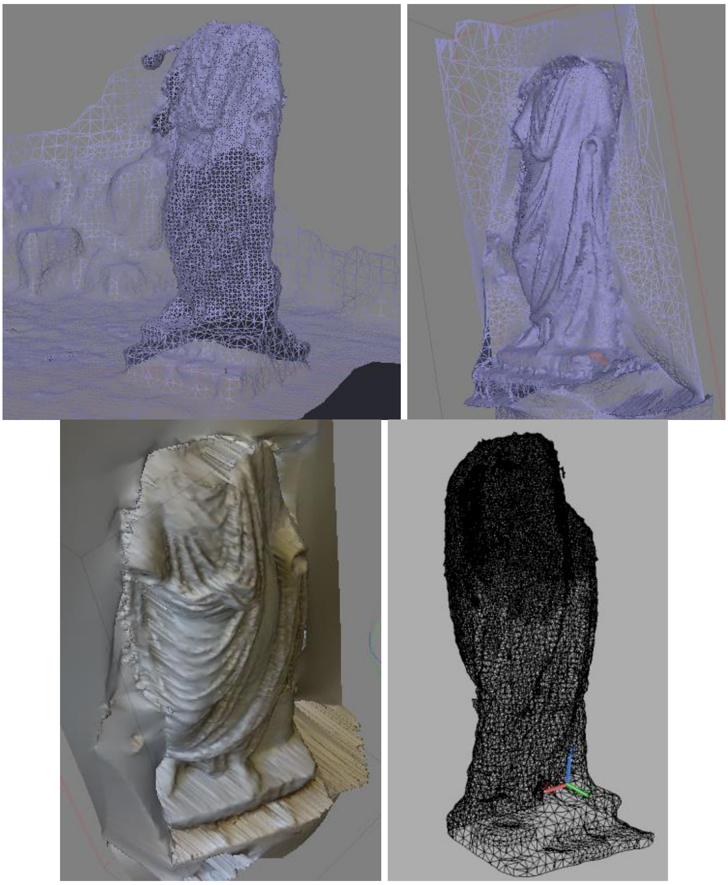

Fig. 5. Photogrammetric survey

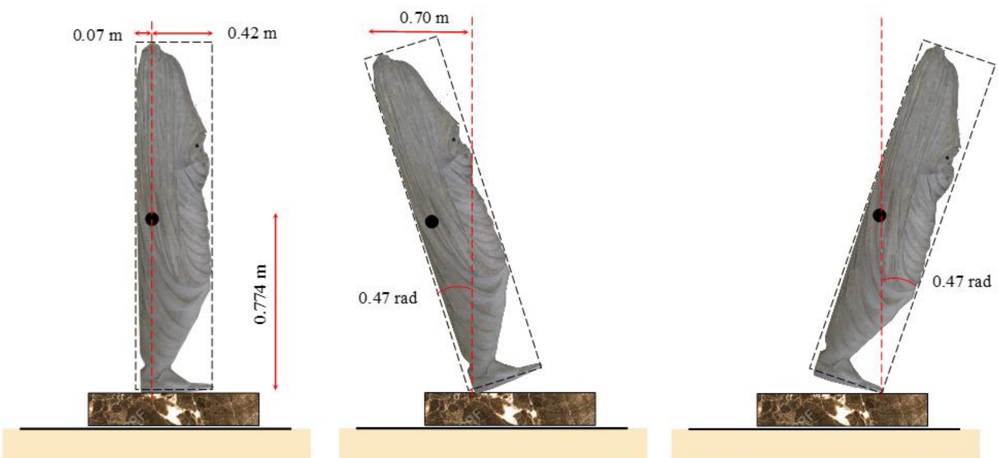

Fig. 6. Range of rotations considered

Table 2. Examined motion conditions.

Conditions	Restitution coefficient	Static friction coefficient	Kinematic friction coefficient	Amplitude [g]	Frequencies [Hz]
A	0.85	0.20	0.15	0.334 0.429	1.5 2.0 3.0 4.5 6.0
B	0.875	0.20	0.15	0.334 0.429	1.5 2.0 3.0 4.5 6.0
C	0.90	0.20	0.15	0.334 0.429	1.5 2.0 3.0 4.5 6.0

The blue curves give the rotation of the statue simply supported on the floor, while the other two lines describe the behaviour of the double block system.

In particular, the red curve and the green one represents the rotation (in radians) of the statue placed on the pedestal and the displacement (in meters but scaled-down of 10^{-1}) of the pedestal sliding on the moving floor, respectively. The pictures report time histories with increasing frequency from top to bottom. In all the pictures, the considered range of rotations is 0.50rad (~29°), relative to the vertical alignment of the centroid with O' (0.47 rad) and corresponding to a top displacement of about 70cm, which is the minimum possible distance among the statue and the back wall.

The analyses highlight in all the examined cases a significant change of the mechanical behaviour with the frequency. In particular, the low frequencies evidence the positive effect of the pedestal, since for f ≤ 3Hz the behaviour of the statue without pedestal presents larger rotations and a faster overturning with respect to the double block system (the blue line is in all the time range superimposed to the red one). In some cases, the presence of the pedestal prevents the overturning and contemporarily reduces the oscillation amplitude. The significant advantage due to the pedestal insertion decreases for frequencies greater than 3Hz. Furthermore, with increasing frequency, the oscillation amplitudes reduce, as it can be expected, so that for very large frequencies, the presence of the pedestal is irrelevant, and the oscillation motion could last for a very long time without overturning.

The range of frequencies to be expected for the floor motion corresponds to the interval in which the pedestal enhances the artefact behaviour. In these cases, the filter's effect of the building is a preliminary step in the evaluation procedure, so to evaluate a realistic base motion of the floor. For all the examined frequencies the values of pedestal displacements are contained within few centimeters, so that the prevailing parameter to be taken into account for the statue placement is the rotation amplitude.

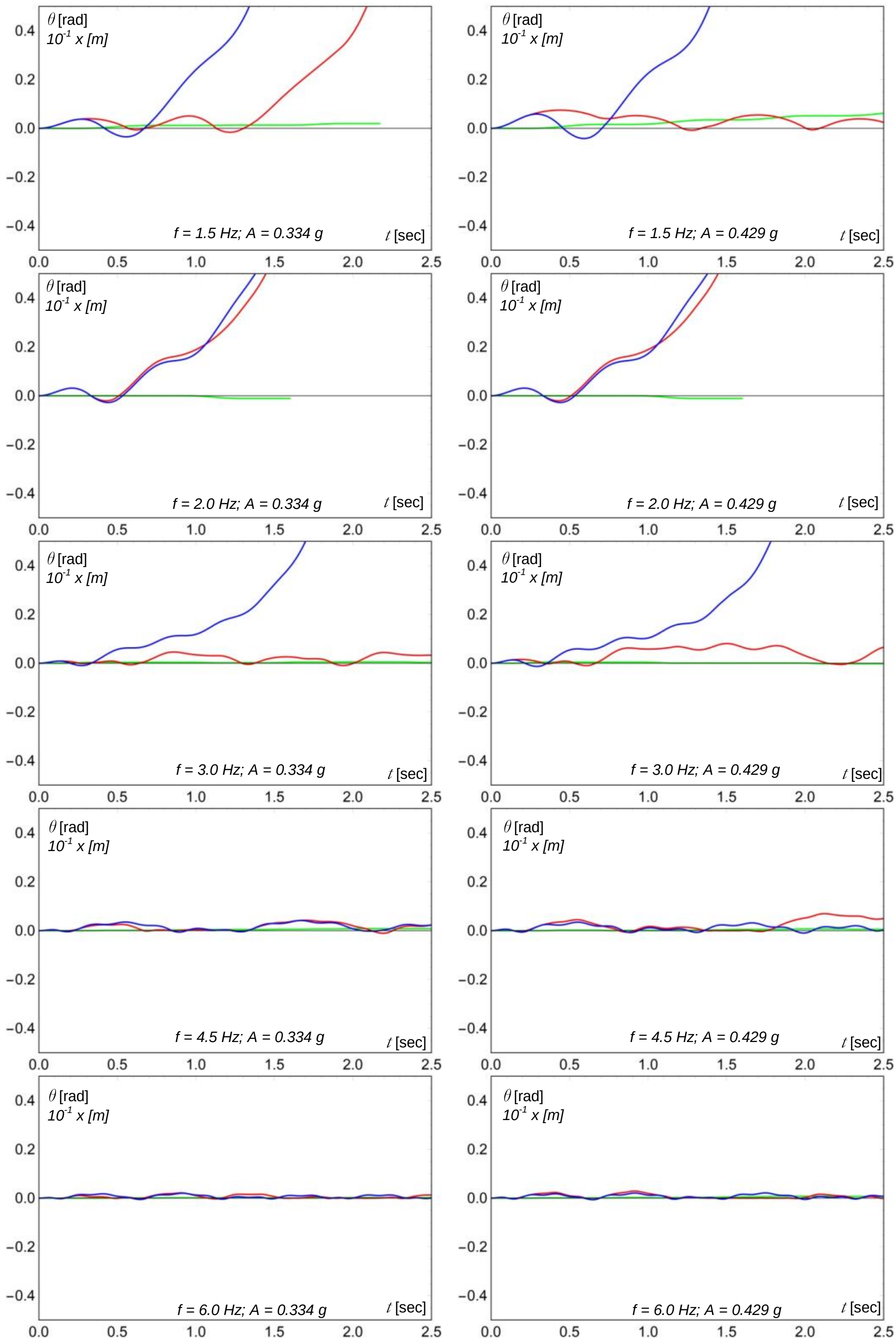

Fig. 7. Time histories for conditions A

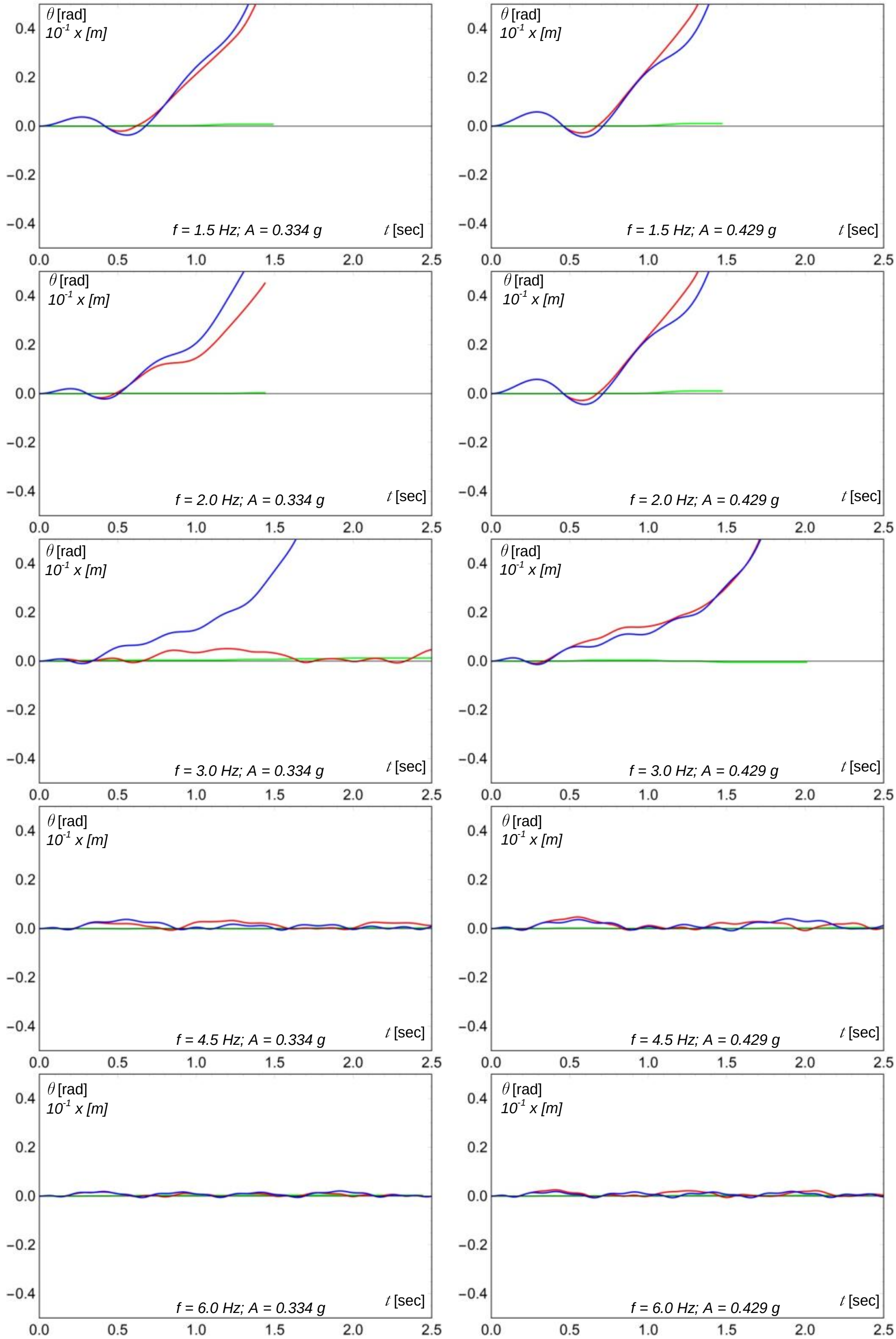

Fig. 8. Time histories for conditions B

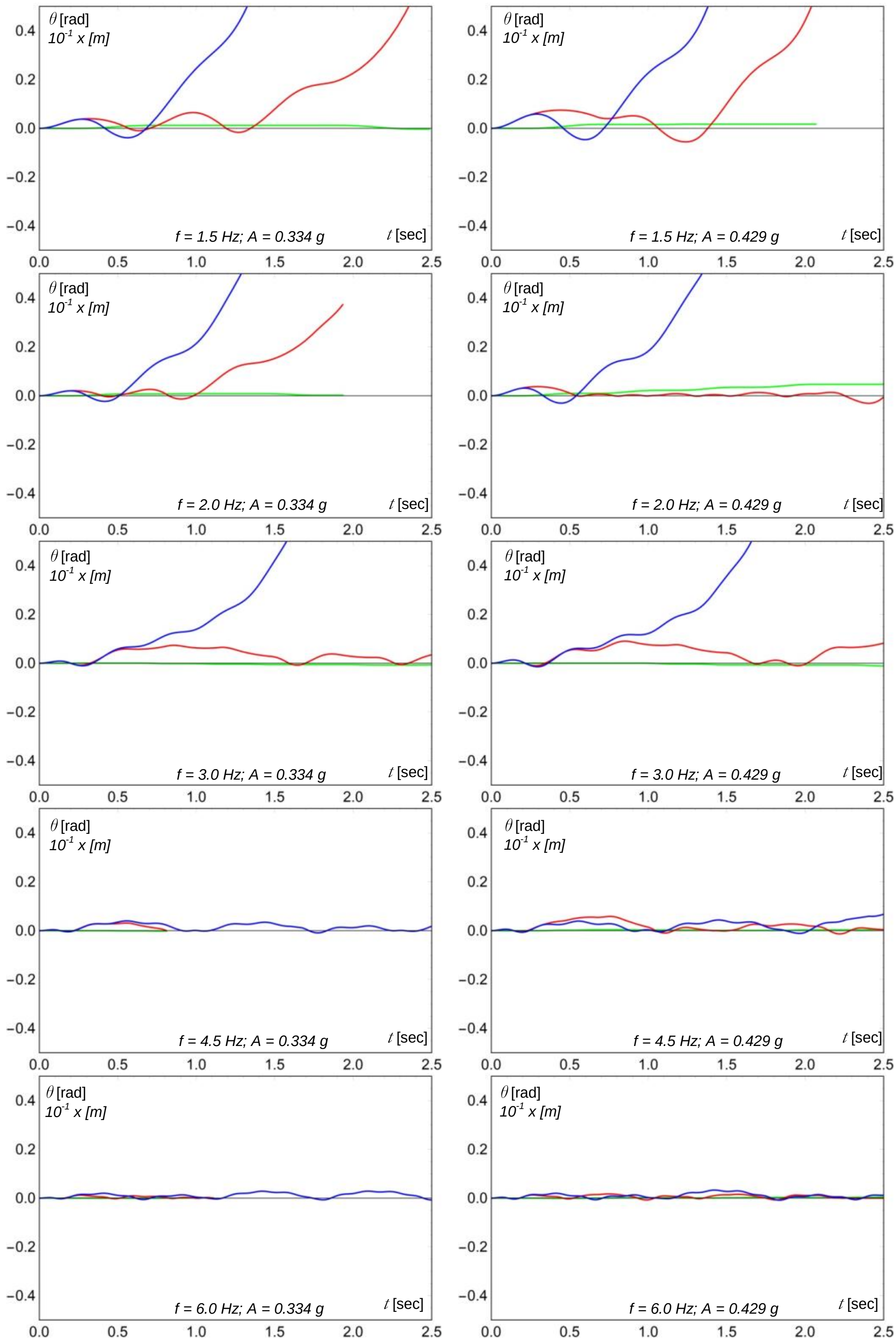

Fig. 9. Time histories for conditions C

Conclusions

In the present paper, a low-cost isolation strategy for museum artefacts is proposed. Many artefacts are simply supported on the ground and when subjected to earthquakes can only exhibit rocking motion. In some cases, because of the relevance of the artefact, high-cost isolation strategies can be afforded. Nonetheless, a large scale, sustainable and low-cost preservation of museum artefacts demands exploring new potential strategies. In the present paper, the dynamic response of a statue standing on a pedestal has been addressed assuming the sliding motion among the pedestal and the floor as a potential mitigation motion. The study has been performed looking at the new collocation of an acephalous marble statue in the Archaeological Museum of Paestum. After a preliminary detailed photogrammetric study, its motion has been described as solving a DAE and explicitly taking the non-symmetric geometry of the statue into account. The focus of the proposed study was not only to evaluate suitable mechanical parameters (such as the mass of the pedestal and the friction coefficient) but importantly to also determine the optimal placement position of the statute in order to avoid any impact against the back wall. As a main result, it is shown that for low frequencies the use of a pedestal has a positive influence, while its strong need vanishes with increasing frequencies. Indeed, in this last case, the oscillations of the artefact reduce significantly and only the rocking motion is activated. Although the sensitive analysis has been conducted without considering the filter's effect of the building, a wide range of possible frequencies of the floor have been analysed.

Acknowledgments

The authors gratefully acknowledge the Ministry of Culture, Archaeological Park of Paestum and Velia for the permission of performing digital survey, taking measurements and using images of the Paestum Archaelogical Museum and contents, all rights reserved.

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Received: November 16, 2021
Accepted: August 12, 2022