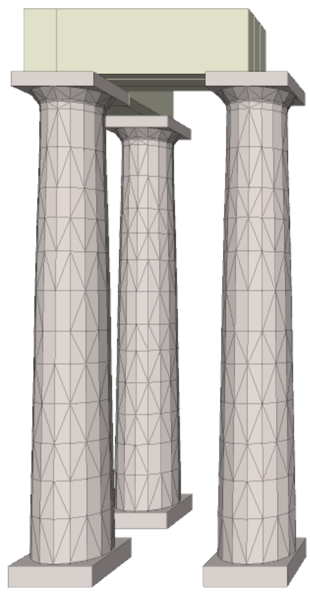
NATIONAL TECHNICAL UNIVERSITY OF ATHENS
SCHOOL OF CIVIL ENGINEERING
POSTGRADUATE PROGRAMME:
“ANALYSIS AND DESIGN OF STRUCTURES”
LABORATORY FOR EARTHQUAKE ENGINEERING

# COMPARATIVE SEISMIC BEHAVIOUR INVESTIGATION OF ANCIENT COLONNADES WITH REFERENCE TO THE PARTHENON



**POSTGRADUATE THESIS**

**KALOGERAKOU VASILIKI**

**SUPERVISOR: ASSOCIATE PROFESSOR MICHALIS FRAGIADAKIS**
**CO-SUPERVISOR: PhD CANDIDATE KONSTANTINA MASTRODIMOU**

**ATHENS, JUNE 2023**

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Kalogerakou Vasiliki, 2023
Postgraduate Thesis
Comparative seismic behaviour investigation of ancient colonnades with reference to the Parthenon
Laboratory for Earthquake Engineering, National Technical University of Athens, Greece

Καλογεράκου Βασιλική, 2023
Μεταπτυχιακή Διπλωματική Εργασία
Συγκριτική διερεύνηση σεισμικής συμπεριφοράς αρχαίων κιονοστοιχιών με αναφορά στον Παρθενώνα
Εργαστήριο Αντισεισμικής Τεχνολογίας, Εθνικό Μετσόβιο Πολυτεχνείο, Αθήνα

## *Thanks to*

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POSTGRADUATE THESIS

# Comparative seismic behaviour investigation of ancient colonnades with reference to the Parthenon

**Kalogerakou Vasiliki**

Supervisor: Associate Professor Michalis Fragiadakis
Co-supervisor: PhD Candidate Konstantina Mastrodimou
June, 2023

## ABSTRACT

The aim of this thesis is to investigate the seismic response of ancient colonnades with reference to the Parthenon, in particular the comparison of the original-intact models characterized by the complete absence of damage and models that have suffered damages, as well as the comparison of different arrangements, and, finally, to draw conclusions regarding the effect of the condition and of each arrangement on the vulnerability of the columns. In a first stage, reference is made to the basic structural and architectural parts that compose the Parthenon in order to understand the structure of the monument in space and to clarify the individual architectural terms. Then, typical structural damages due to the various stresses during the monument's lifetime, with emphasis on the columns, and, also, information on past and ongoing restoration work are presented. For the numerical analysis, six modular models are created based on the SE or 6th column of the Parthenon's Pronaos, using the 3DEC discrete element code (V.5.2, Itasca Consulting Group Inc.), as follows: Models of a single column, a three-column colonnade in a line arrangement and a three-column colonnade in a corner arrangement with the corresponding architraves, where the arrangement is simulated with the original geometry as well as with damages, are subjected to seismic excitations. For this purpose, nine actual seismic records are selected which are applied in the analysis and have been determined to be exactly suitable for the study of the Acropolis monuments. At the end of the analyses, based on the results of the kinematic response of the simulated models, diagrams of maximum absolute and relative displacements in height are generated, from which both quantitative and qualitative conclusions are drawn about the behaviour of these arrangements and the effect of the damages.

ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ
ΣΧΟΛΗ ΠΟΛΙΤΙΚΩΝ ΜΗΧΑΝΙΚΩΝ
ΔΠΜΣ: «ΔΟΜΟΣΤΑΤΙΚΟΣ ΣΧΕΔΙΑΣΜΟΣ ΚΑΙ ΑΝΑΛΥΣΗ ΚΑΤΑΣΚΕΥΩΝ»
ΕΡΓΑΣΤΗΡΙΟ ΑΝΤΙΣΕΙΣΜΙΚΗΣ ΤΕΧΝΟΛΟΓΙΑΣ

ΜΕΤΑΠΤΥΧΙΑΚΗ ΔΙΠΛΩΜΑΤΙΚΗ ΕΡΓΑΣΙΑ

**Συγκριτική διερεύνηση σεισμικής συμπεριφοράς αρχαίων κιονοστοιχιών με αναφορά στον Παρθενώνα**

**Καλογεράκου Βασιλική**

Επιβλέπων: Αναπληρωτής Καθηγητής Μιχαήλ Φραγκιαδάκης
Συνεπιβλέπουσα: Υποψήφια Διδάκτωρ Κωνσταντίνα Μαστροδήμου
Ιούνιος, 2023

## ΠΕΡΙΛΗΨΗ

Σκοπός της παρούσας μεταπτυχιακής εργασίας είναι η διερεύνηση της σεισμικής απόκρισης αρχαίων κιονοστοιχιών με σημείο αναφοράς τον Παρθενώνα, συγκεκριμένα η σύγκριση των αρχικών-άθικτων μοντέλων που χαρακτηρίζονται από πλήρη απουσία βλαβών και μοντέλων που έχουν υποστεί βλάβες, καθώς και η σύγκριση διαφορετικών διατάξεων, και, εν τέλει, η εξαγωγή συμπερασμάτων αναφορικά με την επιρροή της κατάστασης και της κάθε διάταξης στην τρωτότητα των κιόνων. Σε ένα πρώτο στάδιο γίνεται αναφορά σε βασικά δομικά και αρχιτεκτονικά μέρη που απαρτίζουν τον Παρθενώνα προκειμένου να κατανοηθεί η δομή του μνημείου στο χώρο και να αποσαφηνιστούν οι επιμέρους αρχιτεκτονικοί όροι. Στη συνέχεια, παρουσιάζονται χαρακτηριστικές δομικές βλάβες που οφείλονται στις διάφορες καταπονήσεις στη διάρκεια ζωής του μνημείου, με έμφαση στους κίονες, και στοιχεία σχετικά με παλιότερες αλλά και εν εξελίξει αναστηλωτικές εργασίες. Για την αριθμητική ανάλυση δημιουργούνται έξι σπονδυλωτά μοντέλα με βάση το ΝΑ ή $6^{o}$ κίονα της πρόστασης του πρόναου του Παρθενώνα, με τη χρήση του κώδικα διακριτών στοιχείων 3DEC (V.5.2, Itasca Consulting Group Inc.), ως εξής: Μοντέλα ενός μονού κίονα, μιας τρίστυλης κιονοστοιχίας σε ευθεία διάταξη και μιας τρίστυλης κιονοστοιχίας σε γωνιακή διάταξη με τα αντίστοιχα επιστύλια, όπου η διάταξη προσομοιώνεται με την αρχική γεωμετρία καθώς επίσης και με βλάβες, υποβάλλονται σε σεισμικές διεγέρσεις. Για το σκοπό αυτό επιλέγονται εννέα πραγματικές σεισμικές καταγραφές οι οποίες εφαρμόζονται στην ανάλυση και έχουν κριθεί κατάλληλες ακριβώς για τη μελέτη των μνημείων της Ακρόπολης. Με το πέρας των αναλύσεων, βάσει των αποτελεσμάτων της κινηματικής συμπεριφοράς των προσομοιωμάτων, καταρτίζονται διαγράμματα μέγιστων απόλυτων και σχετικών μετακινήσεων καθ' ύψος από τα οποία προκύπτουν τόσο ποσοτικά όσο και ποιοτικά

συμπεράσματα για τη συμπεριφορά των εν λόγω διατάξεων και την επίδραση των βλαβών.

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# 1 INTRODUCTION: THE PARTHENON

## 1.1 Historical data

Many important monuments around the world are the focus of scientific interest in order to study seismic risk, to develop reliable methods for the prediction and assessment of structural damage due to seismic stresses, and, consequently, to achieve technologies for the maintenance and restoration of structural problems that arise during their long life.

A monument of exceptional importance is the ancient temple of the Parthenon, on the Acropolis of the city of Athens (Figure 1). The construction of the temple was carried out during the reign of Pericles, who coordinated the construction also of the other important structures of the site (the Propylaea, the Erechtheion and the Temple of Athena Nike or Aptera Nike); it was the work of the architects Iktinos and Kallikrates and the famous sculptor Pheidias, who had the general supervision of the works and the sculptors. The temple, dedicated to the goddess Athena, began construction in 447 BC and was completed in 438 BC, except for the sculptures, which took another six years, until 432 BC. It is made of Pentelic marble and follows the Doric style, having at the same time many Ionic features. However, in order to alleviate the "heaviness" due to the Doric style, a system of "refinements" was used – such as the curve of the crepis, the stylobate and the entablature, the entasis (convex curve) along the height of the columns, the contraction of the corner intercolumniations and the decrease in the width of the *metopes*, from the center to the corners (Committee for the Conservation of the Acropolis Monuments - YSMA, 2018a) – and it will be shown in more detail in the presentation of the individual structures of the temple. It was this highly sophisticated system of refinements that gave the classical temple its special grace and harmony.

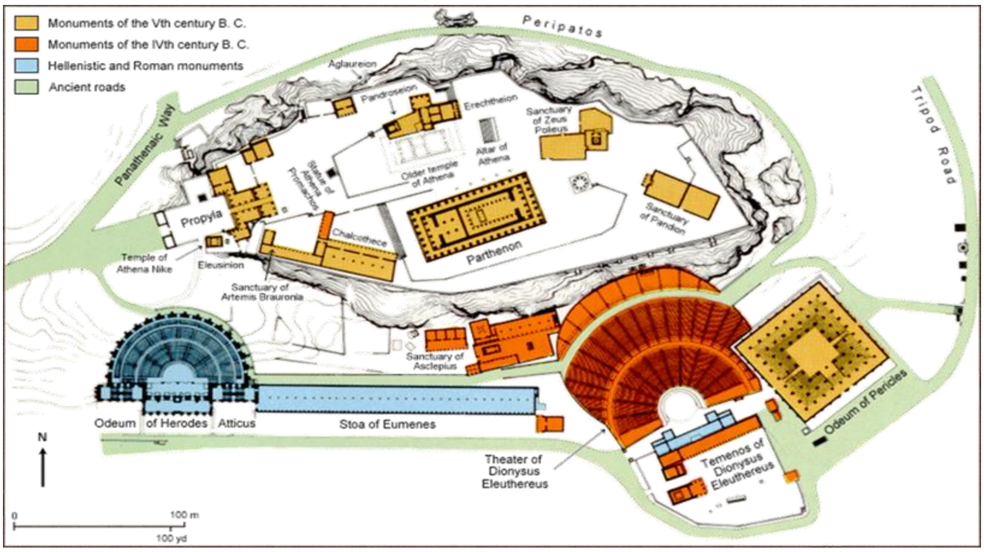


*Figure 1: Plan of the monuments on the hill of the Acropolis*

The Parthenon is a peripteral temple, i.e., its inner rectangular core, cella that is called "sikos", is surrounded by a colonnade - 8 columns on the narrow sides, east and west, and 17 on the north and south sides - and also bears relief fronts. The "sikos" or cella was in the form of an amphiprostyle, in keeping with Ionic norms. As shown in Figure 2, the Parthenon consists mainly of four sections: (I) the Pronaos (front porch), (II) the "Cella", or "Naos" (sanctuary), (III) the Opisthodomos, and (IV) the Opithonaos (rear porch). The Pronaos and the Opisthonaos were the ante-chambers for the two other independent spaces, the "Cella", which was larger, rectangular and oriented to the east, and, the Opisthodomos, which was smaller, square and oriented to the west, respectively.

The main parts that compose the height of the Parthenon temple are the stylobate, the peristyle and the entablature. The last one is also divided into three height zones, the epistyle, the frieze and the pediment, which by its nature can be considered a separate part from the entablature. The stylobate was the upper part of the *crepis*, which was the horizontal stepped base of the Parthenon. The columns of the peristyle rested on the stylobate. The columns are modular structures. They consist of column drums ranging from 10 to 12 and the capitals, which have been constructed as a single piece. In Figure 3 the aforementioned parts can be identified on the eastern front, where it was the entrance to the temple.

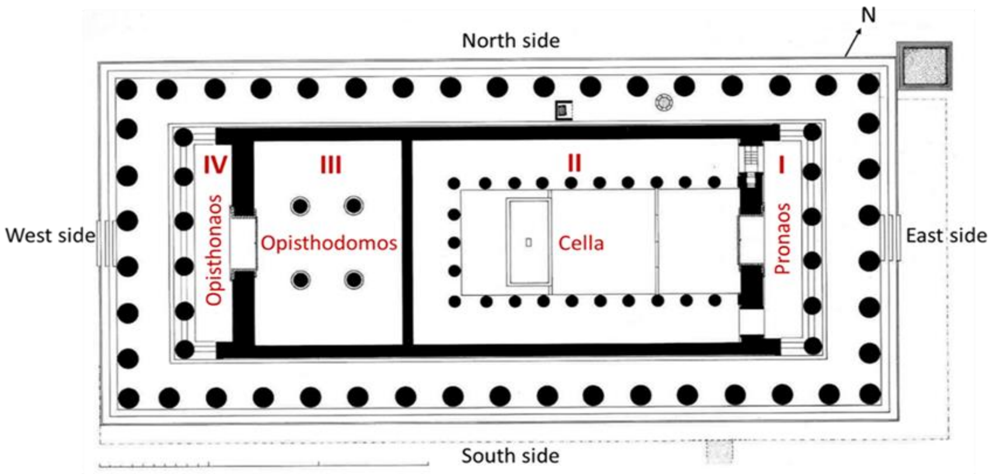


*Figure 2: Top view of Parthenon temple (Korres, 1983)*


*Figure 3: Southeast view of the Parthenon. Main parts at height.*

## 1.2 The stereobate

The “Periclean” Parthenon was built on the site of an older temple, since according to archaeological findings, the predecessors of the peripheral Parthenon (III) were Parthenon I and II and, as it turns out, they were not finished buildings but two plans which were never finalized and remained incomplete. Consequently, most of it was built on the pre-existing foundations, which were more than 10 m deep. Due to the different proportions, the newer temple was built a few meters north of the older one. The relocation of the newer temple towards N did not require significant new foundations, since on the eastern half of the northern side the temple rested directly on the natural rock with the appropriate smoothing, while on the western side three or four horizontal rows of stones (limestones and marbles) were required, without strict composition, in order for the foundation to reach the rock.

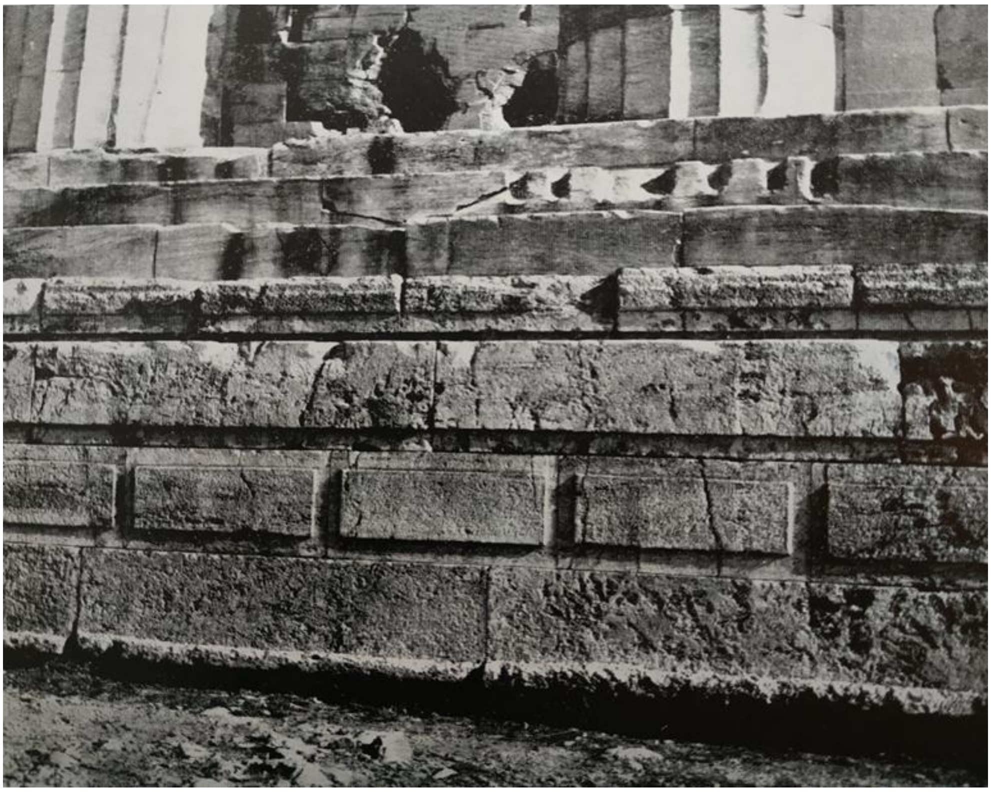

*Figure 4: View of the crepis of the Periclean Parthenon and the upper layers of the stereobate of the S side (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 38)*

## 1.3 The *crepis*

The *crepis* is the horizontal stepped base of the Parthenon. It is made of marble on the outside and inside it consists of the stones of the most ancient stereobate. It is made up of a lowest low layer called the *euthintiria* and three other levels above it, in a stepped arrangement. The uppermost layer serves to support the peristyle columns and is called stylobate.

This lower layer has a small height, varying from 0.18 m in the NE corner, where it rests directly on the natural rock, to 0.299 m in the NW corner. As to its material, it is noted that the *euthintiria* is not marble on all sides of the temple, but only on the north and west; on the east marble is only 5 m towards the NE corner, while the next 7.30 m is carved into the rock. On the rest of the east side as well as the south in its entirety (except for a very small section towards the SW corner) it has been carved on the old limestone foundation. The marble part on the N and W sides consists of regular stones ranging from 1.34 m to 1.936 m long and 1.04 m wide. On the north side, the second and third stones from the NE corner have rectangular bumps of irregular design, serving to move or lift the stones.

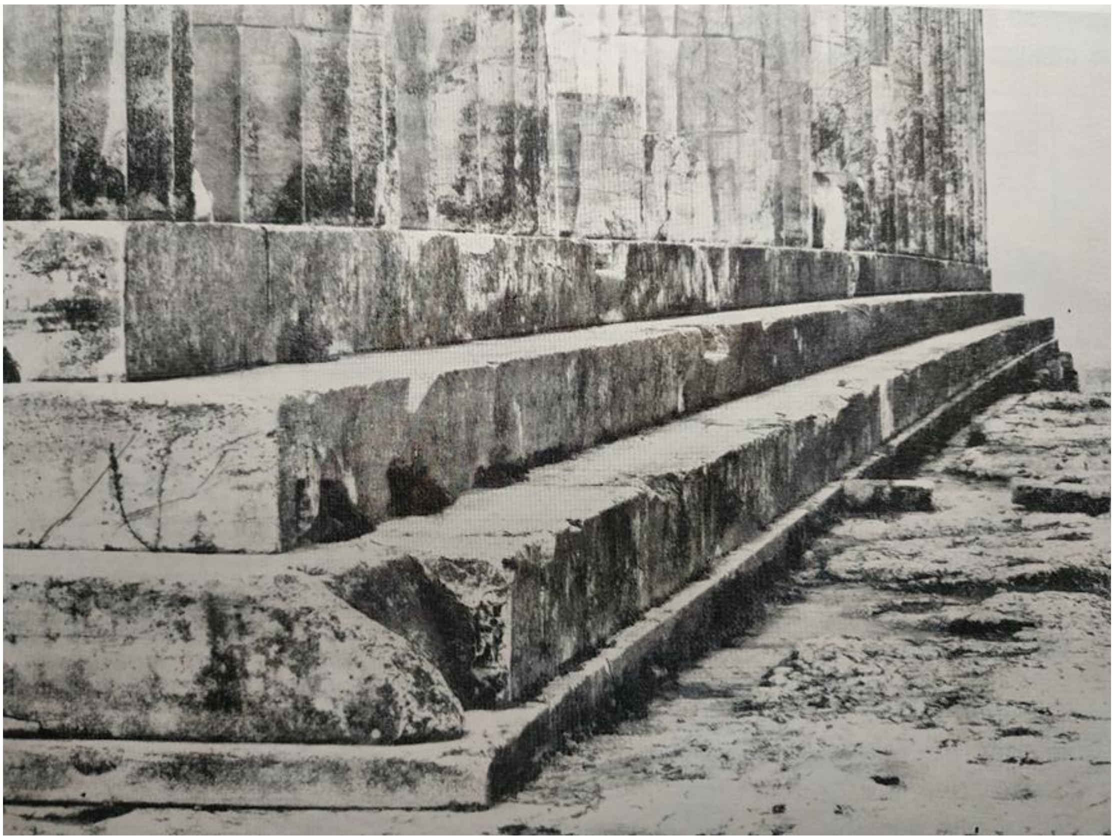

*Figure 5: View of the NE corner of the Parthenon's crepis (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 75)*

The stone bricks of this particular level have a 0.085 m wide *anathyrosis* in their joint, i.e., a narrow strip carved perfectly smooth along the vertical and upper horizontal edges of the bricks at the side of their contact, in the shape of a doorway, in order to achieve the optimal matching of the adjacent stones. The connection of these bricks is made with cast iron double-tau connectors (Figure 6), 0.27 m long, and no vertical restraint dowels are observed.

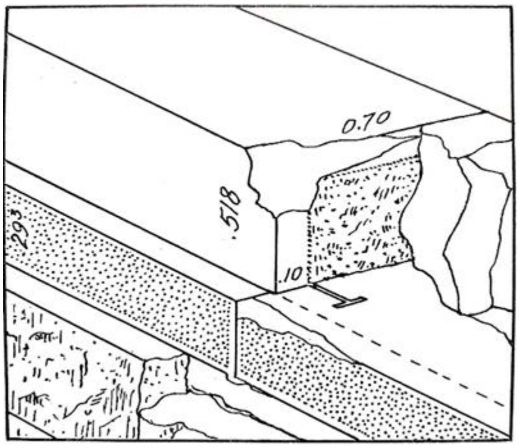


*Figure 6: Part of the crepis where the double-tau link appears at the connection of the bricks. (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 79)*

As mentioned above, there are three other levels which are based on *euthintiria*. The height of the two lowest ones is on average 0.517 m and they protrude by 0.702 m, while the highest one (stylobate) is 0.552 m high. The above metrics make it clear that these are not steps to be climbed but a staggered partitioning of the crepis, which perfectly expressed its character as a pedestal, so that through this form, the building is connected and also distinguished from the surrounding area (ground).

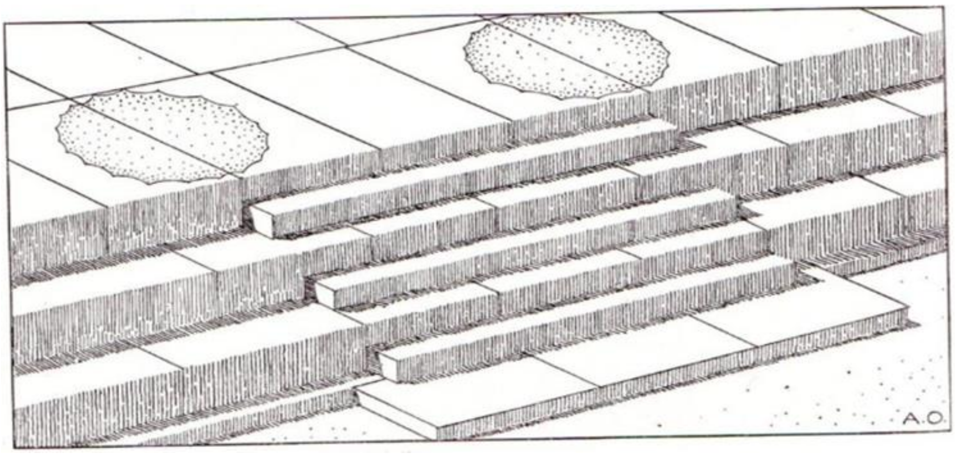


*Figure 7: Illustration of the three movable steps of the Parthenon (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 80)*

The staggered character of the different levels is continuous along the entire perimeter, except for a 4.30 m long section in the middle axis of the eastern and western sides, where, in order to serve the ascent to the temple, small movable steps were added - which, from an architectural point of view, gave the measure of the building in relation to man – of  a height and width equal to half the height and width of the corresponding levels, i.e., 0.26 m high and 0.35 m wide (Figures 7-8).

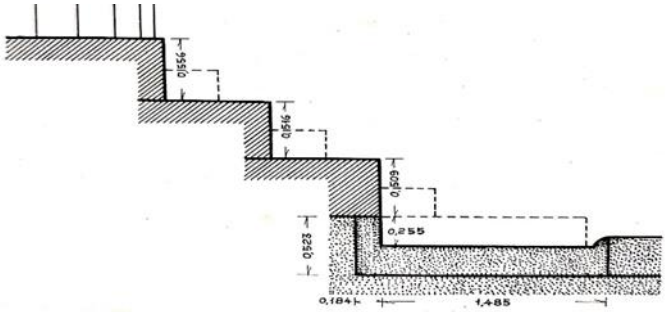


*Figure 8: Section of the levels along the long axis of the temple with focus on the movable steps and the substructure (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 82)*

The stone blocks that form these levels are generally normal. Particularly in the corners they have large dimensions and are completely smooth. They are connected to each other by capillary joints 0.09 m wide, which are achieved by *anathyrosis*. The length of the stones varies on the first level and the stylobate from 1.306 m to 1.65 m (with the exception of the corner stones), while on the intermediate level the length of the stones reaches up to 3.605 on the north side. Due to the interference of these large stones, the distribution of the joints of the *crepis* does not follow the symmetrical and harmonious arrangement observed in other temples. The corner stones of the first two levels are, for stability reasons, axillary, i.e., they have the shape of a capital gamma letter.

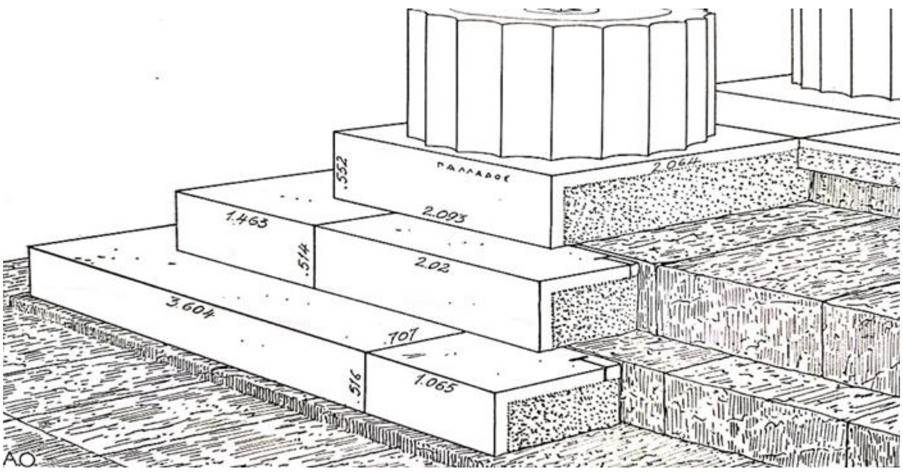


*Figure 9: The SE corner of the crepis (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 83)*

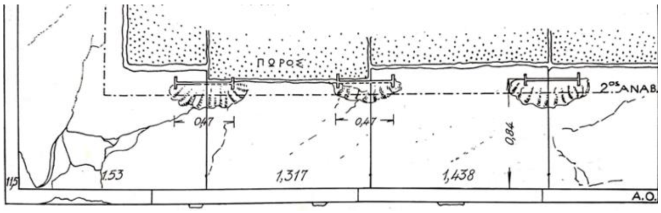


Figure 10: Plan of the first level of the NE corner (north side) showing the double-tau connectors (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 85)

Finally, it is worth mentioning some particular features of the whole *crepis* that are part of the "refinements" that had mentioned above, and which in turn shape the architecture of the Parthenon visually. The upright sides of the levels are not vertical but inclined inwards (following the general inward inclination of almost all the upright parts of the temple) by 0.004 m, and the horizontal surfaces are not actually horizontal but inclined outwards (thus serving to drain rainwater) by 0.0015 m, as a consequence of the curve of the entire horizontal surfaces of the *crepis*. The curve of the *crepis* or *entasis* (Figures 11-12) is thought to have been intended to prevent the possible impression of subsidence as well as to embellish the "pulse" of the interior of the temple. It is noted that this curve is observed on the upper surfaces of all three levels. The figures directly below are qualitatively indicative of these specific "refinements".

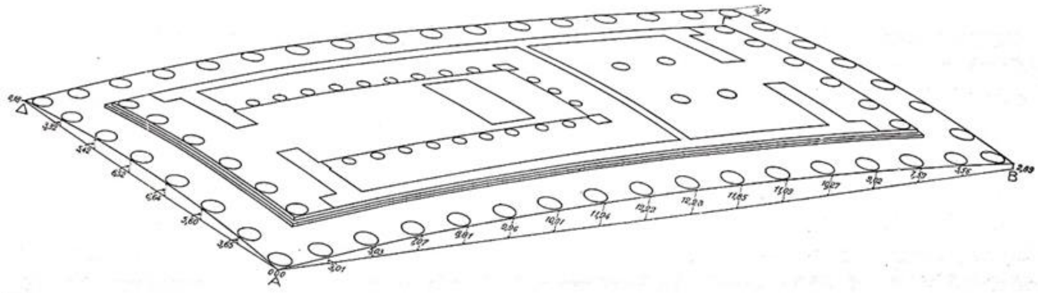

*Figure 11: Perspective representation of the general curve of stylobate and cella (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 88)*

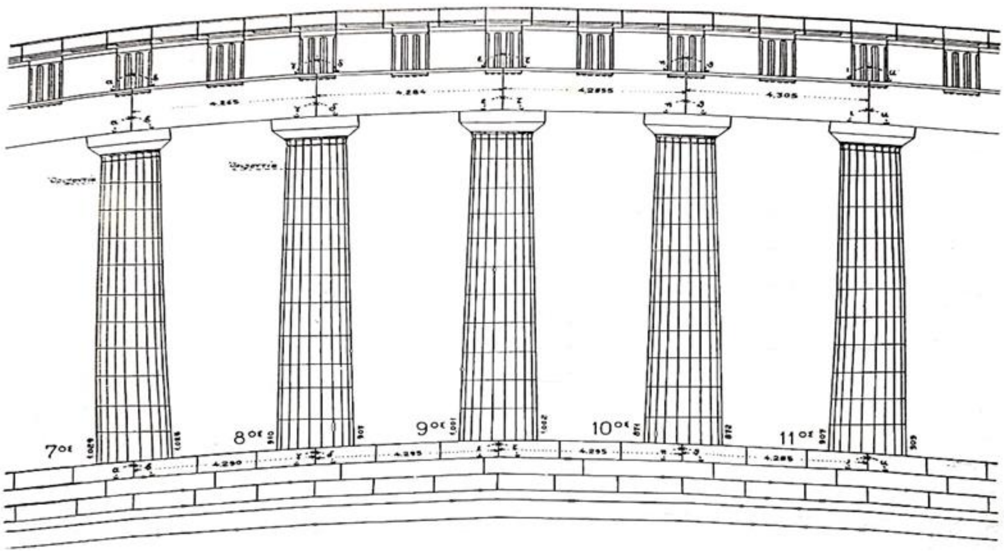

*Figure 12: The curve of the northern side of the Parthenon (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 89)*

## 1.4 The peristyle

### 1.4.1 The *pteron*

The *pteron* or *peristasis* is placed as a horizontal continuation of the stylobate. Its width, measured from the outer line of the stylobate to the bottom step of the cella, is 4.833 m on the small sides and 4.26 m on the large sides. The two marble plaques that form it (Fig. 13), whose good assembly is also achieved here by *anathyrosis*, are 0.247 m thick, while their length varies from 1.275 to 1.452 m on the large sides and from 1.133 to 1.448 m on the small sides. This layer also shows curve both in width and length.

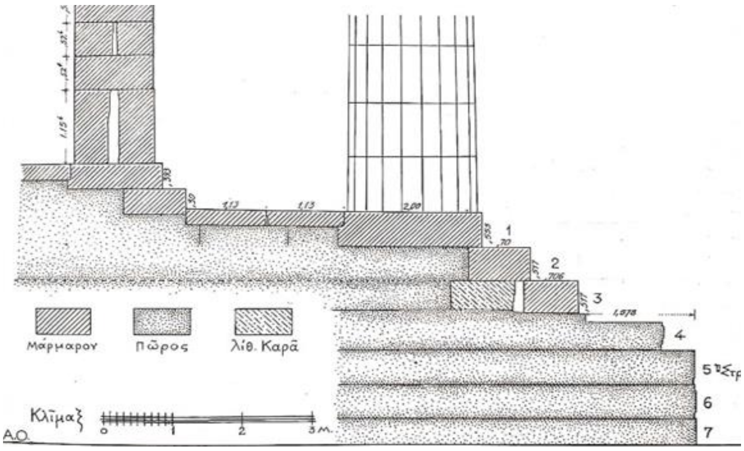


*Figure 13: Section of the crepis and pteron on the south side (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 94)*

### 1.4.2 The *pteron* columns

The *pteron* columns are resting on the stylobate. The number of columns is eight on the narrow sides of the temple, in contrast to the six on the narrow sides of all the *peripteral* temples of the main Greek area, and ten on the large sides. As to the distance of the columns from axis to axis, this is called the *metaxon* and shows some slight variations: On the narrow sides it ranges from 4.290 m to 4.305 m and on the large sides from 4.266 m to 4.309 m, while as regards the distance of the corner columns from their adjacent ones it is shorter, with values between 3.668 and 3.711 m.

Each such column consists of a total of 11 column drums and the capital, i.e., a total of 12 pieces. Exceptions can be seen in the NE corner column, which consists of 10 column drums, and in the second column from the east on the south side, which has 12 column drums. The height of column drums ranges between 0.584 and 1.088 m. The total height of the *pteron* columns (from the column base to the upper surface of the capitals) averages 10.433 m, but varies depending on the column and the point (side) measured on each column, due to the inward curve of the column base and the slope of the upper surface of the capitals. The bottom diameter of the average outer columns is equal to 1.905 to 1.920 m (measured from edge to edge), while 3.1 cm larger occurs in the corner columns (thickening).

As for the assembly of the column drum, each one does not touch the underlying and overlying surface except by a 0.153 m wide peripheral ring and a small 0.24 m diameter ring in the centre (A and B, respectively in Figure 14), which are carved completely smooth. Between these rings are interposed two others 0.39 m and 0.17 m wide (Γ and Δ). This choice of technique serves the purpose of achieving a more perfect assembly of the drums, since the smaller contact surface means the best possible assembly without compromising the strength of the column. It has been calculated that the lower drum can support 135 tones and the bearing surface area is 17600 cm$^2$, so that the compression equals 8 kg/cm$^2$, while marble has a compressive strength of 200-500 kg/cm$^2$.

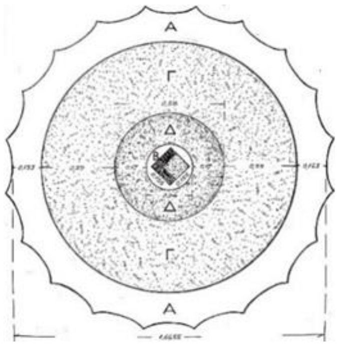

*Figure 14: The bearing surface of a column drum (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977)*

For optimal assembly of the column drums, additional smoothing by friction was applied by rotation between them. In order to apply the above technique without the risk of moving the centre of the upper drum, a cylindrical hardwood (skull) shaft, the *pole* (Fig. 15-16), was used. To fix the pole, cubic carvings of 0.155-0.115 m side and 0.10-0.075 m depth were drilled in the upper and lower surface of each drum, in which wooden (cypress wood) bodies of similar shape, the *empolia* (Fig. 15-16) were placed.

A cylindrical hole 0.057 m in diameter was drilled in each *empolio*, which reached beyond the middle of its thickness and into which the pole, which was twice as long as the hole as it then entered the *empolio* of the overlying drum, was inserted. It is worth noting that the function of the poles extends to the vertical restraint of the column drums during the various disasters (earthquakes, explosions) that have affected the temple.

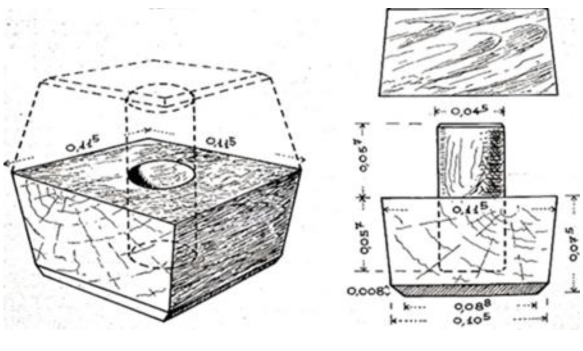

*Figure 15: Poles and empolia (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 99)*

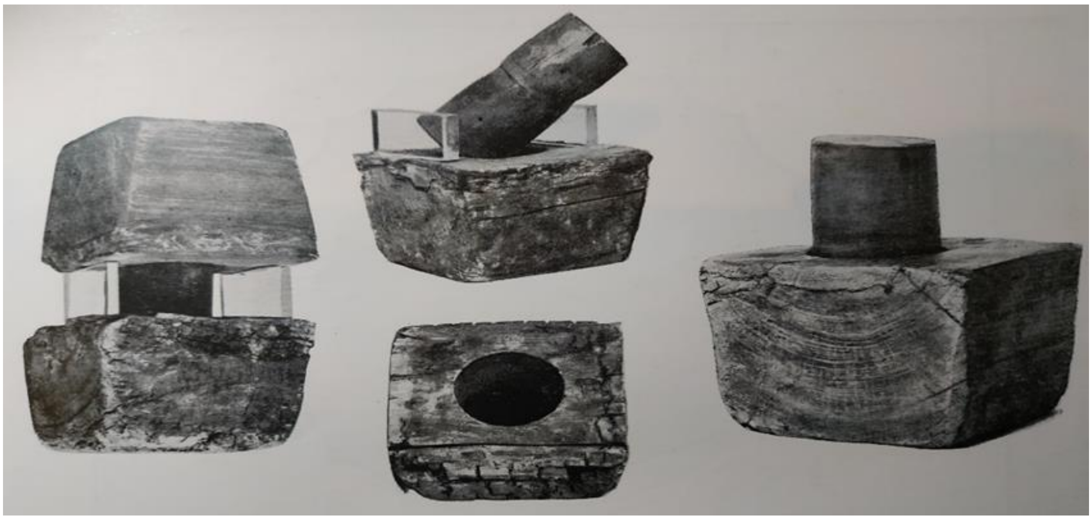

*Figure 16: Poles and empolia (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 100)*

The columns of the *pteron* indicate *meiosis*, *entasis* and “inclination”. The *meiosis* (decrease) refers to the fact that they are not strictly cylindrical but have a columellar shape, meaning that the diameter is not kept constant from bottom to top, but decreases as it progresses towards the capitals. In addition to this decrease, another deviation from the straight cylindrical shape occurs in the columns, the noticeable bulging at about the middle of their height (*entasis*). This is the result of the outward curve of the stems. The “inclination” refers to the inward uniform inclination of all the columns of the peristyle.

Another characteristic that dominates the aesthetic configuration of the columns is the existence of the ribs. The ribs (or scallops) are continuous shallow, grooved carvings (20 in number) surrounding the columns.

The capital of the columns (Figures 17-18) is constructed as a single piece of stone block (monolithic joints) and is distinguished into the “sub-capital”, which is a small part of the body attached to the lower part of the capital, and the main capital which consists of two parts, the *echinus* and the *abacus*. The *echinus* has the shape of an inverted cone and is the transition from the cylindrical shaped body-trunk to the rectangular *abacus*. At the bottom of the *echinus* is a solid ring, 0.07 m wide, with five superimposed rings like straps. The cross-section of the *echinus* is characterised by an *entasis* - convex curve that gives it an aesthetic element of mobility (Figure 17). In particular, the tangent of the *echinus* curve forms an angle of 48°7' to the horizontal axis. The *abacus* is a square, parallelogram-shaped prism that receives the vertical loads of the overhead structures, which are then transferred, via the *echinus*, to the column. The height of the *abacus* is approximately the same in all of them (0.35-0.354 m), while the length of the sides varies considerably: In the ordinary ones it varies between 2.002 and 2.059 m and in the corner ones between 2.0475 and 2.09 m.

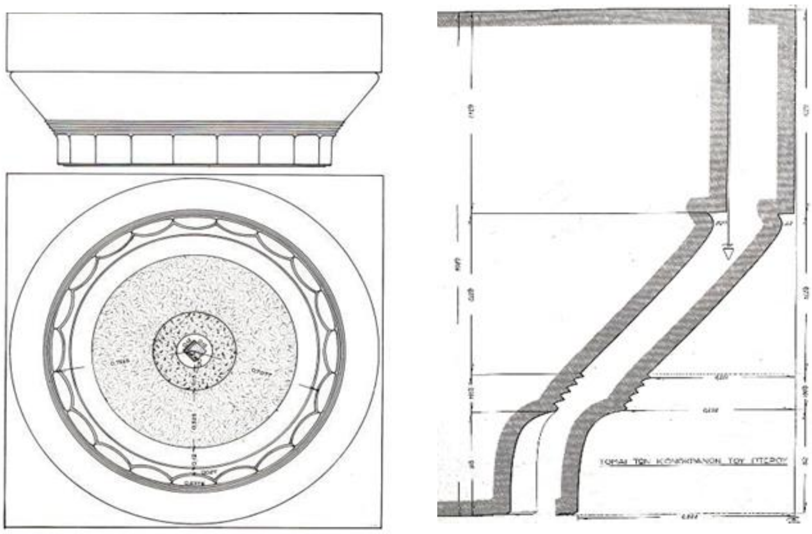

*Figure 17: (left) Capital of a peristyle column, (right) Vertical sections of two capitals of the peristyle (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977)*

*Figure 18: Capital of peristyle (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 118)*

## 1.5 The entablature

The entablature is the highest zone of the temple which rests on the vertical supports of the *peristasis* and, as noted in 1.1., is divided into three zones of height, the epistyle, the frieze and the pediment. The lower zone of the entablature, the epistyle, is 1.35 m high and 1.77 m wide and is not a solid beam but consists of three individual beams, an outer or main epistyle and two inner ones (as shown in Fig. 19-20). Each beam extends horizontally from the axis of one column to the axis of the adjacent column, with the exception of the epistyles resting on the corner columns (Fig. 20). This division had the advantage that in case of the fracture of one of the two, the other two would be statically sufficient until its reconstruction, and in addition, it made it easier to transport the marble blocks.

The connection of the epistyles to each other and to the capitals of the columns is achieved by the installation of iron connectors and dowels (Fig. 20). Other characteristics of the epistyle are the appearance of inclination in all parts and *entasis* in the vertical plane, as well as its simple aesthetic arrangement.

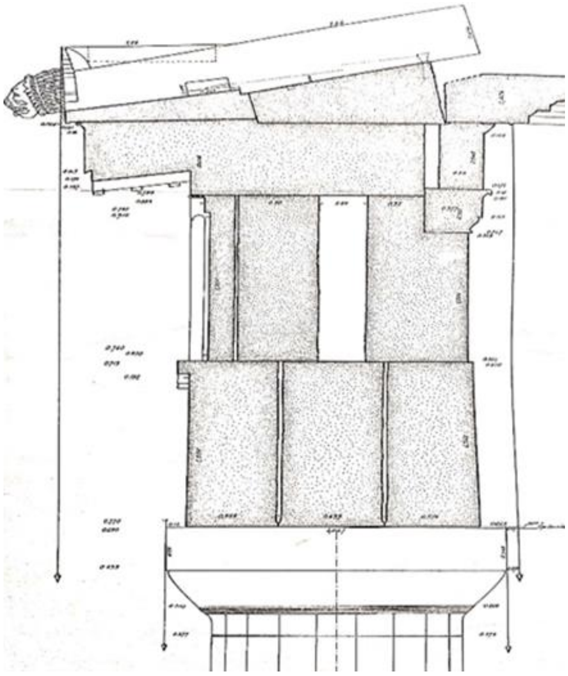

*Figure 19: (left) View of the composition of the epistyle and the frieze at the NE corner of the temple - (right) Vertical section of the entablature, (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977)*

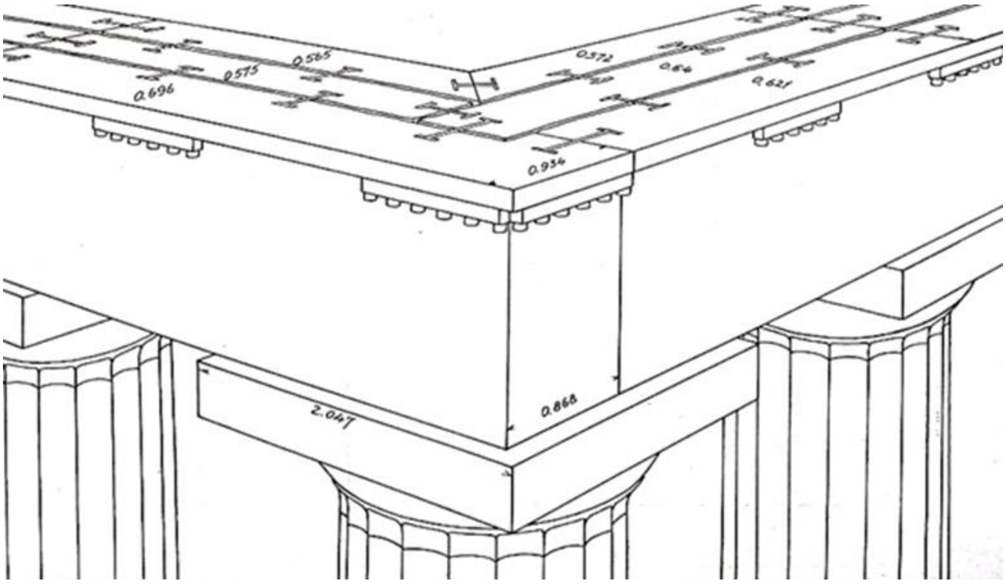


*Figure 20: Composition of corner epistyles (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 128)*

The frieze (or *triglyph*) is the second highest zone of the entablature. It rests on the epistyles and is structurally divided respectively into three widthwise layers, the first being the *triglyphs* and *metopes* and the second and third being the "antitheses" (or *antithimata*) (Fig. 21). Unlike the epistyle, the frieze exhibits considerable architectural movement and rich sculptural decoration.

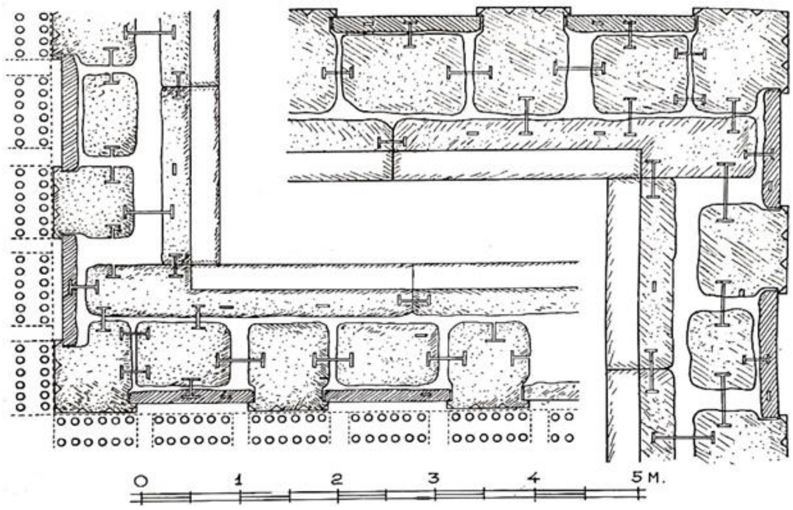


*Figure 21: Composition of triglyphs, metopes and antitheses in horizontal section (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 147)*

The pediment is the highest zone of the entablature. It is attached to the stones of the frieze and protrudes from it, so that it serves to protect the sculptural decoration from rainwater and other atmospheric influences (Fig. 19).

## 1.6 The cella

The cella or "sikos" is an independent building inside the peristyle. It surrounds the main body of the temple and is distinguished from the level of the *peristasis* by the two levels of the corresponding *crepis*.

The upper level of the cella *crepis*, 59.02 m long and 21.72 m wide, served on the narrow sides as a stylobate of the *prostasis* columns and as a base of the long side walls on the long sides. The stones that make up this *crepis* vary in length and are connected to each other by double-tau links. A further characteristic of the cella *crepis* is the *entasis* (convex curve), which is parallel to the curve of the outer stylobate. The walls of the cella - two longitudinal and three transverse - are made up of a high bottom layer, consisting of two stones of equal thickness (the *orthostates*) on which are placed equal layers of rectangular parallel stones. The thickness of the walls varies according to the position of the wall and, in particular, according to the load it bears. For example, the thickness of the wall separating the main cella (sanctuary) from the rear section is 0.902 m, while the thickness of the doorway walls is 2.06 m. In addition, the walls of the cella have the other features also found in the temple; another example of the application of this specific system of "refinements".

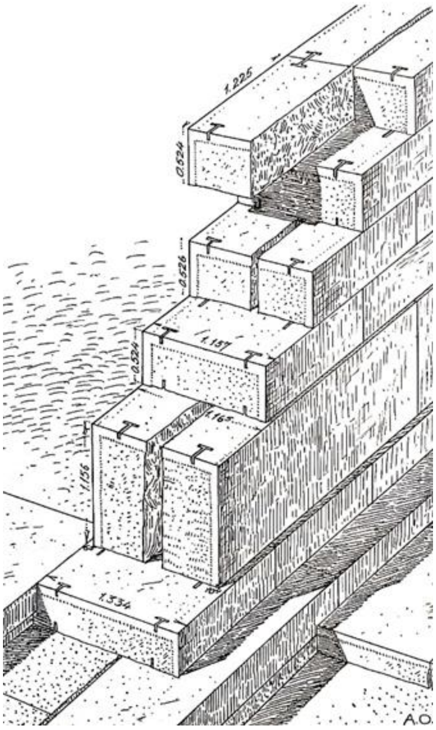


*Figure 22: Composition of the longitudinal walls of the cella (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 171)*

*Figure 23: View of the north-western part of the internal wall of the cella (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 179)*

## 1.7 The columns of the Pronaos

The pronaos serves as the antechamber of the main temple and is the easternmost part of the temple. It is delimited by the six-post colonnade of the porch to the east and the doorway wall to the west. To the north and south the pronaos is enclosed by the corner columns of the porch and the two pilasters ("parastades") that protrude 1.70 m from the doorway wall (Fig. 42-43). In terms of its general dimensions, the pronaos is 21.71 m long and 5.43 m wide.

The floor of the pronaos consists of rectangular plaques of two types: Those that form the stylobate of the columns of the *prostasis* and have a thickness equal to the height of the upper level of the cella *crepis* (0.391 m), and those that cover the rest of the surface of the rectangle. The last ones are thirteen in length and three in width, and are 0.064 m deeper than those of the stylobate, forming a shallow basin measuring 3.665 x 18.425 m between the stylobate and the base of the doorway wall. The bottom of this basin follows the curve of the *crepis*.

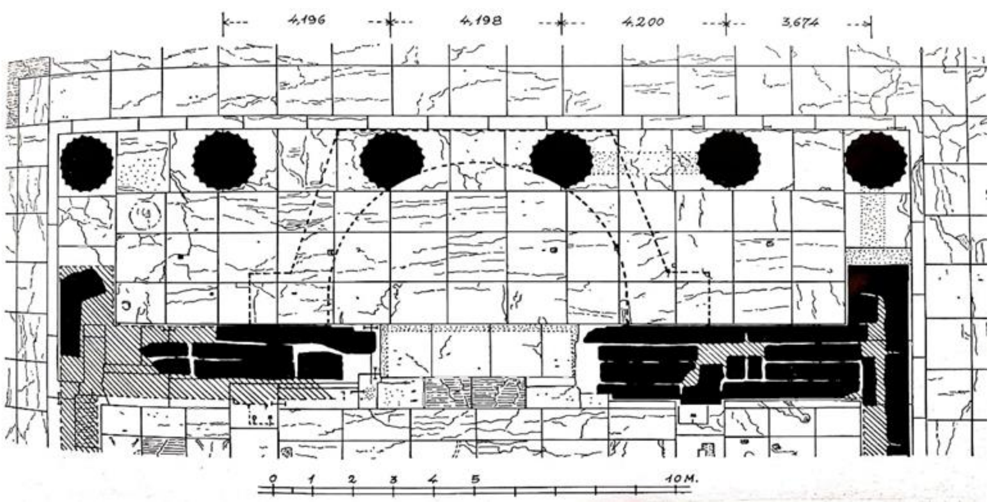


*Figure 24: View of the Pronaos (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 192)*

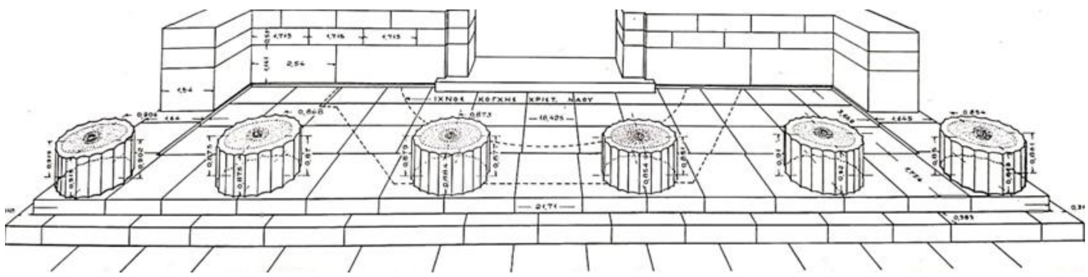

*Figure 25: Prospective view of the lower column drums of the pronaos (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 194)*

The columns of the *prostasis* follow the system of positioning used in the peristyle, according to which the corner columns rest on square plaques, while the intermediate columns are positioned so that the axis of the base is on a joint between two consecutive plaques (Fig. 24-25). These are Doric columns, consisting of twelve column drums each, which are connected to each other with "*empolia*", just as in the *pteron* columns. Of these columns, the extreme south-eastern one was preserved intact but was extensively damaged, especially on the inner side, and was restored by the Hellenic Restoration Service, the extreme north-eastern one was preserved only along the two lowest drums but has deviated from its normal position and is slightly tilted towards N and the four intermediate columns have been partially preserved and partially restored along the first three or four column drums. The columns of the *prostasis* have a maximum (i.e., from edge to edge) lower diameter of 1.641-1.651 m, i.e., smaller than that of the columns of the *peristasis* (1.905-1.920 m), a maximum upper diameter of 1.274 m and a height of about 10.00 m. They also bear 20 ribs with a chord of 0.261 m and an arc of 0.047 m at the base, and 0.20 m and 0.034 m respectively at the top diameter. It is noted that the restored southeastern column of the pronaos has "inclination" and *entasis*. Its inclination is to the NE and was calculated to be 0.064 m (Figure 45), and the *entasis* – convex curve shows a maximum value (0.015 m) between the sixth and seventh drum (numbered from below), i.e., at a height of 4.773 m from the column base.

As for the upper part of the columns, i.e., the capitals, these are constructed as single pieces, as in the peristyle. Apart from that of the SE column, two other capitals are preserved on the ground. From a capital that probably belongs to the NE column, the total height, including the "sub-capital", was measured to be equal to 0.704 m. Of this, the sub-capital occupies 0.148 m, the rings-like-straps 0.0485 m, the *echinus* 0.219 m and the *abacus* 0.2885 m. The square of the reconstructed abacus has a side length of 1.708 m. In addition, the rings-like-straps are limited to three, instead of the five observed in the peristyle capitals, and the tangent of the curve of the echinus forms an angle of 53° to the horizontal axis, which is greater than that of the peristyle capitals.

Finally, only a small section of corner epistyle has survived from the entablature above the columns.

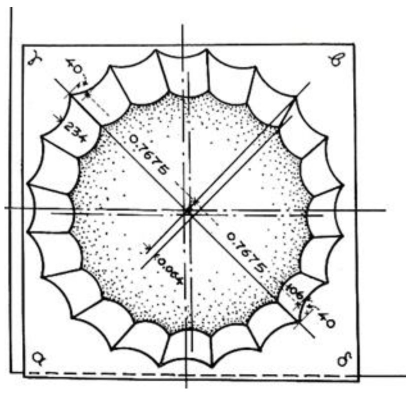


*Figure 26: Inclination of the SE column of the pronaos to the NE (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 202)*

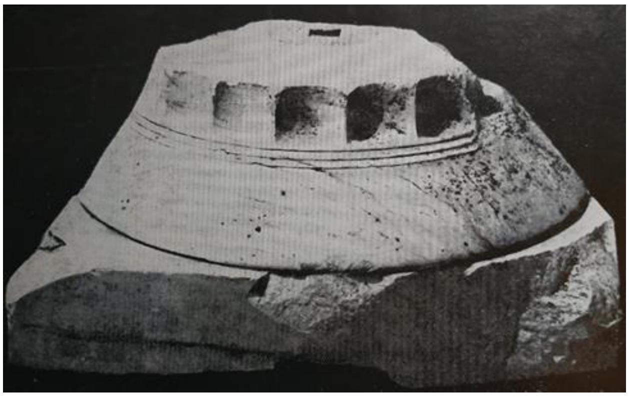

*Figure 27: Capital of the pronaos, upside down (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 203)*

*Figure 28: A view of the columns of the prostasis with the restored SE column in the background. On the left is the east side of the peristyle, with the wide east pteron extending between the two. (The Architecture of the Parthenon, A. K. Orlandos, vol. B, The Archaeological Society at Athens, Athens 1977, fig. 195)*

# 2 EXISTING DAMAGE ON THE PARTHENON

## 2.1 Environmental effects

As mentioned in chapter 1, for the construction of the Parthenon columns and the other monumental structures of the Acropolis, marble blocks were used which were placed in horizontal layers or stacked on top of each other, without any adhesive material. The foundation of the columns was laid in rock, thus ensuring the stability of the structural system. In addition, the installation of iron clamps and dowels, in appropriate cuttings carved into the marble stones, provided additional resistance to earthquake movements. Ancient builders constructed iron fasteners to resist rust by pouring molten lead around the iron, in the place provided for that purpose, between the cut and the iron fastener. The joints between the marble blocks were perfect, providing protection of the clamps from environmental influences and corrosion. For various reasons, e.g., due to earthquakes and explosions in earlier times, the joints were damaged, allowing corrosion agents to enter the interior of the columns.

During the restoration of Balanos (1896-1902 and 1923-1933), iron and copper clamps were placed in the marble without adequate insulation, resulting in their exposure to the surrounding air and moisture. This lack of insulation resulted in corrosion and swelling of the copper clamps. The swelling was due to the larger molar volume of the corrosion product than that of the metal, as well as the mechanism of corrosion involving the diffusion of metal cations through the corrosion product into the corrosive environment. Large mechanical stresses were generated which led to cracking of the marble and mortar and caused material loss and deterioration. The corrosion products also had a bad colour effect on the marble surfaces.

Other types of corrosion that have been reported can be summarised in the following points (Bouras and Korres 1983):

1. Natural sandblasting and abrasion on surfaces because of strong winds (*Aeolian* corrosion), which resulted into loss of material and disappearance of sculpture details.

2. Particulate colloidal matter (metal oxides, soot etc.) suspended in air participates on marble surfaces. Apart from the bad colouring effect, those substances contribute to the deterioration of marble.

3. Damage from purely human factor.

4. Biological forms of corrosion, such as sulfur oxidising bacteria which metabolises reduced inorganic and organic compounds of sulfur by oxidising them into sulfuric acid. They caused acid attacks the marble.

5. The chemical (acidic) and electrochemical (sulfation) attacks which affect the parts of the monument that can be reached by rainwater causing extensive loss of material.

## 2.2 Structural damages

### 2.2.1 Restoration works

During the 25 centuries since the construction of the Parthenon and related monuments on the Acropolis hill, various milestone events have caused significant damage. For the Parthenon in particular, the most significant events were the big fire in the 3rd century AD – specifically in 267 AD, its modification in 529, 1205 and 1456 AD, in order to be used as a Christian church, a cathedral by the Franks and a mosque by the Turkish conquerors, respectively; the blowing up in 1687 by Morosini's army - perhaps the most devastating event in the history of the monument; the expropriation of parts of the sculptures by Thomas Bruce, 7th Earl of Elgin, in 1801 and 1812 —eighteen pedimental statues, 15 metopes and 56 blocks of the Ionic frieze were forced out the monument and today are housed in the British museum in London (YSMA, 2018a); the explosion in the Propylaea in 1940. In addition to the above historical events, the Acropolis monuments suffer significant damage due to environmental causes, as well as major seismic events that have affected the Athens area. One such seismic event, which caused extensive damage to the monument, was the earthquake that occurred on 24/02/1981, centered on the Corinthian Gulf.

*Figure 29: Orthophotomosaic top view of the Acropolis hill (Kaimara, 2012)*

In general, the works for the restoration of the Acropolis monuments started after 1833. However, it was not until 1973 that the documentation of structural damage began in a systematic manner with the establishment of the Committee for the Preservation of the Acropolis Monuments (YSMA). Since the establishment of the technical office of the YSMA and the archive of the Acropolis works in 1976, the pre-existing and emerging structural problems have been the subject of study and extensive documentation, in collaboration with other national foundations and institutions such as the National Technical University of Athens (NTUA), the "Demokritos" Nuclear Research Centre and the Institute of Geological and Metallurgical Research. Figure 29 is a highresolution orthophotomosaic depiction of the current state of the Acropolis monuments, where restoration work continues on the Parthenon, while restoration work has been completed on the Erechtheion, the Propylaea and the Temple of Athena Nike.

Bouras and Korres (1983) published the first study of the overall works planned for the Parthenon. This included an examination of the monument as a whole, listed the problems that existed at the time and gave a theoretical basis for the restoration projects. Their work proposed twelve restoration projects for the Parthenon. These are as follows: the east façade, the north colonnade, the south colonnade, the west façade, east inner hexastyle façade, Pronaos – east wall – transversal wall of Cella, the north wall of the Cella, the south wall of the Cella, the west inner hexastyle façade, Opisthodomos – west wall of the Cella, ceiling of the west pteron, as well as the "parapets"- *crepis* blocks and "pavements". It should be noted that the restoration of the eastern side of the Parthenon, which had suffered very serious damage due to the earthquake of 1981, took place between 1984 and 1991 and was based on the proposal of Bouras and Korres (1983).

Casanaki and Mallouchou (1985), presented the conservation, restoration and research work carried out between 1975 and 1983 on the monuments of the Acropolis Hill. Among other things, they examine the physical and chemical damage and structural problems of the Parthenon. In their research papers they deal with the physico-chemical damage to the monuments as factors that could have affected the static and seismic capacity of the monument. Korres et al. (1989) focus mainly on the restoration of the Pronaos, the structural problems of the Parthenon's restoration and the conservation of the marbles of the monument. Drawings of the condition of parts of the Pronaos and plans were provided by Korres (1989). The restoration of the Pronaos was based on these studies and was carried out between 1995 and 2004. The restoration of the Opisthonaos, the other porch, began in 1992, based on the study by Koufopoulos (1994) and was completed in 2004. In addition, Korres (1994) examines the condition of the western wall and the western door of the Parthenon, giving a detailed report of the remaining parts and suggestions for restoration. Toganidis (1994) reports on the restoration project of the long walls of the Cella, while Paraschi and Toganidis (2002) discuss the restoration of the southern wall of the Parthenon. Toganidis and Matala (2002) examine the restoration of the northern wall of the Parthenon. The restoration of the Parthenon walls is still in progress.

Zambas (2002) reports the structural damage observed on the north side of the Parthenon and presents proposals for restoration. The restoration of the northern side of the Parthenon began in 2001 and was completed in 2014, based on Zambas (2002) and the implementation study by Lambrinou and Christodoulopoulopoulou (YSMA, 2018b). Eleftheriou et al. (2015) provide a detailed report of the structural damage observed on the western side of the Parthenon and also study restoration proposals; currently, this work is still ongoing. The most recent study by Ioannidou and Lebidakis (2011), provides a brief overview of the restoration works on the Acropolis monuments between 2001-2011. In addition, a detailed overview of the completed interventions on the Parthenon between 2001-2012 can be found in Bouras and Eleftheriou (2018a), Bouras and Eleftheriou (2018b), and Bouras and Eleftheriou (2018c).

In the following sections, a more detailed description of each monumental structure of the Parthenon is given separately. The information on the damage and the restoration work that has been carried out or is to be carried out is presented.

*Figure 30: Restoration works. Western side, external view of Opisthonaos*

*Figure 31: (left and right) Restoration works of the Opisthonaos (2021)*

## 2.2.2 The Opisthonaos and the Opisthodomos

The Opisthodomos and the western side of the Parthenon presented the most serious problems (Koufopoulos, 1994). This was attributed to the devastating fire and the direct hits from the cannons that caused damage and fractures to the marbles. However, on the other hand, the best preserved adornment, traces of original colouring, and remains of wall painting can still be found in this part of the Parthenon. Several structural problems can be also observed at Opisthonaos. In particular, there is a slight settlement of the stylobate under the first and third columns (from the south) of Opisthonaos. The corners of the entablature have been pushed outward and the epistyle (architrave) of the SW corner seats precariously. The columns have moved from their original position also deforming the entablature. The blocks of the epistyle have moved away, resulting in damage to the clamps and dowels, as well as fractures in the SW corner. There is also fragmentation of the frieze blocks and supports; corrosion of the fasteners causing loss of the ability of the rows of frieze blocks and frieze supports to maintain their tensile strength and loss of the internal faces of the burnt epistyles, supports and coronet members. Significant corrosion and disintegration of the marble has been observed in the cracks and joints, caused mainly by trapped moisture and microorganisms (Koufopoulos, 1994).

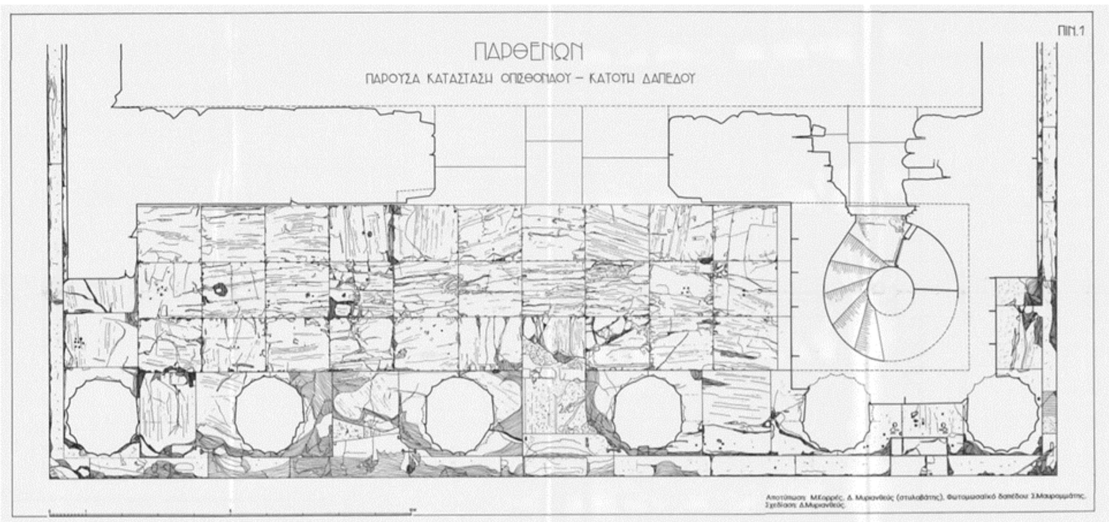


*Figure 32: Plan of the damaged Opisthonaos (Study for the restoration of the Parthenon, P. Koufopoulos, vol.3a, YSMA 1994)*

The usual typical problems caused by rusty iron clamps and dowels and poorly designed previous interventions, such as the extensive use of Meyer glue mix, cement mortar, etc., or the example of the spiral staircase area, which is an addition to the Opisthonaos during medieval times, where problems are caused by moisture seeping downwards, causing corrosion of the building materials and mortar, were also observed. In Figure 33 to Figure 36 (Koufopoulos, 1994), the condition of the Opisthonaos is shown. In addition, the west side of the Opisthodomos suffers from increased soot deposition due to the protective roof.

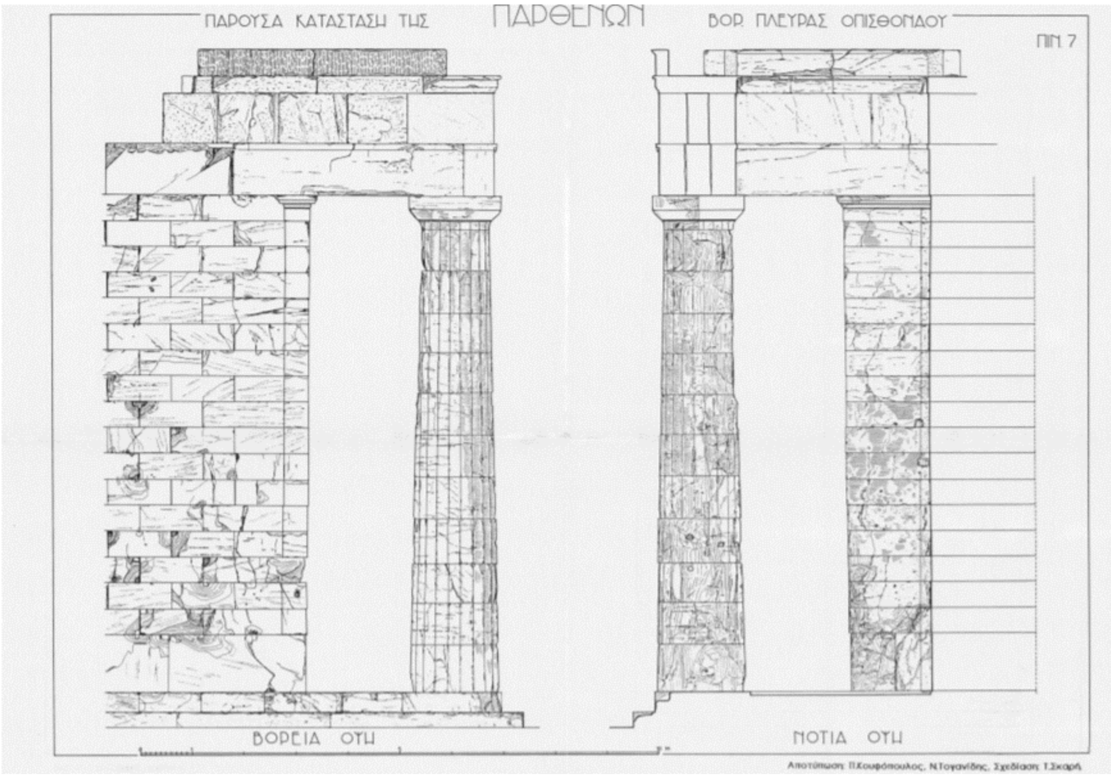


*Figure 33: North side of Opisthonaos (left: north view, right: south view) (Study for the restoration of the Parthenon, P. Koufopoulos, vol.3a, YSMA 1994)*

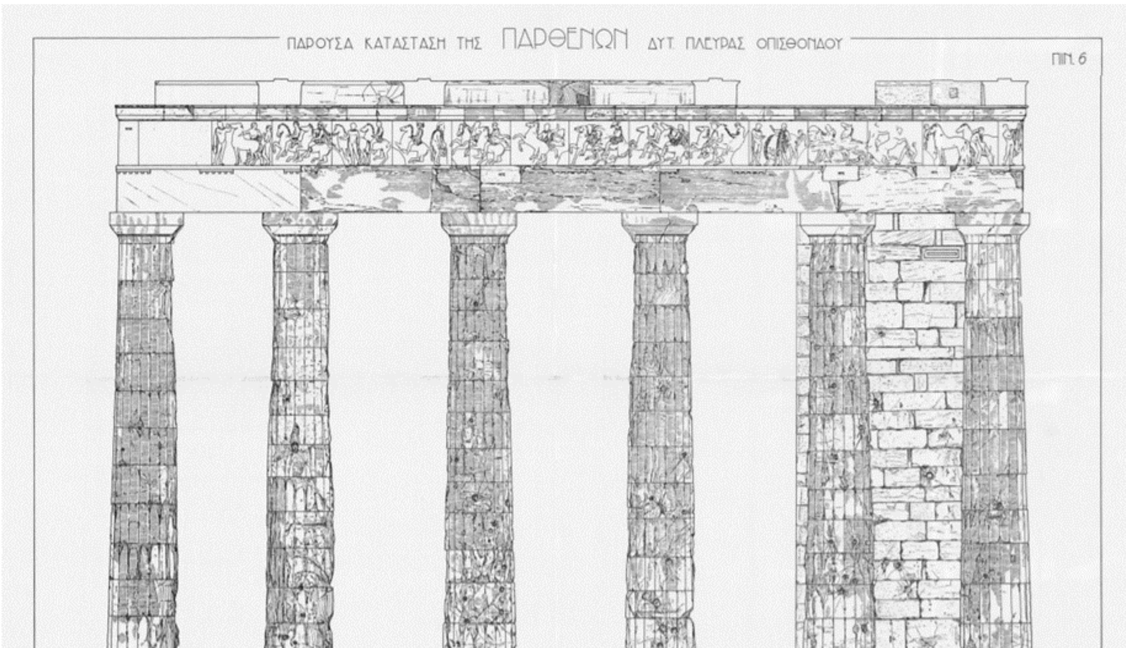


*Figure 34: West side of Opisthonaos (Study for the restoration of the Parthenon, P. Koufopoulos, vol.3a, YSMA 1994)*

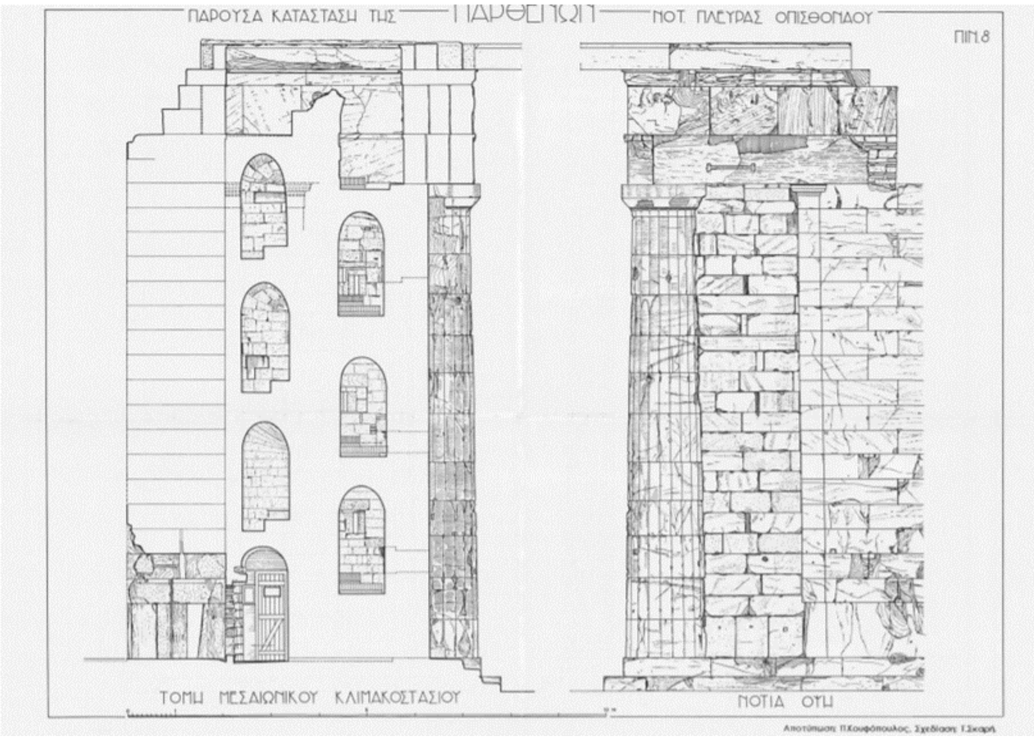


*Figure 35: Opisthonaos (left) Mediaeval staircase - (right) South view (Study for the restoration of the Parthenon, P. Koufopoulos, vol.3a, YSMA 1994)*

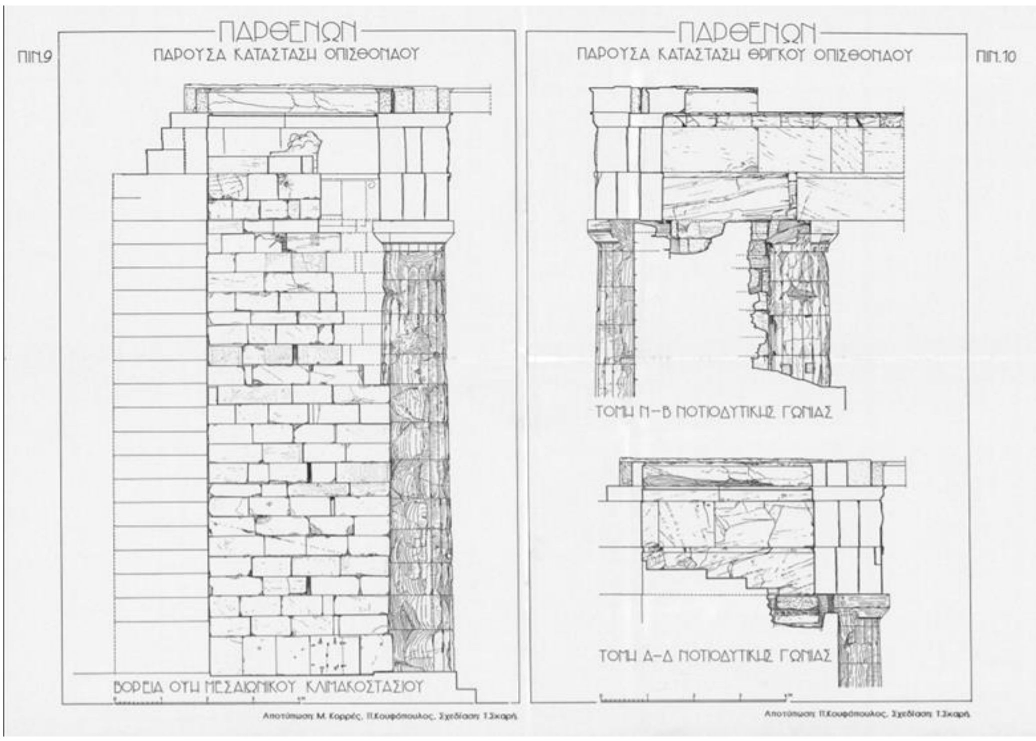


*Figure 36: (left) North side of the Mediaeval staircase, (right) The entablature of Opisthonaos - SW corner. (Study for the restoration of the Parthenon, P. Koufopoulos, vol.3a, YSMA 1994)*

The study by Zambas (1994) describes in detail the structural problems of the Opisthodomos and Opisthonaos. More specifically, it refers to the collapse of parts of the structure, the breakage of the marble, the deformation of the structure or parts of the structure and the failure observed in the joints (Figure 37, right). In Opisthonaos, there is extensive fracture of the stylobate and column drums with wide penetrating cracks and significant loss of material (Figure 37, left). In addition, the upper parts of the entablature and epistyle are fractured both at the joints and at intermediate locations (Figure 37, right). The same situation is also present in the ceiling. The failure observed in the joints at the level of the epistyle and higher up in the entablature is due to corrosion of the iron clamps. It should be noted that dismantling of the Western Frieze revealed extensive damage to the clamps and dowels.

Regarding the dislocations observed in the Opisthonaos, these can be related to those of the entire western section of the Parthenon, including the Opisthodomos and the western part of the peristyle. The horizontal deformations of the stylobate of the peristyle, the cella "*toichobate*", the stylobate of the Opisthonaos and the columns of Opisthonaos have been measured in Zampa's study and are given in Figure 39 (they are, however, illegible). A detailed explanation of the distances shown in this figure and the deformation calculation procedure can be found in Zampas (1994).

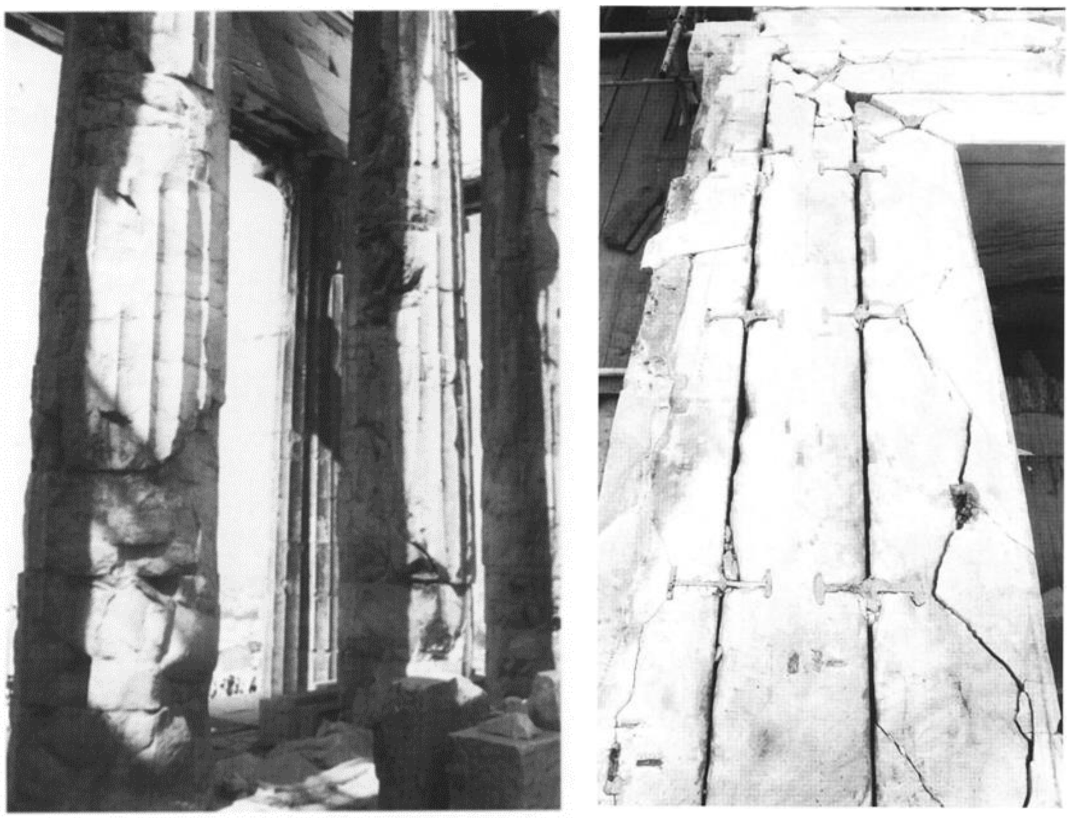

*Figure 37: (left) Columns of Opisthonaos, (right) Epistyle block of SW side of the Parthenon with extensive fracturing at the joints (Study for the restoration of the Parthenon, K. Zambas, vol.3b, YSMA 1994)*

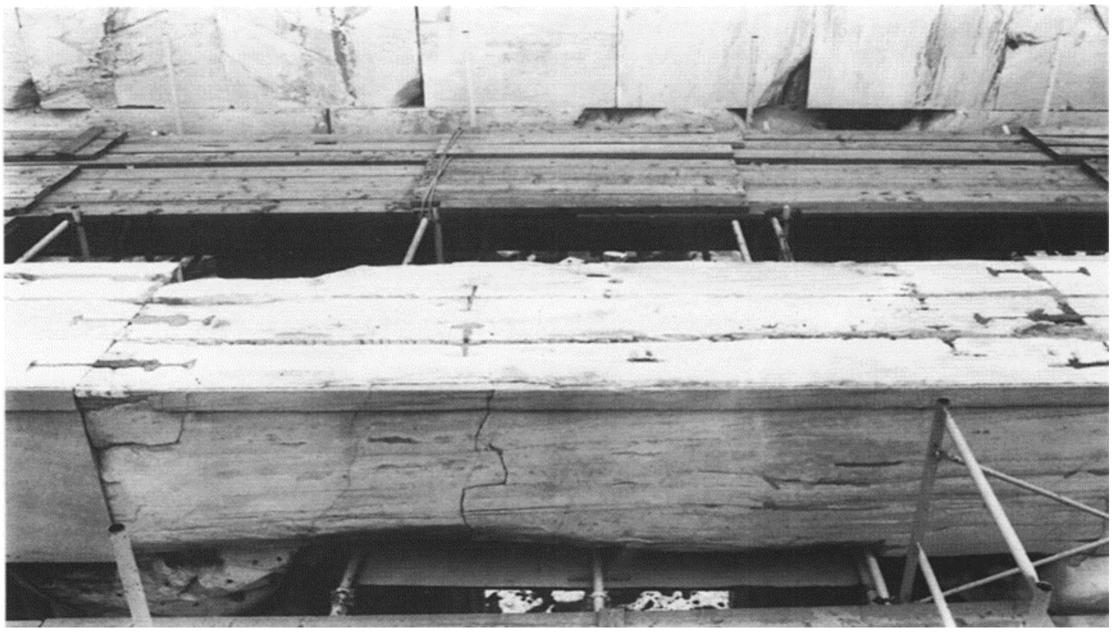

*Figure 38: Part of the epistyle of Opisthonaos (Study for the restoration of the Parthenon, K. Zambas, vol.3b, YSMA 1994)*

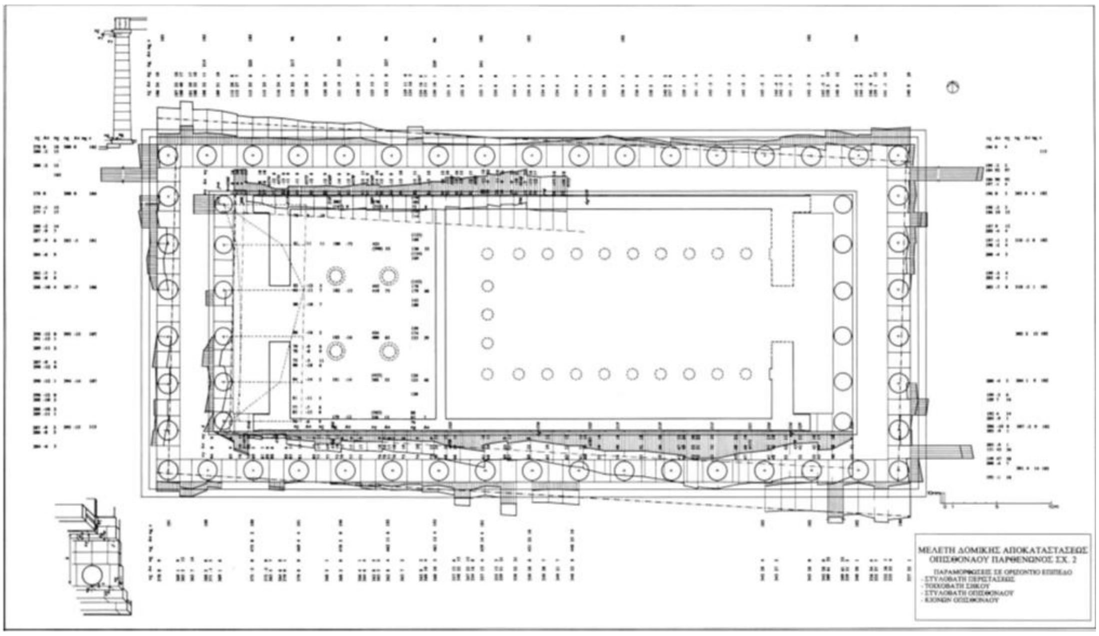


*Figure 39: Horizontal deformations of the stylobate of the peristyle, the cella toichobate, the stylobate of the Opisthonaos, and the columns of Opisthonaos, (Study for the restoration of the Parthenon, K. Zambas, vol.3b, YSMA 1994)*

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Generally indicative of the condition of the west side is the West Door, on the inner face of which there is extensive thermal breakage in the stone blocks - plinths similarly on the surface of the retained inner wall (Figure 40). The displacements of the four edges of the inner face of the West Door wall (Figure 41) were measured by considering a vertical plane parallel to the reference axis of the west façade. Thus, since the wall was originally vertical, the differences in these distances from the distance of a fixed point on the West Door provide the horizontal displacement of the plinths' edges shown in Figure 41 (Zambas, 1994b).

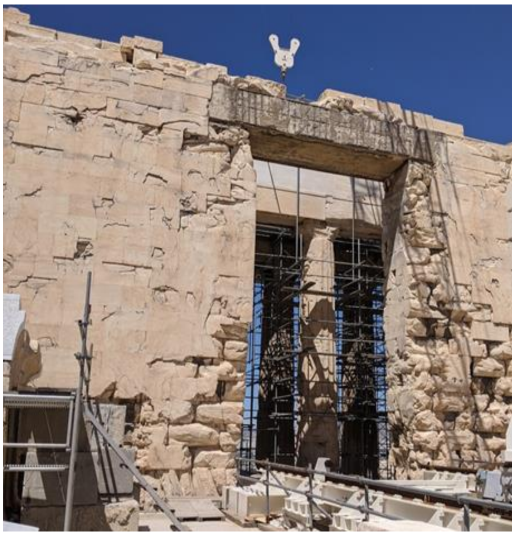


*Figure 40: (left) The inner face of the West Door with extensive thermal fracturing observed on the plinths (Study for the restoration of the Parthenon, K. Zambas, vol.3b, YSMA 1994), (right) The preserved West Door.*

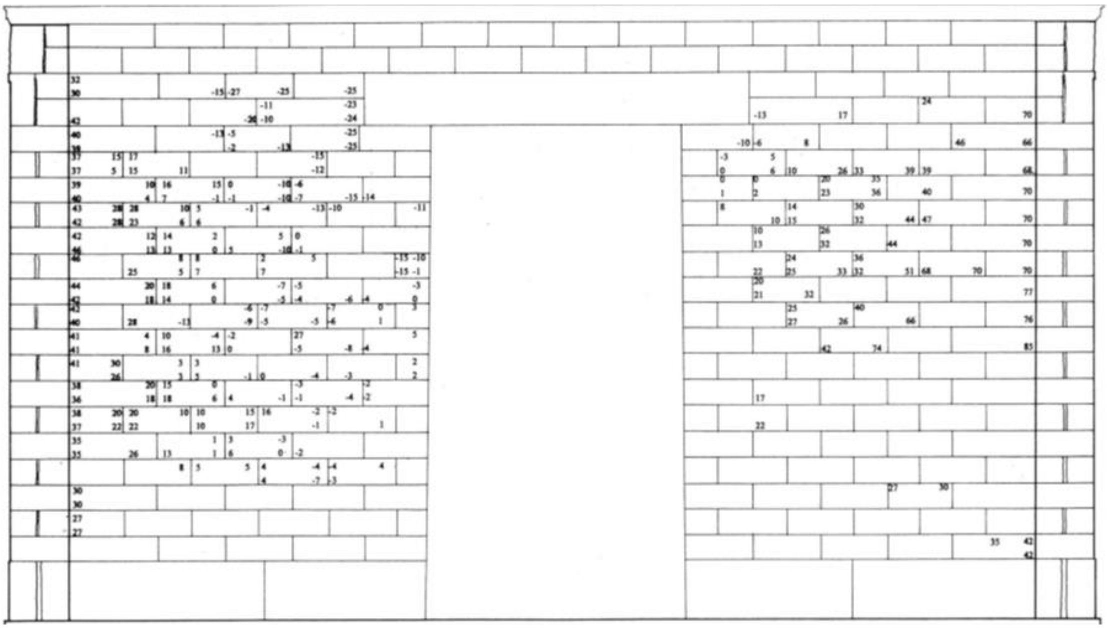


*Figure 41: West wall of cella (West Door). Horizontal displacements of the plinths' edges (Study for the restoration of the Parthenon, K. Zambas, vol.3b, YSMA 1994)*

The axonometric drawing in the Figure 42 shows additional types of structural damage. As for the columns of Opisthonaos, the main structural failures identified in them are displacement of the column drums, cracks in the drums and loss of volume due to fracture. Noteworthy is the displacement of the column drums in the two pairs of corner columns O.K. 1, O.K. 2 and O.K. 5, O.K. 6 (Figure 42, left), where O.K. 1 is the 1st column of Opisthonaos, O.K. the 2nd column of the Opisthonaos, and so on. Measuring these displacements has been extremely difficult, since many parts of the column surfaces have been destroyed by fire. Even where the ribs (or the flutes) survive, they are very deteriorated, especially near the joints (Zambas, 1994).

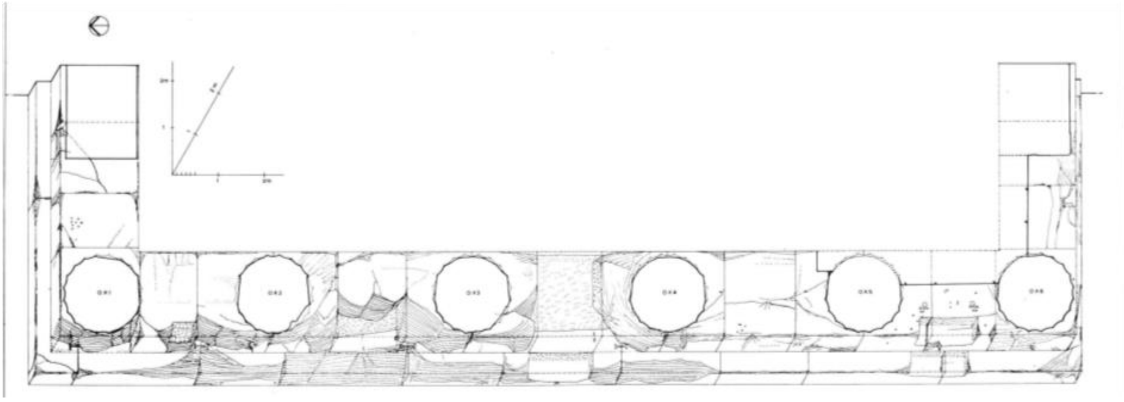


*Figure 42: Damages to the stylobate of Opisthonaos (Study for the restoration of the Parthenon, K. Zambas, vol.3b, YSMA 1994)*

The sub-capital advance is the algebraic sum of three factors: the motion of the stylobate, the movement due to possible rotation of the stylobate plinth blocks about the horizontal axis and the relative displacements of the column drums.

Figure 43 shows the displacements of the drums of the columns of the Opisthonaos, as well as the curvature of the stylobate, which is their base (Figure 43, right). To measure the displacement of the drums of the columns, a special tool was devised consisting of two hard plexiglas moulds, which were used to reproduce the shape of the flutes near the joints. According to Zambas (1994) the conclusions that can be drawn about the condition of the Opisthonaos are the following: (i) All the columns of the Opisthonaos have the same diameter $D_d$ = 1.609 m at the lowest point of the column shaft, and $D_u$ = 1.231m at the uppermost, thus there is a decrease of $\mu$ = 0.378 m. (ii) The columns are vertical by construction. (iii) The difference between the distances of the lowest and uppermost points of the fluting was initially 37.8/2 = 18.9 cm. The horizontal displacements of the drums are shown in Figure 42 (right).

Apart from the values of the relative displacements between the column drums, of particular interest is the state of the drums with respect to the fracture of the edges of the ribs, as a result of stress from stress concentration, the loss of mass resulting in the impairment of the bearing surfaces of the drums and the fractures, which affect the response of the columns to earthquake stress. Figures 44 to 47 show an illustration of a random drum of each column. In these, where there is significant mass loss, the thickness of the lost segment at the position corresponding to the deepest point of the rib is given in cm. In the faults, the width W and depth B are given, similarly in cm.

According to the drawings, fractures with numerical data appear at the following locations:

In O.K. 1: in the 1st column drum with W = 0.1 cm, in the 3rd drum with W = 0.5 cm and B = 30 cm,
In O.K. 2: in the 1st drum with W = 0.3 cm and B = 30 cm, in the 3rd drum with W = 0.4 cm and B = 70 cm, in the 4th drum with W = 0.3 cm and B = 105 cm, in the 5th drum with W = 0.3 cm and B = 100 cm, in the 6th with W = 0.3 cm and B = 30 cm,
In O.K. 3: in the 1st drum a fracture with W = 0.6 cm and B = 50 cm and one with W = 0.5 cm and B = 30 cm, in the 2nd one with W = 0.3 cm and B = 45 cm and one with B = 35 cm, in the 3rd with B = 60 cm, in the 8th with B = 120 cm, in the 9th with W = 0.5 cm,
In O.K. 4: in the 3rd column drum with W = 0.2 cm and B = 50 cm.

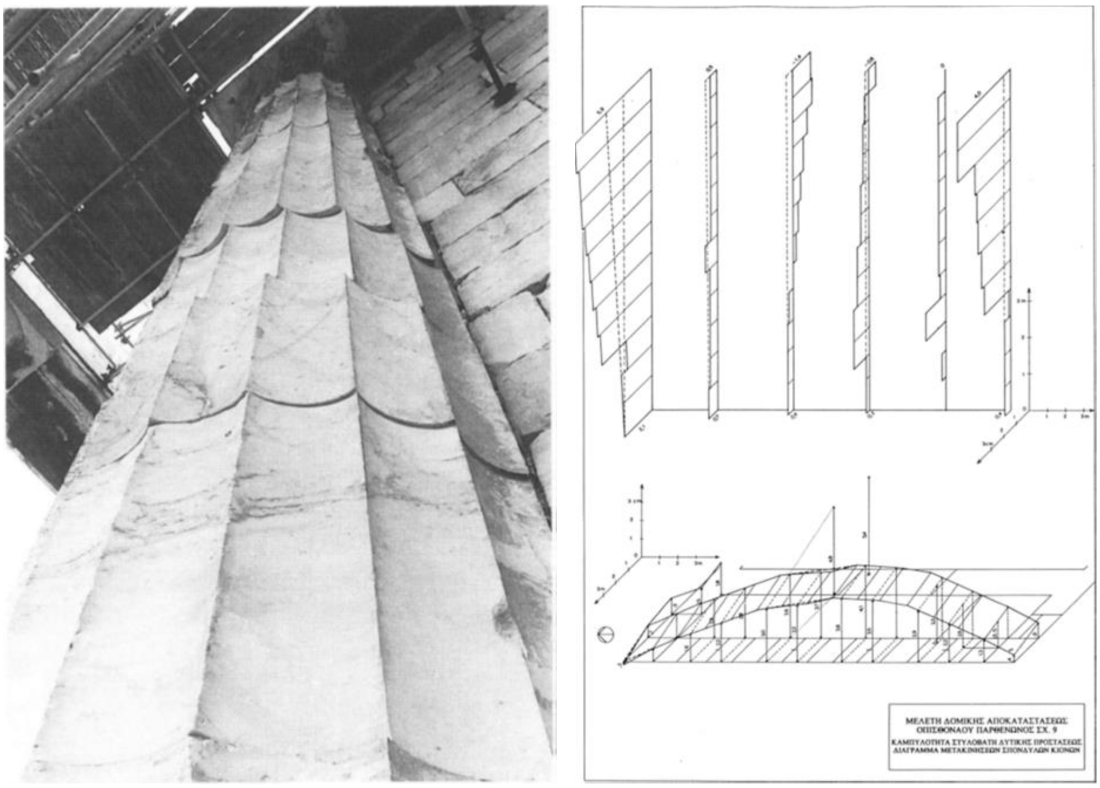


*Figure 43: (left) SW column of Opisthonaos, (right) Curvature of the stylobate, diagram of the displacements of the drums of the columns (Study for the restoration of the Parthenon, K. Zambas, vol.3b, YSMA 1994)*

The most important fractures in the column drums are in principle perpendicular to the marble layers, i.e., upright. Their direction is generally the same as that of the length of the column (N-S). In some cases, in the presence of these fractures, the column drums are bisected. Particular attention is paid to the response of columns to possible seismic stresses in the case of through-going fractures, which are characterized by continuity from drum to drum in terms of location and direction. Such fractures are present in the first three drums of O.K. 1, the first five drums of O.K. 2, the first two drums of O.K. 3, as well as in the fourth, fifth, sixth, seventh, eighth and ninth drums of O.K. 3, and the first two drums of O.K. 4.

With regard to the mass losses, these are located on the posterior and lateral parts of the surfaces of the columns and are mainly due to thermal fracture of the columns. They are obviously greater in the lower column drums. The depth of the losses is measured from the edge of the rib, is up to 24 cm and is indicated on the axonometric drawings of the individual drums. For example, in the 1st drum of O.K. 1 the depths of loss are 19 cm (the maximum), 14, 13 and 12 cm. In the 1st drum of O.K. 2 they are 20 cm (maximum), 16 cm and 13 cm. In the 2nd drum of O.K. 2 it is 12 cm (maximum) in three positions and 11 cm. In the 1st drum of O.K. 3 it is 19(?) cm (the maximum), 15, 13, 10, 8 and 5 cm, in the 2nd drum it is 17 cm and in the 3rd drum it is 9 cm (the maximum). In the 1st drum of O.K 4 the maximum depth of loss is 18 cm, in the 2nd 14 cm and in the 3rd drum it is 16 cm.

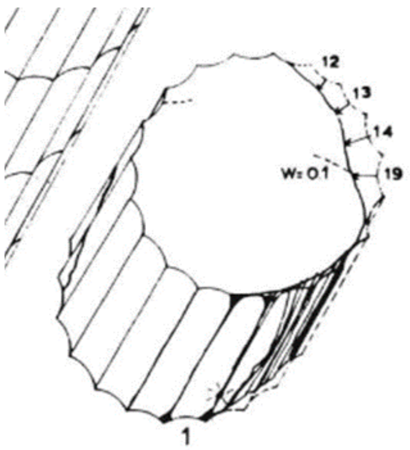



*Figure 44: Condition of the 1st column drum of O.K. 1 (Study for the restoration of the Parthenon, K. Zambas, vol.3b, YSMA 1994, part of fig. 10)*

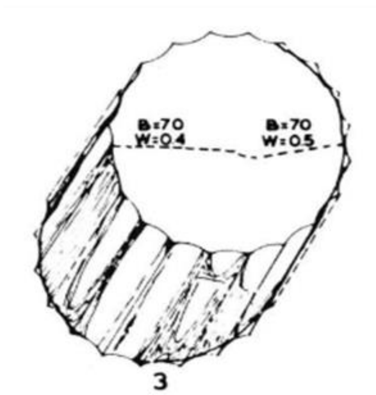



*Figure 45: Condition of the 3rd column drum of O.K. 2 (Study for the restoration of the Parthenon, K. Zambas, vol.3b, YSMA 1994, part of fig. 11)*

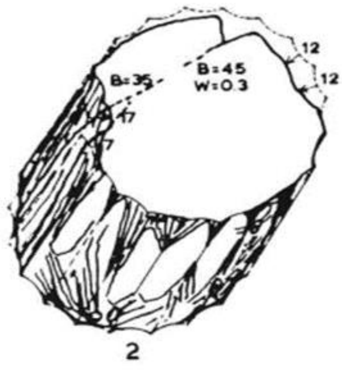



*Figure 46: Condition of the 2nd column drum of O.K. 3 (Study for the restoration of the Parthenon, K. Zambas, vol.3b, YSMA 1994, part of fig. 12)*

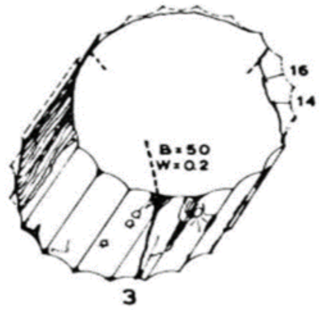



Figure 47: Condition of the 3rd column drum of O.K. 4 (Study for the restoration of the Parthenon, K. Zambas, vol.3b, YSMA 1994, part of fig. 13)

During the interventions of the first period (1992 - 1996) in the Opisthonaos, the three upper rows of the entablature were disassembled, while all the volumes of the entablature were structurally restored. At the same period, the columns were supported with grout. During the second period of the restoration works (2000-2004), all the disassembled ancient elements were structurally restored through reinforcements and fillers made with new marble. In addition, during this period new members were constructed – mainly for the rear volumes and the composite architectural members of the frieze – while the new frieze members were also cast from artificial stone (Bouras & Eleftheriou, 2018b).

A detailed documentation and interpretation of the structural pathology and condition of the individual blocks, including the anchorage areas of the clamps and dowels, is provided by the study of Toumbakari (Bouras & Eleftheriou 2018b). The damages observed in the anchorage areas of the marble blocks can be attributed to the mechanical action of the connectors, which are mobilized by externally imposed displacements. Numerical calculations are also included in this study to understand the behaviour of the undamaged and damaged blocks. The main findings of the aforementioned study are summarized below:

1) The beams of the ceiling are not pegged.

2) The failure of the anchorage areas of the connectors are concentrated on the upper part of the frieze and not on the upper part of the crown blocks.

3) Failures are concentrated on the anchorage areas of the longitudinal connectors and not on the transversal connectors of the epistyle blocks.

4) Failures of the anchorage areas of the pegs are concentrated on the interface of the epistyle blocks and the frieze and not on the interface of the frieze and the crown blocks.

5) Conservation of the anchorage areas of the pegs of the column capitals and failure of the anchorage areas of the pegs on the lower part of the epistyle blocks.

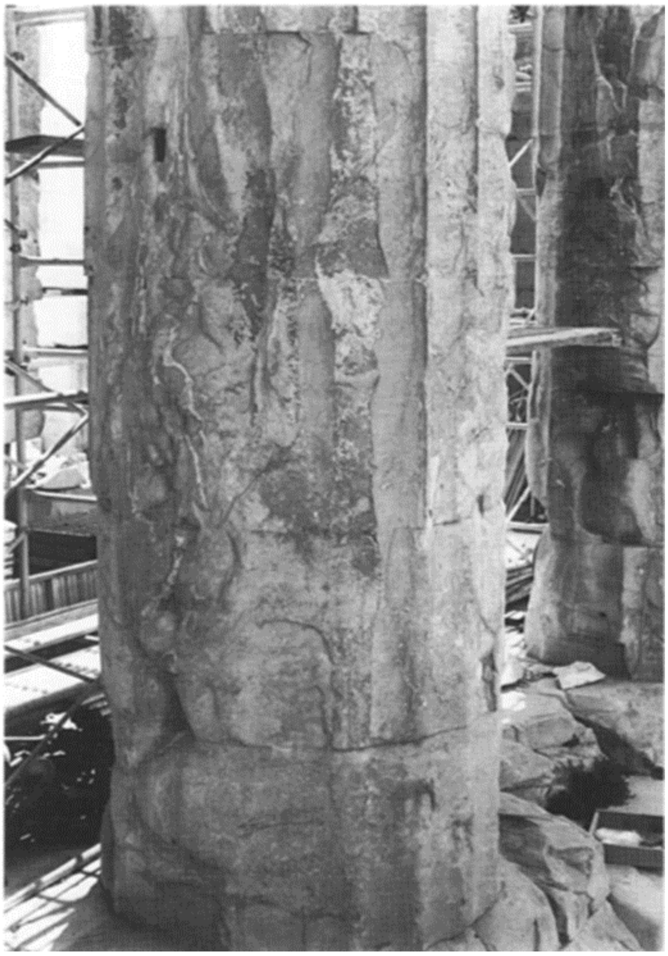


*Figure 48: The first four drums of column O.K 3 with newer fillings in their fractures (Study for the restoration of the Parthenon, K. Zambas, vol.3b, YSMA 1994)*

### 2.2.3 The North Side

The first restoration works on the northern side of the monument took place in the period 1842-1844 with the restoration of the columns of the *peripteral* colonnade and the walls of the cella (by K. Pittakis and A. R. Rangavis) (Fig. 49). In this period two columns were fully restored and three were partially destroyed on the north side (Zambas, 2002). In the period 1923-1930 the restoration of the north side columns was supervised by N. Balanos. The columns from the $4^{th}$ to the $11^{th}$ (from the NE corner), the epistyle and a large part of the entablature were restored. The restorations of this period were made using existing fallen marbles and reinforced concrete to fill in the gaps (Zambas, 2002).

*Figure 49: The Parthenon from NW after the restoration of 1844. Fully restored columns 9 and 11 and partially restored columns 6, 7, 8 and 10 are visible. (Study for the structural restoration of the northern side of the Parthenon, K. Zambas, YSMA 2002)*

However, the use of reinforced concrete caused damage due to oxidation and expansion of the steel clamping elements. This damage was already evident ten years after the restoration. The most serious damage was found in the entablature (Fig. 50-52). The most typical problems of the entablature are the following:

1) The precarious equilibrium condition of the pieces from the bottom corners of the horizontal parapets due to oxidation of embedded steel beams: The filling in, through the steel beams, of the lost sections, using reinforced concrete during the 1930s restoration resulted in the marbles cracking due to the oxidation and swelling of these steel beams, so that the lower sections of the cornices become crumbling. The maintenance and restoration works include the landing of a piece, the dry restraint with a titanium pin and the support with external steel frames.

2) The concrete of the tail sections of the cornices is crumbling and is being broken by oxidation of the reinforcement. The damage is found in all the restored cornices except

for one section, ΒΓ 29, which was restored without a concrete filling since it survives in its full length.

3) The risk of the cornice overturning due to failure of the anchors: the cornice ΒΓ 29 was not filled with concrete despite the losses due to thermal breakage, which has reduced the counterweight required to balance it. In addition, the anchorages have failed due to marble cracking from the swelling of the anchors used during the 1930s restoration.

4) The breakage of the Doric frieze filler stones by steel links.

5) The breakage of horizontal joints and the lifting of marbles due to the swelling of horizontal joints and steel in-settings. The resulting movements cause new stresses in the joints and connections and thus a general instability in the brickwork.

6) The deformation of the epistyles by swelling and oxidation of embedded steel beams.

7) The breakage of the epistyles by embedded suspension bars used in the middle stones of the epistyles.

An indication of the continuing destructive effects of the oxidized clamps is the fact that although in 1973 and 1974, just prior to the establishment of the YSMA, many cracks had been filled and dangerous fractures had been reinforced with bronze bars over a large area. In many cases these fillings failed (Zambas, 2002). The restored south side, the restoration of which was completed in 1933, also have similar problems.

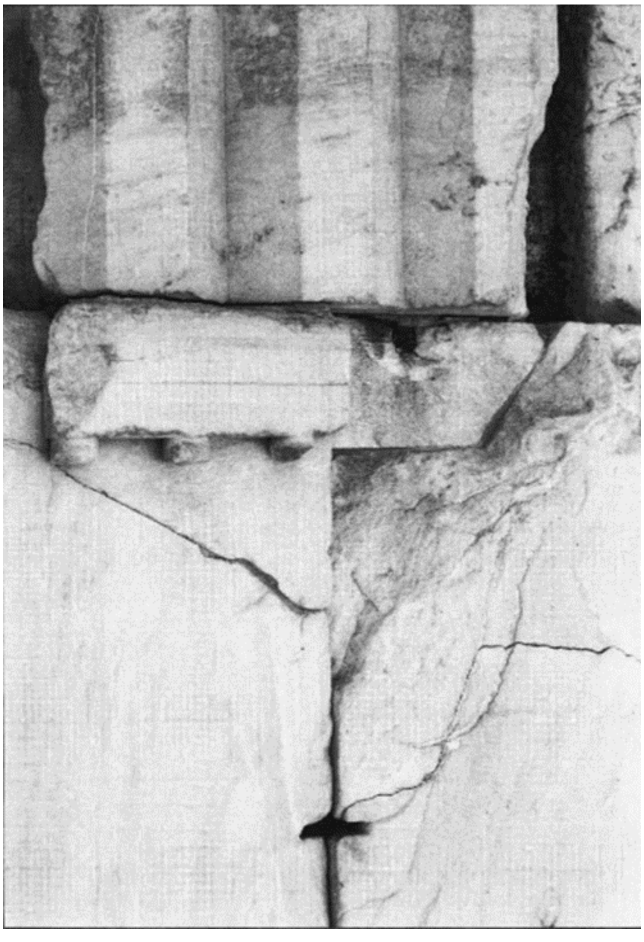


*Figure 50: Triglyph uplifting by a link of the epistyle (Study for the structural restoration of the northern side of the Parthenon, K. Zambas, YSMA 2002)*

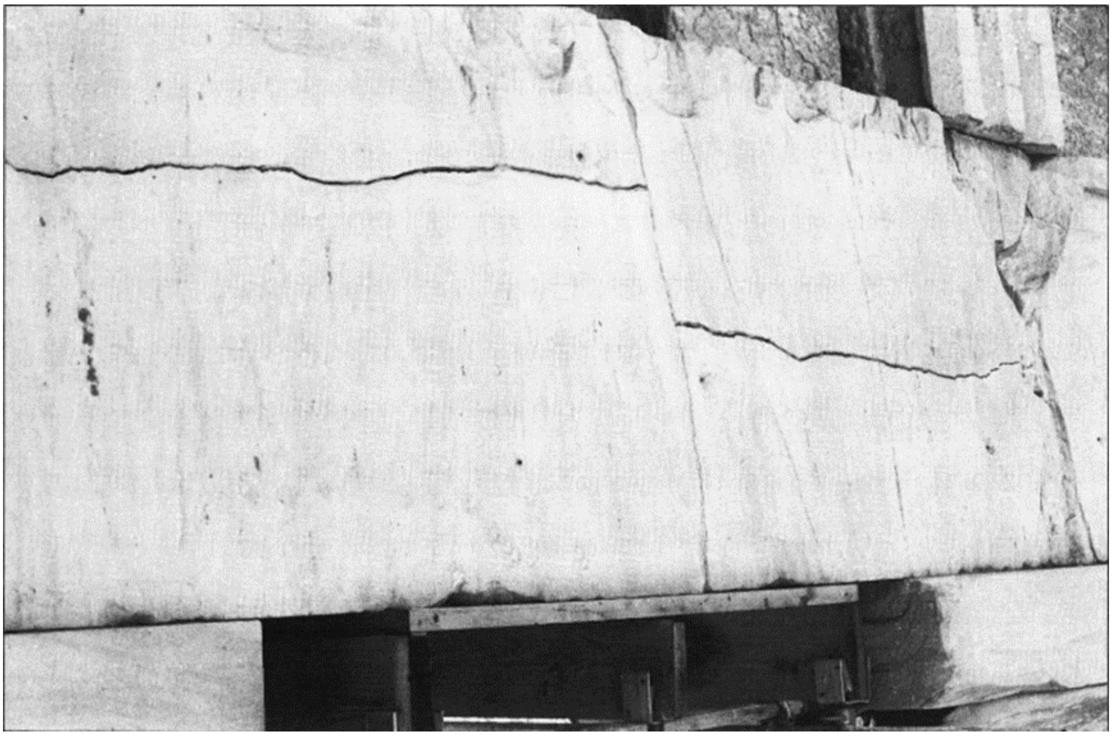


*Figure 51: Breakage of an epistyle from an embedded steel beam. The crumbling lower sections were under-supported. (Study for the structural restoration of the northern side of the Parthenon, K. Zambas, YSMA 2002)*

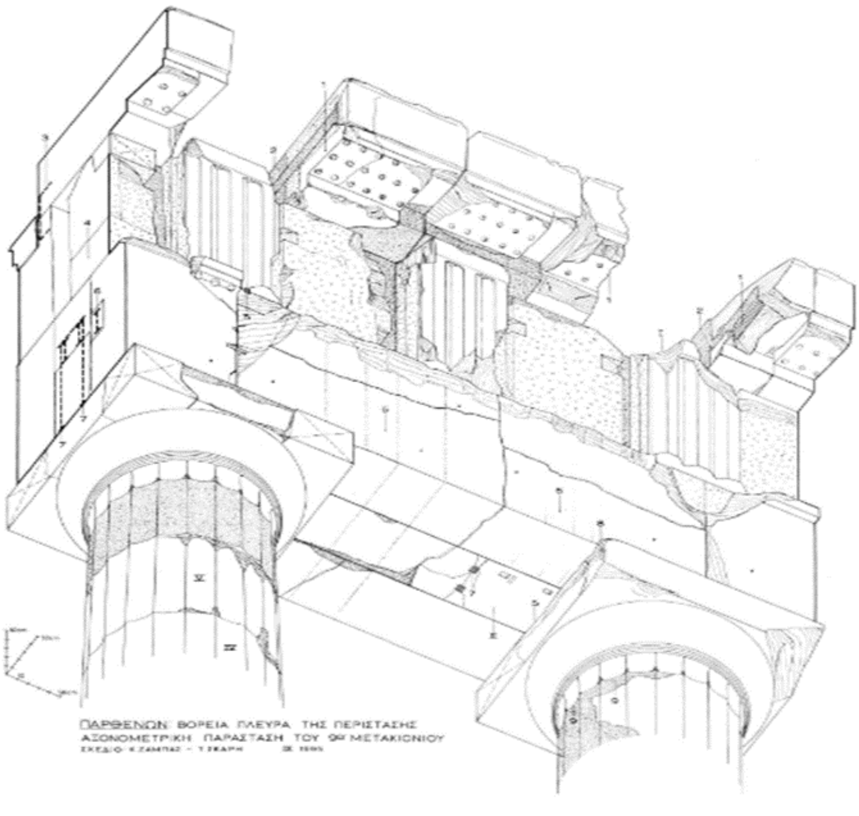



*Figure 52: Drawing of the typical damage to the entablature of the north side . (Study for the structural restoration of the northern side of the Parthenon, K. Zambas, YSMA 2002)*

The most severe damage to the north side columns was due to the steel clamps and steel reinforcement in the concrete fillings. The clamps caused the drums to crack, but even worse they imposed uplift forces on the overlying drums. As a result, they opened up the joints and created a general instability in the columns. The steel reinforcing beams in the concrete were anchored to the marble. The beams had oxidized and, in many places, cracked the concrete and marble at the anchorage points. The capitals were assembled from fragments and marble fillings with steel clamps. The exterior clamps were replaced in 1974 with bronze clamps, but the invisible ones on the interior have oxidized and caused new cracks (Zambas, 2002) (Fig. 53-55).

*Figure 53: Marble breakage from a concrete reinforcement bar on BK 8, where BK stands for the north side column. (Study for the structural restoration of the northern side of the Parthenon, K. Zambas, YSMA 2002)*

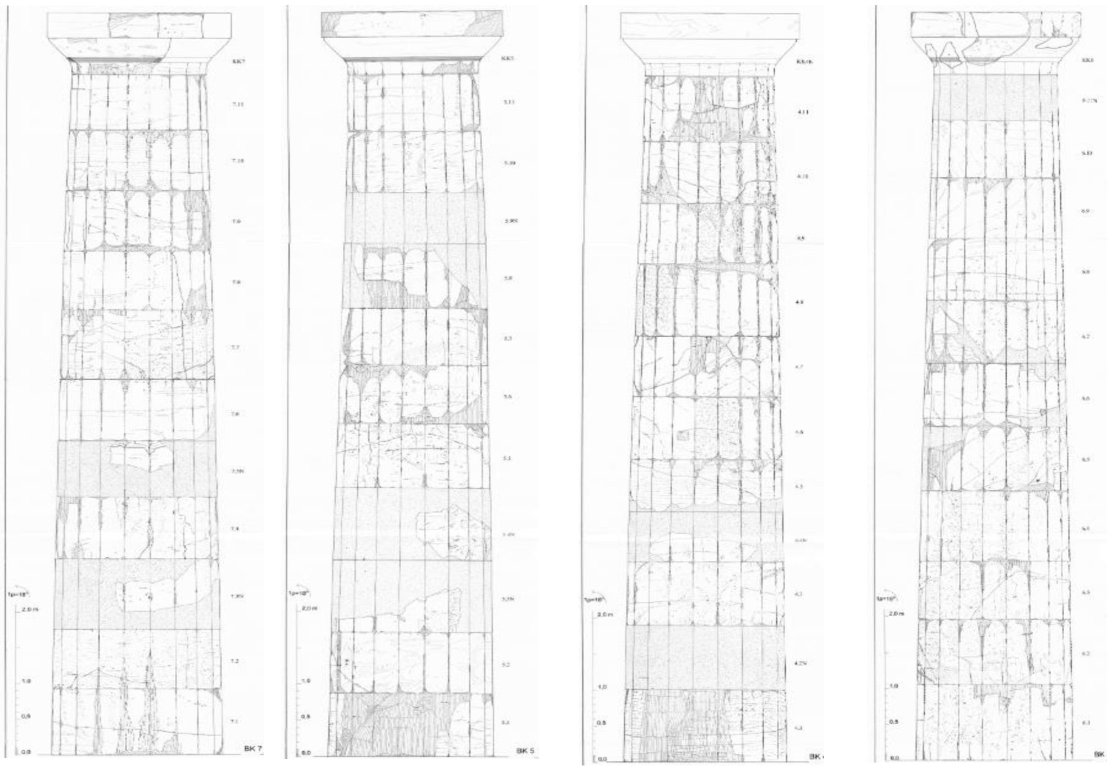


*Figure 54: Condition of the columns BK 4-7 after the restoration of 1930 (Study for the structural restoration of the northern side of the Parthenon, K. Zambas, YSMA 2002)*

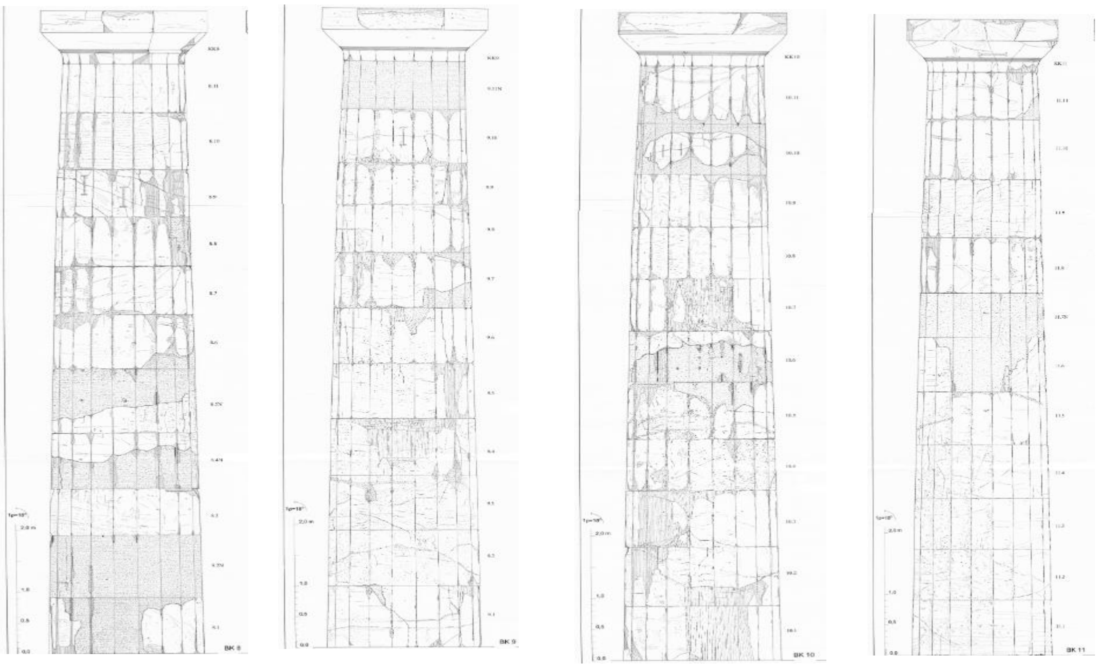


*Figure 55: Condition of the columns BK 8-11 after the restoration of 1930 (Study for the structural restoration of the northern side of the Parthenon, K. Zambas, YSMA 2002)*

In 1996, numerical simulations of the seismic behaviour of the columns were carried out in cooperation with the National Technical University of Athens (NTUA) in the framework of the European Programme "Environment". The simulations were based on the discrete element method, using the UDEC software. These simulations were compared with vibration table tests carried out at the Laboratory for Earthquake Engineering of the NTUA. The specimens tested were 1:3 scale. The experiments have once again demonstrated the complexity of the dynamic response and the high sensitivity of the response of a free standing multi-drum column to seismic accelerations, especially when the drums are already displaced. Based on this research, the general conclusion is that the entablature and columns of the north side of the Parthenon are unstable (Zambas 2002).

The most recent restoration of the northern colonnade of the Parthenon began in 2011. The study required the disassembly of eight columns and the corresponding parts of the entablature above, replacing the concrete fillings of the previous intervention with new marble fillings. In addition, all the ancient pieces had to be repositioned on the monument and also the clamps and dowels had to be replaced with titanium clamps. The restoration of the architectural members is aimed at returning the members to their original position and correcting previous misplacement. The project is still ongoing (YSMA, 2018b) (Fig. 56).

Toumbakari's (2018) study, also mentioned in 2.2.2, provides a detailed documentation and interpretation of the structural pathology and condition of the individual blocks, including the anchorage areas of the clamps and dowels in the frieze on the north side of the Parthenon (Bouras and Eleftheriou 2018a). During these works, an ancient remaining clamp was uncovered that is considered unique. Toumbakari carried out a study of the microstructure and deterioration of this ancient clamp. In addition, she carried out a numerical study to determine the developing stresses in the anchorage areas under tension and the applied shear forces. Finally, the study evaluated the bearing capacity of the damaged anchorage areas filled with new marble. The numerical analyses showed that there were cases where this bearing capacity is low and eventually the failure of the marble could occur before the failure of the reinforcement. This analysis showed that the design of clamps and dowels should be based on the results of the analysis of the response of the whole structure against external actions.

Figure 56: North side of the Parthenon: (left) view from inside the cella, (right) view from outside.

### 2.2.4 The Pronaos

As far as Pronaos is concerned, the various disasters it suffered caused the collapse or the subsequent demolition of the inner six-column *prostasis* (façade) and the eastern side of the cella. This is therefore a part of the temple that has been irreparably damaged. Most observations on Pronaos are found in the Study of the Restoration of the Parthenon, Volume 2a, M. Korres, N. Toganidis, K. Zampas, Th. Skoulikidis, et al., Hellenic Ministry of Culture, YSMA (1989). In the same work, reference is made to the different architectural features of Pronaos, such as, for example, the noticeably thinner columns compared to those of Opisthonaos. The parts of the columns that had survived up to that time showed good preservation on the pteron-facing side, while on the wall-facing side the damage is extensive, with very few parts of the original surfaces surviving and even some of them were in partial detachment due to multiple exfoliation cracks. On the east wall almost all the *orthostates* of the south side with four of the overlying stones survived in place and about half of the *orthostates* of the north side.

Fragmentation due to thermal fracture is observed. Two different types of fractures are observed: (i) fractures with planes running parallel to the surface (primary thermal fracture or exfoliation) and (ii) fractures with planes running perpendicular to the surface (transverse fracture or deepening cracks and especially secondary thermal fracture). The shape of the exfoliations depends more on the external shape of the pieces than on their internal structure. On the other hand, the location and nature of transverse cracks depend more on the internal morphology of the stones and, in particular, on the distribution of discontinuities in the material. The latter is present in all types of building stones and marbles. All the inward-facing surfaces of Pronaos ended up in this condition. In addition, fragmentation due to static and dynamic loading, which occurs along the edges subjected to high stress. Generally, this occurs at the perimeter of the columns along the joints due to variations in ambient temperature and due to seismic vibrations. The two causes act independently but also influence each other.

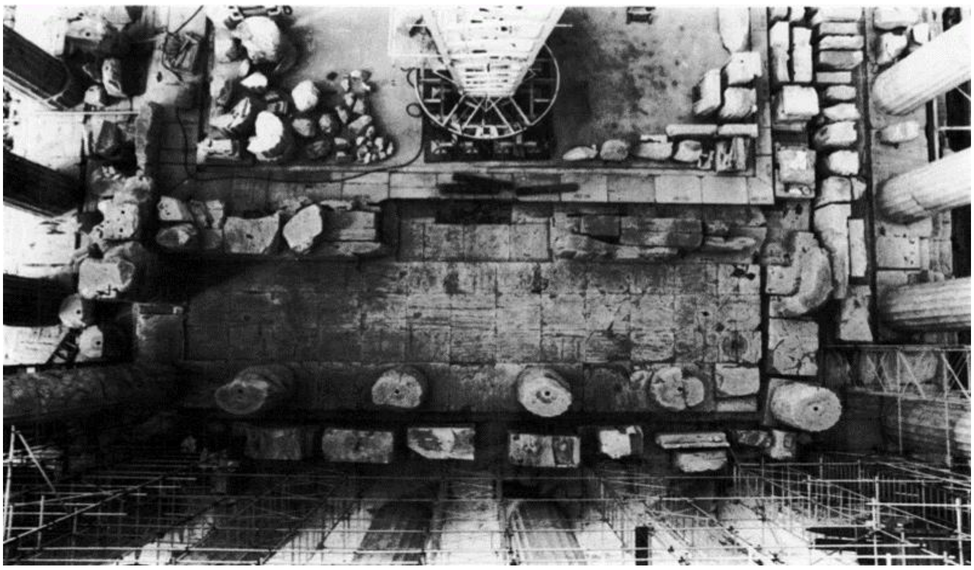


*Figure 57: View of Pronaos. (Study of the Restoration of the Parthenon, vol. 2a, M. Korres, N. Toganidis, K. Zambas, Th. Skoulikidis, et al., YSMA 1989)*

Indicative were the mass losses observed on the eastern side of certain column drums: the first drum of Π.Κ. 1, the first of Π.Κ 2, the second of Π.Κ. 3, the third of Π.Κ. 4, the fifth of Π.Κ. 5, as well as the fourth and sixth column drum of Π.Κ. 6, where PC stands for Pronaos' column.

Another type of structural damage is related to the destruction of surfaces due to the force exerted by heavy tools and include deep channels around the joints for lead and steel extraction, breaking of masses all along the edges of the blocks, cutting the blocks into large sections by creating deep V-channels in the marble or only with force concentrated along the desired cut line.

Other types of damage are also:

(i) The cutting of blocks with explosives; caused by the blowing up of 1687.

(ii) Breakage and breakage due to rusting and swelling of ancient metal clamps and dowels.

(iii) Breakage due to swelling of metal added by the conservators. The phenomenon is strongly visible in the ten restored drums of the 6$^{th}$ column and in the three restored blocks of the SE "*parastades*".

From past analyses, in particular with the three Pronaos columns and the epistyles in their original state, with fractures, losses and various cases of connections, it has been shown that such failures as those of the Pronaos columns imply a significant reduction in stability.

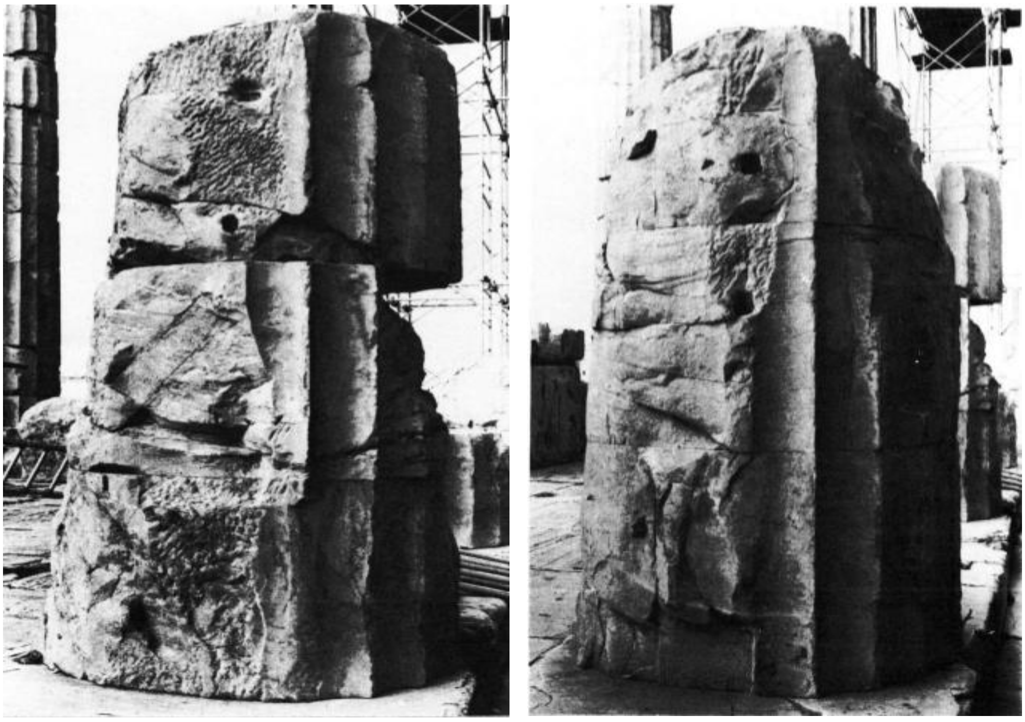


*Figure 58: Columns of the Pronaos (Study of the Restoration of the Parthenon, vol. 2a, M. Korres, N. Toganidis, K. Zambas, Th. Skoulikidis, et al., YSMA 1989)*

Korres (1989) provides specific plans on the state of the remains of Pronaos. Figure 59 explains the graphical conventions adopted; particularly useful for understanding the type of damage observed. Some of the aforementioned drawings are shown below, in Figure 60 to Figure 66. During the partial restoration of Pronaos between 1998 and 2004, the second of M. Korres' four recommendations (Figure 67) was applied (Bouras and Eleftheriou, 2018a).

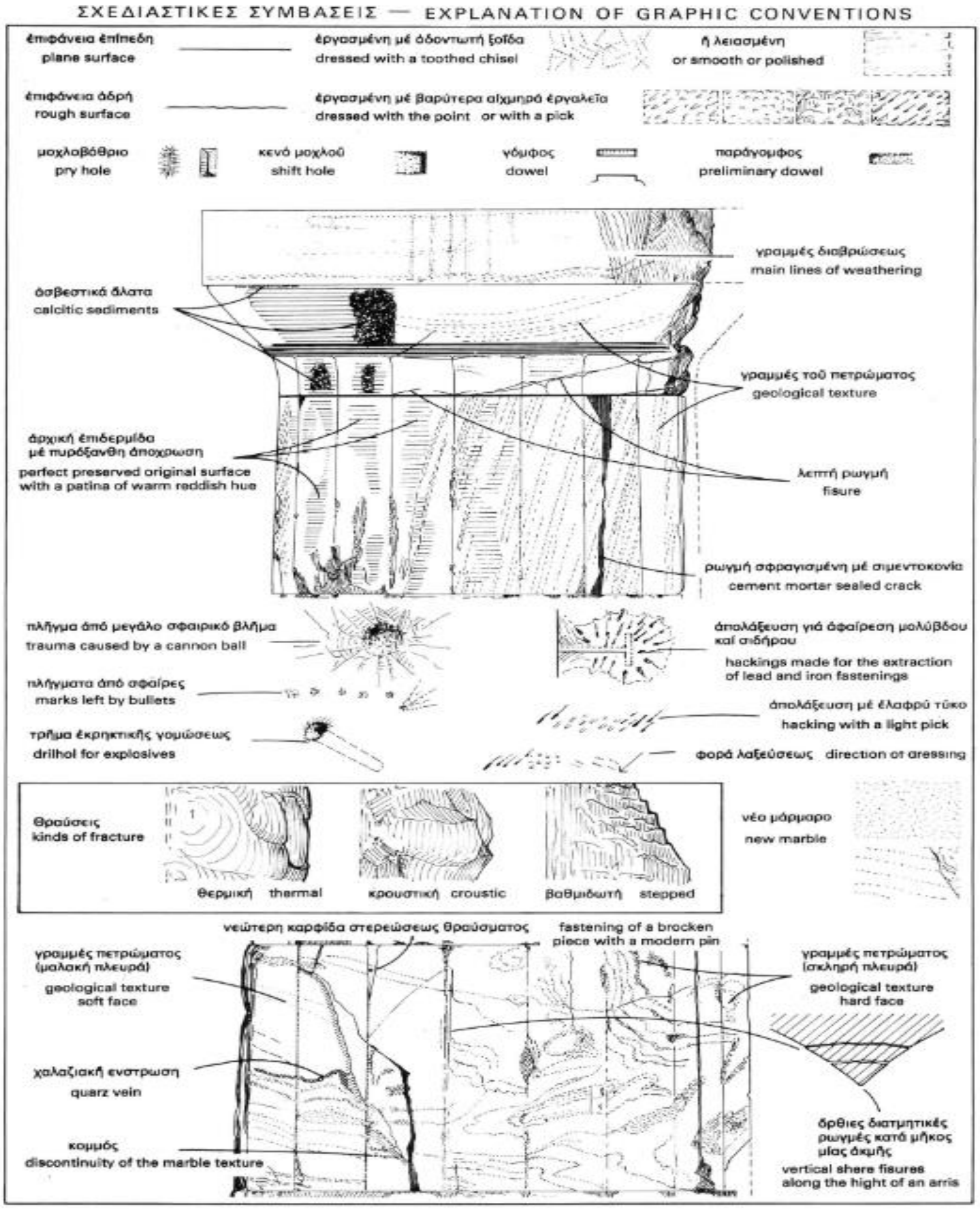



*Figure 59: Explanation of the graphic conventions (Study of the Restoration of the Parthenon, vol. 2a, M. Korres, N. Toganidis, K. Zambas, Th. Skoulikidis, et al., YSMA 1989)*

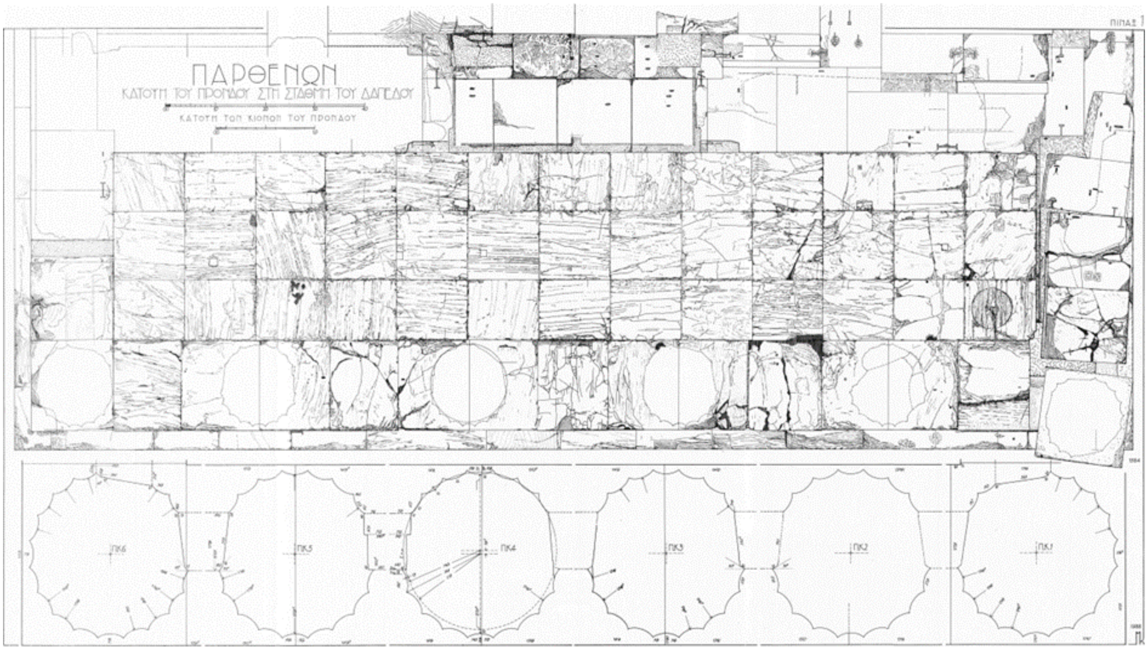



*Figure 60: Plan of Pronaos (Study of the Restoration of the Parthenon, vol. 2a, M. Korres, N. Toganidis, K. Zambas, Th. Skoulikidis, et al., YSMA 1989)*

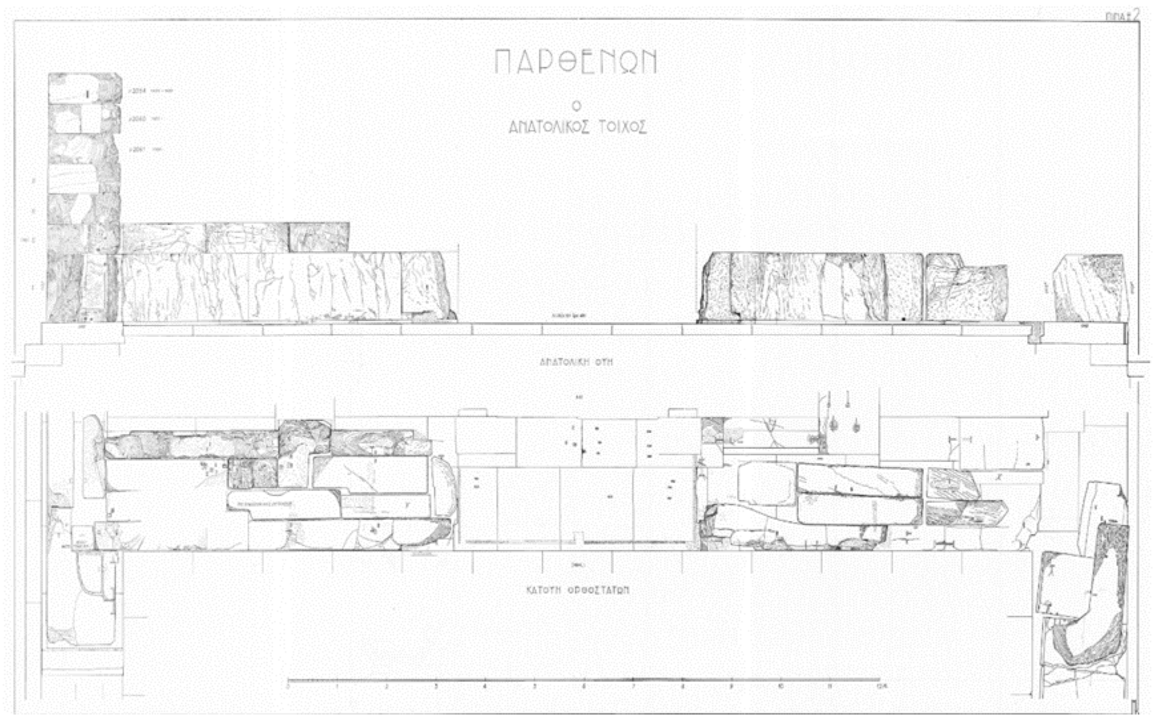



*Figure 61: Side view and plan of the east door wall (Study of the Restoration of the Parthenon, vol. 2a, M. Korres, N. Toganidis, K. Zambas, Th. Skoulikidis, et al., YSMA 1989)*

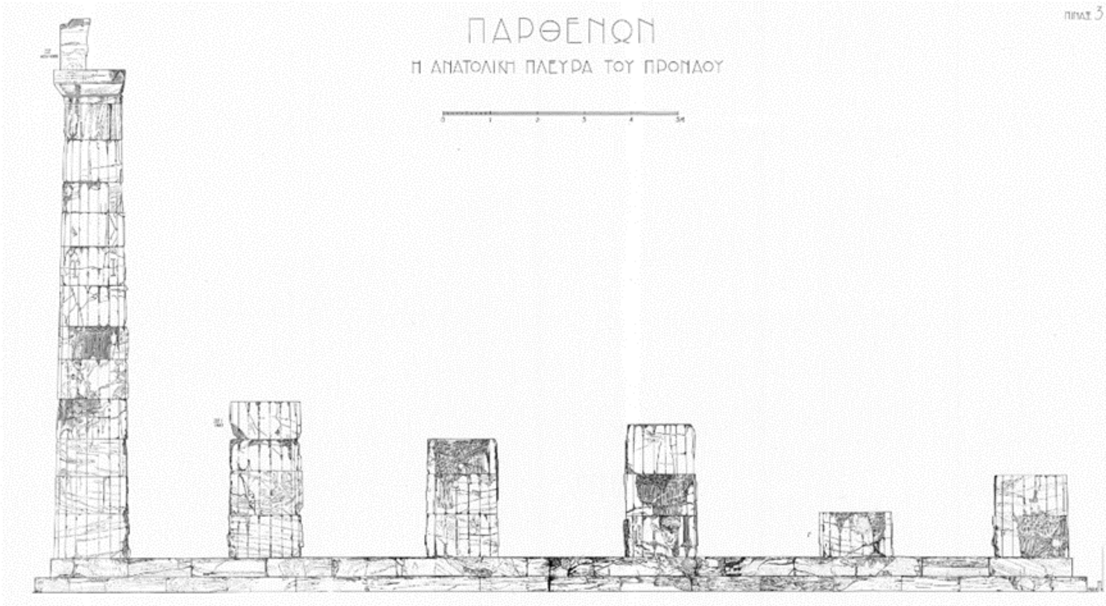



*Figure 62: East side of the Pronaos (Study of the Restoration of the Parthenon, vol. 2a, M. Korres, N. Toganidis, K. Zambas, Th. Skoulikidis, et al., YSMA 1989)*

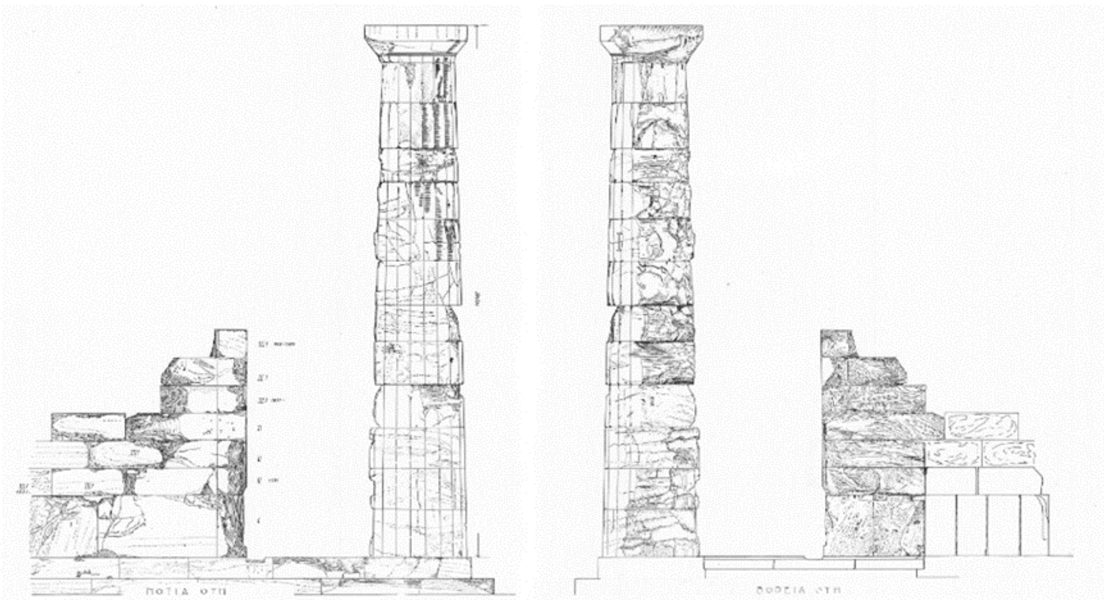


*Figure 63: South side of the Pronaos (Study of the Restoration of the Parthenon, vol. 2a, M. Korres, N. Toganidis, K. Zambas, Th. Skoulikidis, et al., YSMA 1989)*

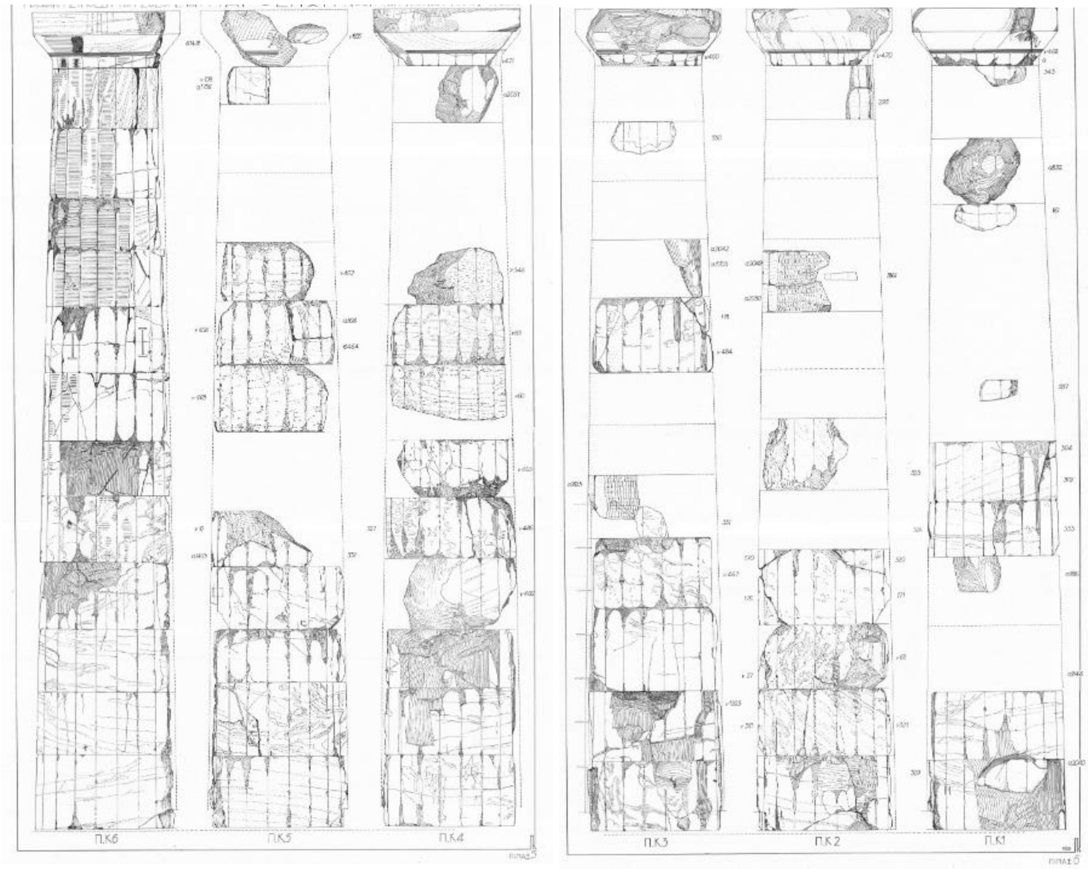


*Figure 64: Graphic representation of the surviving blocks of the columns Π.Κ. 1-6 of Pronaos (Study of the Restoration of the Parthenon, vol. 2a, M. Korres, N. Toganidis, K. Zambas, Th. Skoulikidis, et al., YSMA 1989)*

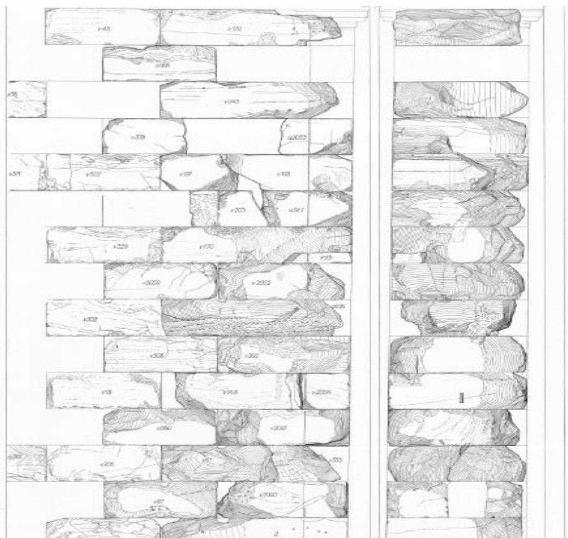


*Figure 65: Graphic composition of the surviving blocks of the SE parastade (parapet). (Study of the Restoration of the Parthenon, vol. 2a, M. Korres, N. Toganidis, K. Zambas, Th. Skoulikidis, et al., YSMA 1989)*

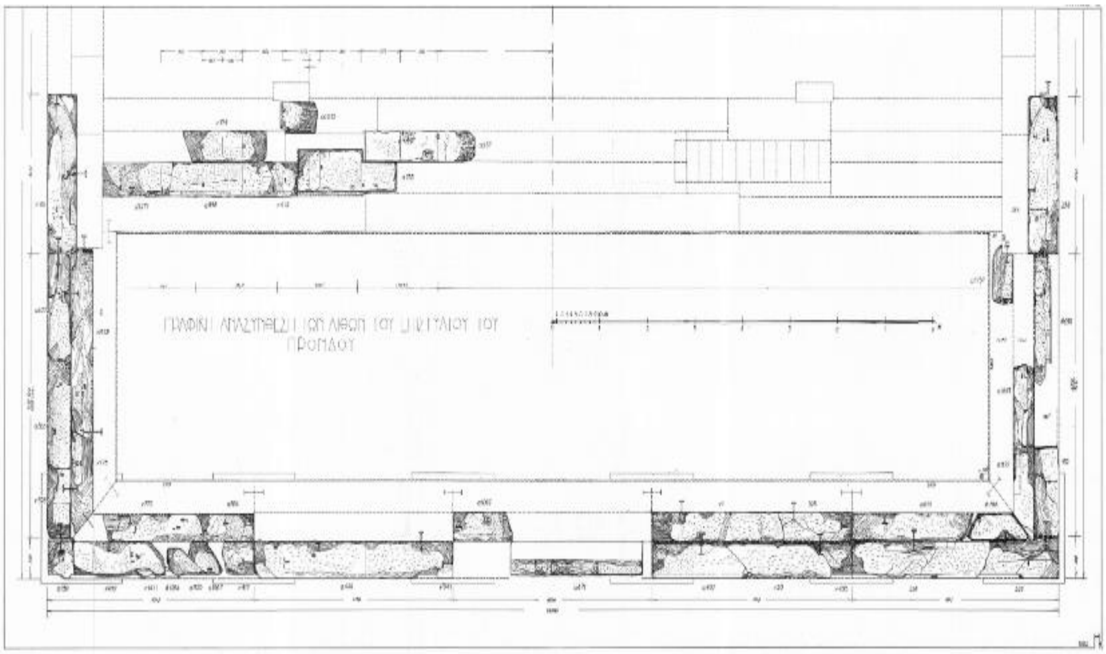


*Figure 66: Graphic composition of the surviving blocks of the epistyles of Pronaos (Study of the Restoration of the Parthenon, vol. 2a, M. Korres, N. Toganidis, K. Zambas, Th. Skoulikidis, et al., YSMA 1989)*

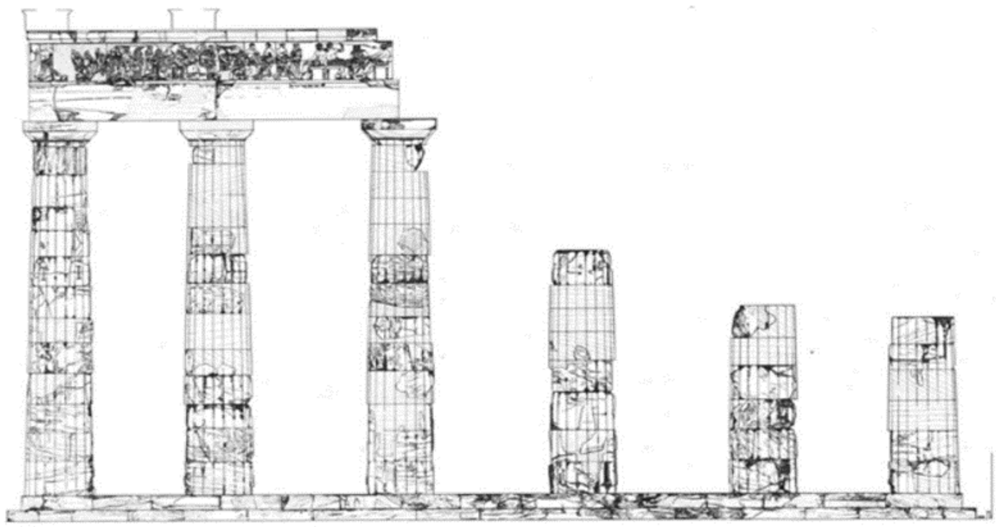


*Figure 67: The second restoration proposal of M. Korres for the Pronaos (Ioannidou and Lembidaki, 2011)*

Figure 68 shows the current state (2021) of Pronaos. It is worth noting that the new sections and the additions added during the restoration were made with Dionysos marble due to the depletion of the ancient marble quarries of Penteli. Dionysos marble has the closest physical and mechanical properties to Pendelian marble and is also used as an experimental material in studies on the mechanical behaviour of the ancient material (Bouras and Eleftheriou, 2018b).

*Figure 68: Current state of Pronaos (2021)*

The sixth column of Pronaos was a case study for a comprehensive study of the failure modes of drum columns and the fracture mechanism, which has been done by Mentzini (included in Bouras and Eleftheriou, 2018b). This selection was made because this column bears the marks of all the types of damage suffered by the monument (earthquakes, fires, bombardment, explosion) and has been restored twice, namely by N. Balanos and by the Acropolis Restoration Service. The drums have undergone a thorough field survey. The cracks and deformations have been studied, recorded and classified. The major conclusion of this study was that there is existing cracking and consequent loss of mass in the drums. This does not appear to be of concern nor does it appear to compromise the stability of the structure. However, it could be dangerous if it was not repaired and restored.

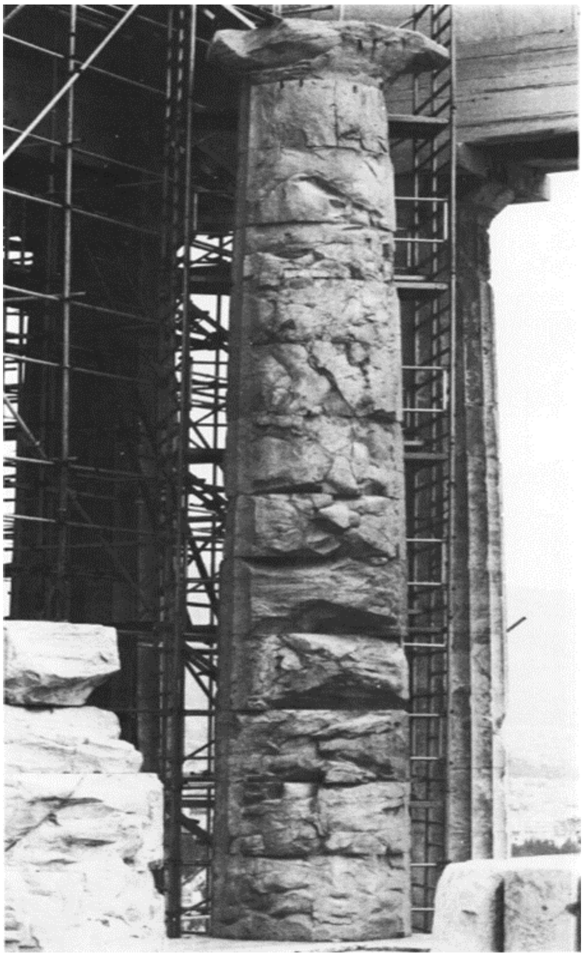


*Figure 69: The sixth column of the Pronaos (Study of the Restoration of the Parthenon, vol. 2a, M. Korres, N. Toganidis, K. Zambas, Th. Skoulikidis, et al., YSMA 1989)*

# 3 NUMERICAL SIMULATIONS

## 3.1 Validation of 3DEC software

The study of the seismic response of modular structures, such as the Acropolis monuments, is an extremely complex and parameter-sensitive problem (Psycharis et al. 2000, Psycharis 2007), to even small changes-perturbations related to the geometry and characteristics of ground motion. Summarizing the conclusions of previous studies, both theoretical and experimental, we can mention that that rocking is the dominant form of oscillation while the sliding of the column drums is usually limited to the upper part of the columns, where significant accelerations capable of overcoming frictional forces are developed. The four forms of rocking oscillations of a two-solid body system for plane motion are given below (Fig. 70). Note that the number of possible modes of rocking increases exponentially with the number of column drums. Also, for motion in space and drums of circular cross-section, as are practically the drums of columns, rotational motion (wobbling) also occurs.

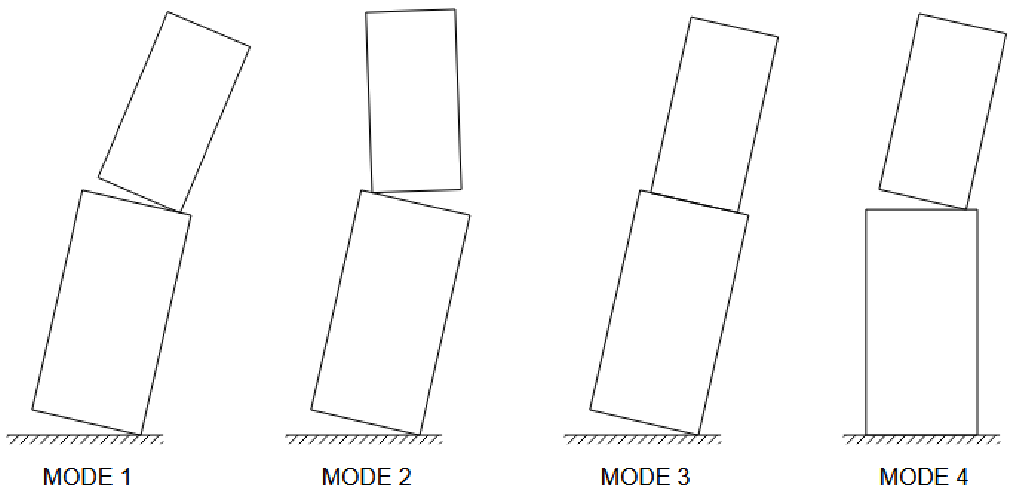



*Figure 70: The four modes of oscillation of a two-solid body system (Psycharis, 1990)*

In Psycharis' report on the selection of suitable accelerographs for dynamic analyses of the Acropolis monuments (2015), it is noted that modular structures do not have natural (eigen)-modes in the classical sense. The period of free oscillations of a rocking solid body depends on the amplitude of the oscillation and decreases with the number of impacts occurring at the base.

The non-linearity of the problem lies in the fact that, during a strong earthquake, the response constantly alternates between the different modes of oscillation. Each form of oscillation is governed by different equations of motion. As a result, a structure may overturn for a particular seismic excitation and not overturn for the same excitation magnified by a factor greater than unity (Psycharis, 2015).

At the same time, the aforementioned sensitivity of the response has also been verified experimentally, since repetition of the same experiment gave quite different results in some cases (Mouzakis et al. 2002, Dasiou et al. 2009a). In analytical solutions, the sensitivity of the behaviour is also evident since insignificant changes in the parameters can cause substantial changes in the response. The significant out-of-plane motion that usually occurs for purely planar excitation is another effect of sensitivity. In some experiments, the out-of-plane motion was similar in magnitude to the in-plane deformation of the column drums in the plane of the excitation.

Following all this, it becomes clear that the calculation of the response of such structures to seismic excitations can only be done using appropriate software programs, which can take into account the rocking and sliding of the structural elements. Previous studies and comparisons with experimental results have shown that the Distinct Element Method (DEM) can predict their response with satisfactory accuracy, subject, of course, to the use of the correct parameters in the joints and the selection of appropriate seismic excitations. The distinct (or discrete) element method proposed by Cundall in the 1970s in the framework of rock mechanics and later extended to three-dimensional problems has been found to be the appropriate methodology for the analysis of stone masonry structures, particularly those consisting of drum columns and architraves (epistyles), such as classical temples (block models).

The development of the method led to the 3DEC code of the Itasca Consulting Group, Inc., which is also used in the present work for the simulation and analysis of columns and colonnades.

The discrete element method uses an explicit algorithm for solving the equations of motion of the blocks, taking into account the large displacements and rotations (Papantonopoulos et al.); is iterative and performs the calculation of the body motions taking into account the forces developed at the interfaces at each step. It differs from the finite element and finite difference methods and can be described as hybrid because, in general, it combines elements of both continuous and discontinuous behaviour. Codes based on the two aforementioned methods have weaknesses in solving such problems, requiring immediate calculation of new contacts and conditions at each iterative step, and responding to more complex dynamic loadings, are more unstable in cases of large movements and, most importantly, have very high computational costs. In contrast, numerical simulation by the discrete element method is considered, as already mentioned, for example, more suitable for dynamic problems, non-linear problems, wave propagation problems and large displacement problems.

The bodies are considered either as rigid or deformable pieces interacting at their contact surfaces allowing for shear motion, rotation of the pieces and complete separation – detachment of the pieces. The mechanical behaviour of the joints is simulated by means of the generalised Mohr-Coulomb model. The whole theoretical background including the equations applied to describe the motion of the bodies is given by the program guide in the section "3DEC Theory and Background" (http://docs.itascacg.com/3dec700/3dec/docproject/source/theory/theory.html?node2046).

An early use of the discrete element method is its application to drum columns by Papastamatiou and Psycharis; the method has also been used in the study of the seismic behaviour of arches and other types of stone masonry structures.

The choice of the 3DEC code has been validated (Papantonopoulos et al. 2002, Dasiou et al. 2009b) as there is evidence from numerical analyses in combination with experiments carried out at the Laboratory for Earthquake Engineering of the NTUA, according to which this code predicts with satisfactory accuracy the response of such modular structures. In fact, it is also mentioned in the literature (Study for the structural restoration of the northern side of the Parthenon, K. Zambas, YSMA 2002, p. 48) that as early as 1996, within the framework of the European Union's "Environment" programme, numerical investigations of the seismic behaviour of columns were carried out using the 3DEC code, which were subsequently verified by experiments in the seismic table of the NTUA on a marble model of a single column of the Parthenon pronaos and a colonnade of three Parthenon columns at a scale of 1:3 (Mouzakis et al. 2002, Dasiou et al. 2009a). The comparison of the results from the numerical simulation and from the experiment showed a satisfactory correlation between them, which allows the use of 3DEC to study the behaviour of ancient columns under seismic excitation despite the complexity and high sensitivity to changes of such systems.

Here, for this investigation, the version 5.20 of 3DEC is used.

## 3.2 The different models of the colonnades

### 3.2.1 Single column

The column chosen in order to investigate its seismic behaviour is the restored (6th or south-eastern) column of the pronaos (Fig. 69). The column is first simulated without damage ("intact model") and then also with damage ("damaged model"). The geometric data were obtained exclusively by graphical measurements on the drawings as presented in the literature, in particular in the Study of the Restoration of the Parthenon, Volume 2b, M. Korres, Hellenic Ministry of Culture, YSMA, Athens 1989 (Figure 62, 71). The scale for the graphical measurements is obtained by correlating the measured values with the total height of the column, given in the literature as 10.081 m, and the maximum bottom diameter, which is measured as 1.649 m. The column consists of 12 column drums, each of which is simulated as a "poly drum" with different lower and upper diameters (Figures 72), and the column capital which is simulated as a single piece (Figure 73). In addition, a rectangular base (dimensions 1.724 x 1.876 m) has been placed below the lower column drum.

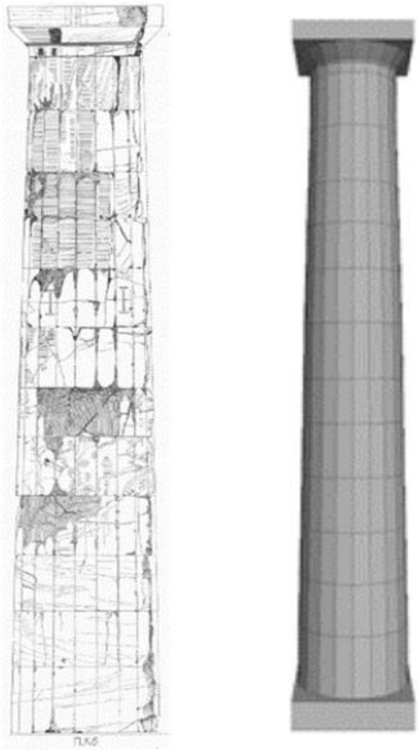


*Figure 71: The 6th column of the pronaos (with damages) as given in the literature (Study of the Restoration of the Parthenon, vol.2b, M. Korres, YSMA, Athens 1989) & Simulation of the 6th column of the pronaos in 3DEC without damages*

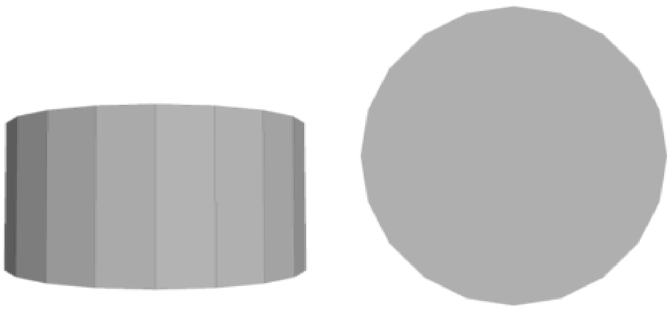


*Figure 72: Side view and top view of a typical non-damaged column drum (poly drum) in 3DEC*

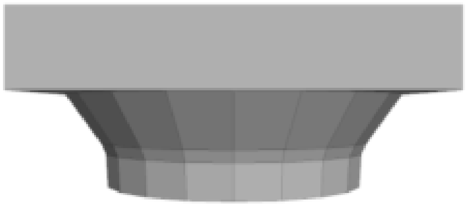


*Figure 73: Simulation of the column capital as a single block, without damages, in 3DEC*

In order to apply the material losses to simulate the damaged model, the column drums are simulated as a “poly prism” using 16 principal points on the lower and upper surfaces (Figure 74) to which additional points, different numbers as appropriate, are added to model the selected damages. An attempt has been made to ensure that the applied damages approximate as closely as possible to some of those shown in the drawing in Figure 71 (Korres, 1989). Figures 74 to 92 show the damages of each individual section of the column in comparison with the intact one so that it can be made visible and understood.

The geometry code files for the intact and damaged model, respectively, are provided in their entirety in Appendix 1, as they are included in the code files for intact and damaged colonnades discussed below.

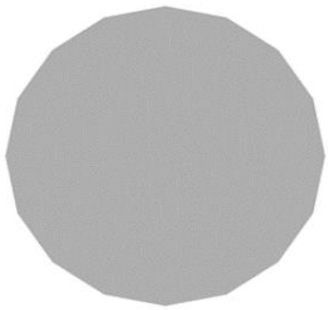


*Figure 74: View of a typical column drum as a poly prism with 16 points in 3DEC without damages*

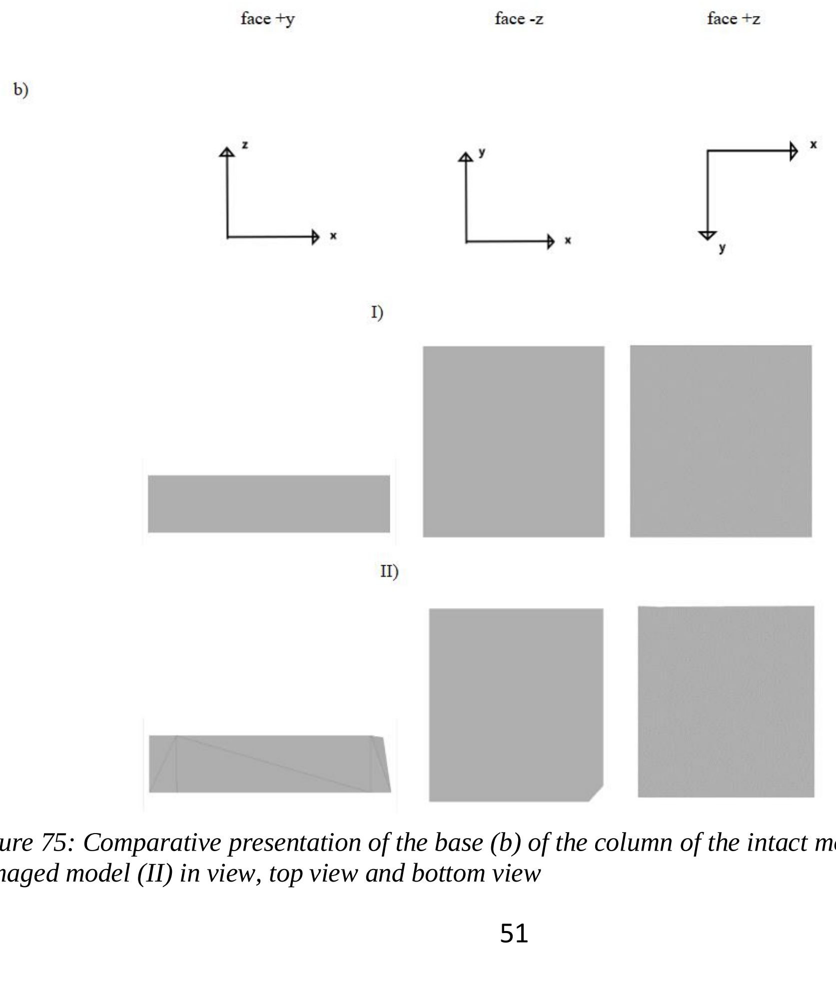



*Figure 75: Comparative presentation of the base (b) of the column of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

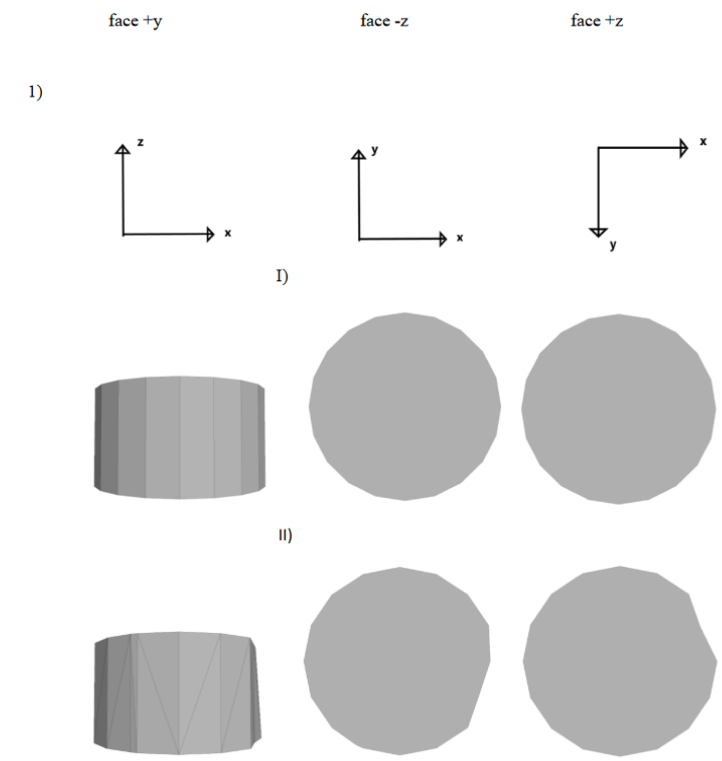



*Figure 76: Comparative presentation of the 1st column drum of the column of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

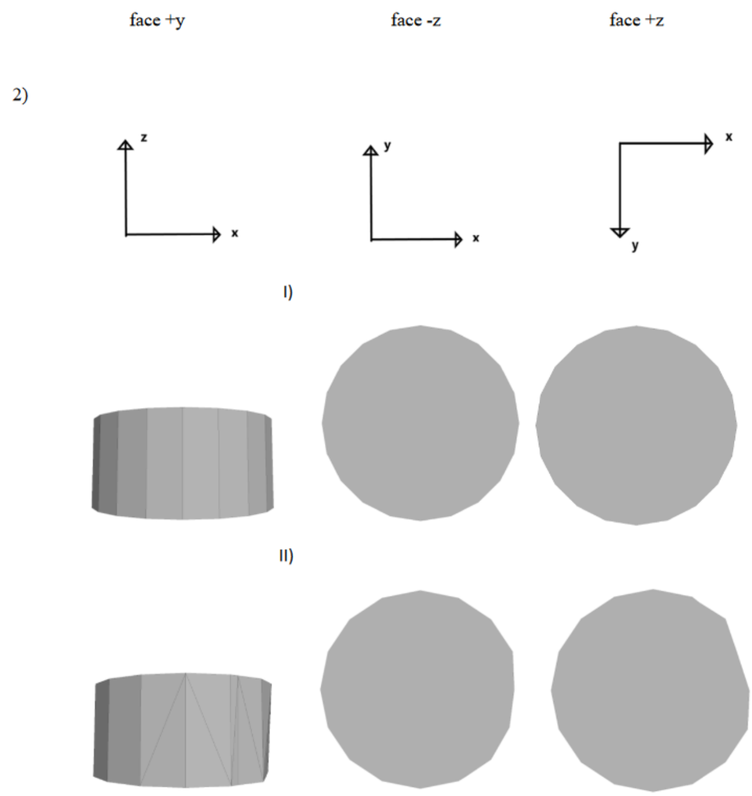



*Figure 77: Comparative presentation of the 2nd column drum of the column of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

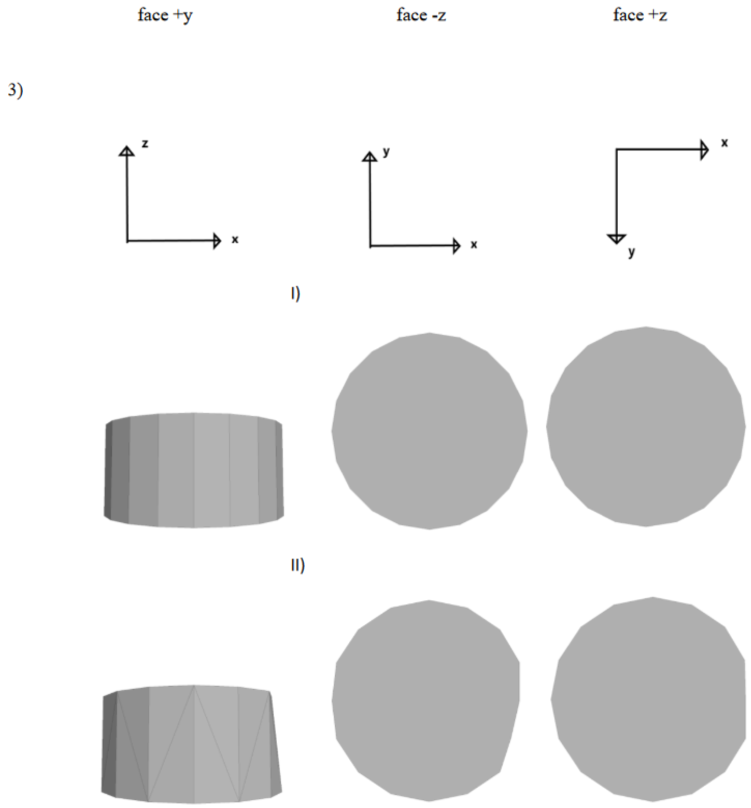



*Figure 78: Comparative presentation of the 3rd column drum of the column of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

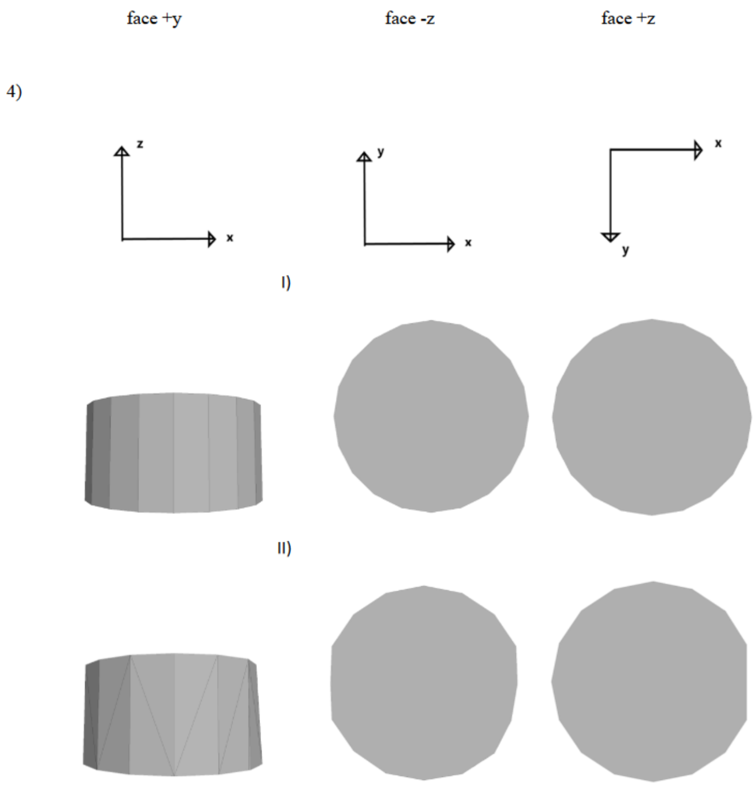



*Figure 79: Comparative presentation of the 4th column drum of the column of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

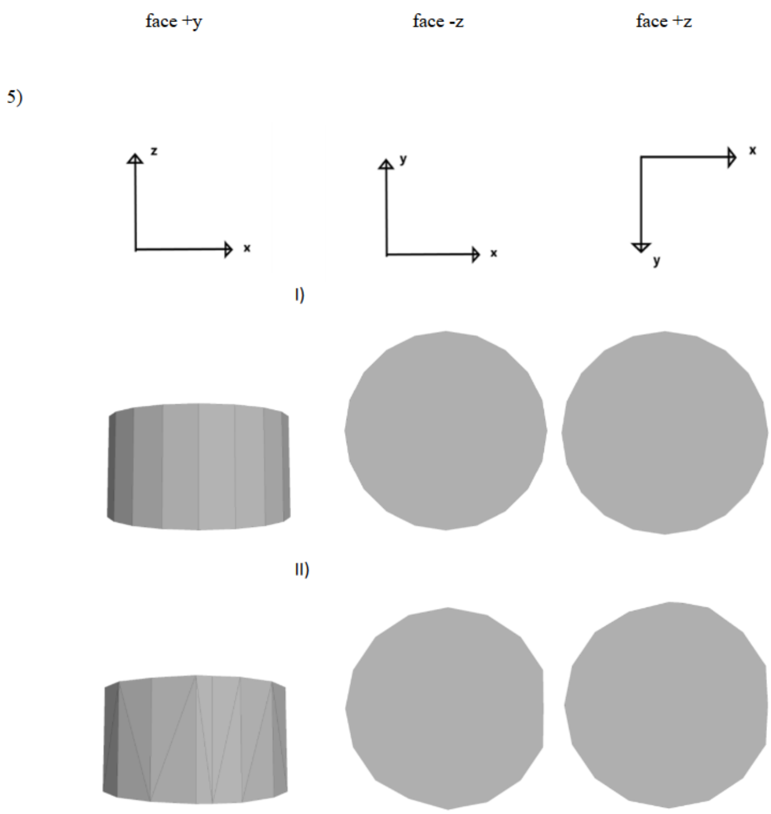



*Figure 80: Comparative presentation of the 5th column drum of the column of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

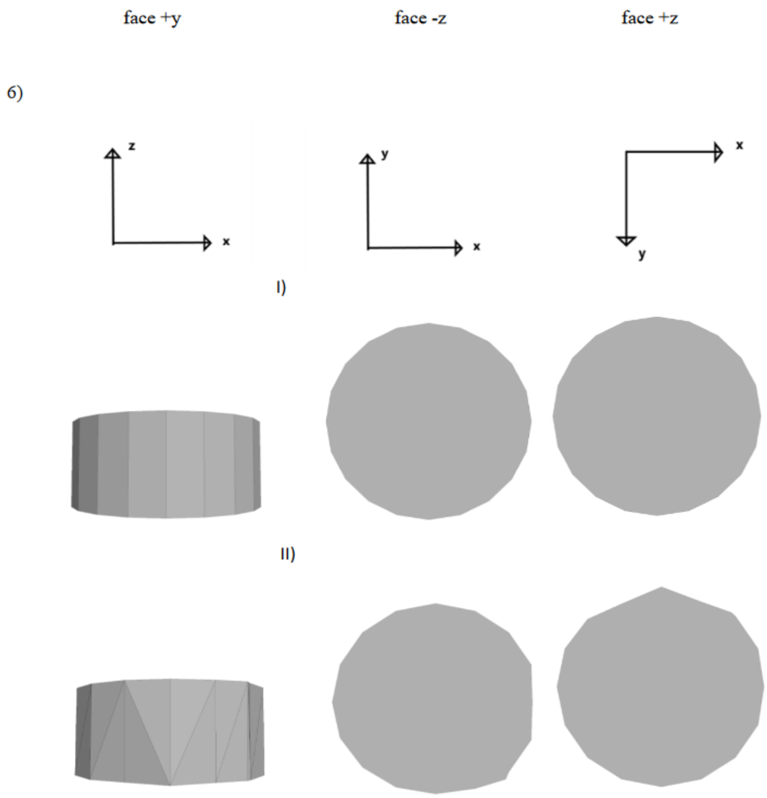



*Figure 81: Comparative presentation of the 6th column drum of the column of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

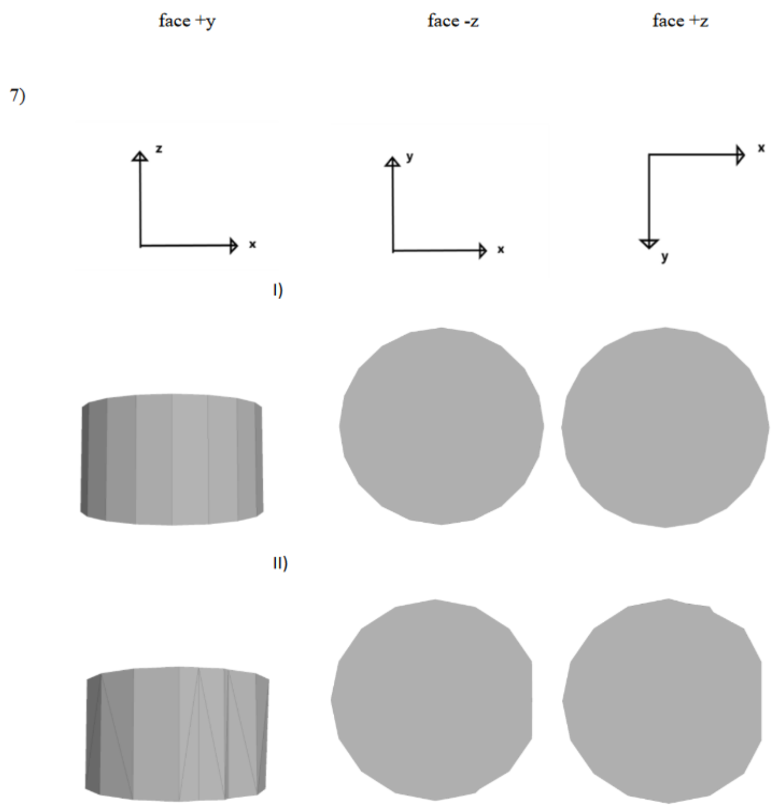



*Figure 82: Comparative presentation of the 7th column drum of the column of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

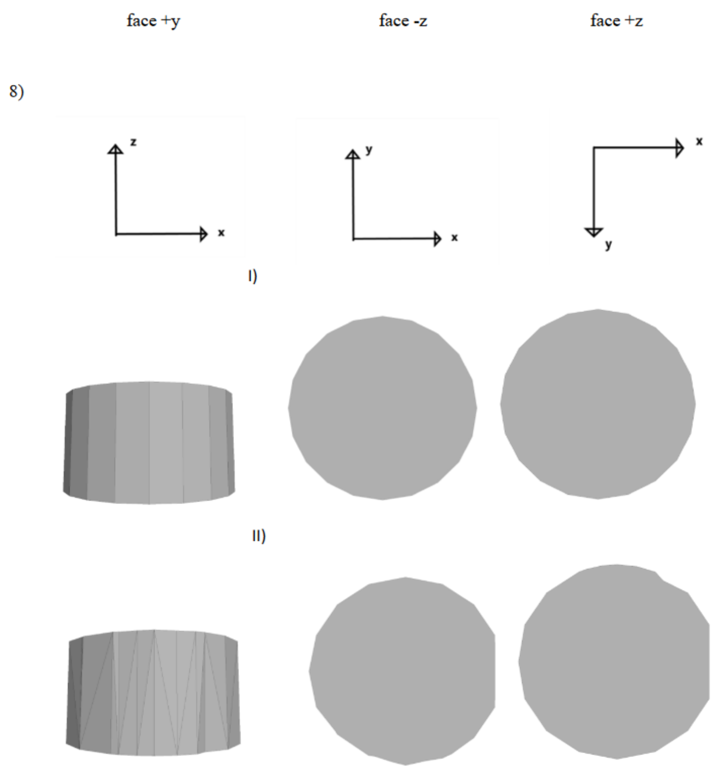



*Figure 83: Comparative presentation of the 8th column drum of the column of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

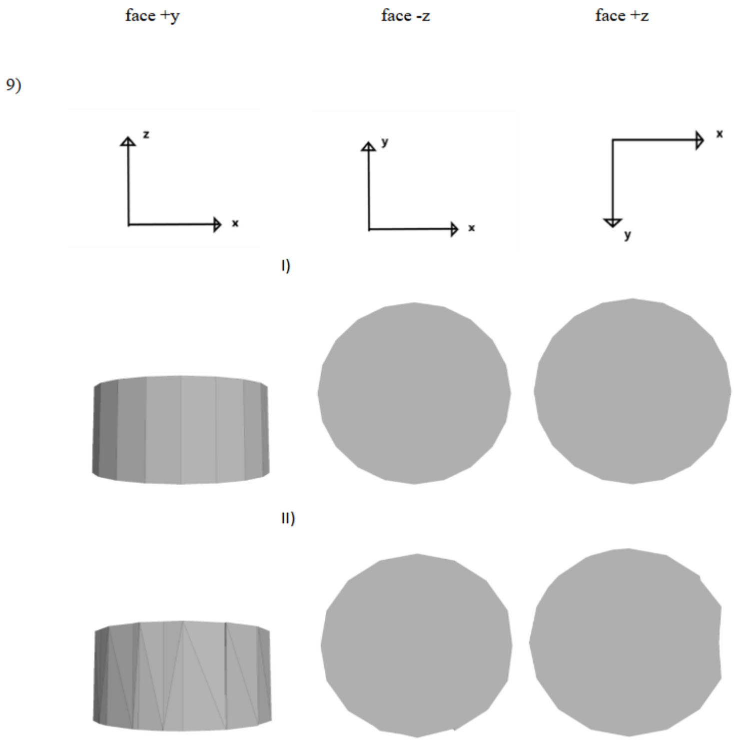



*Figure 84: Comparative presentation of the 9th column drum of the column of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

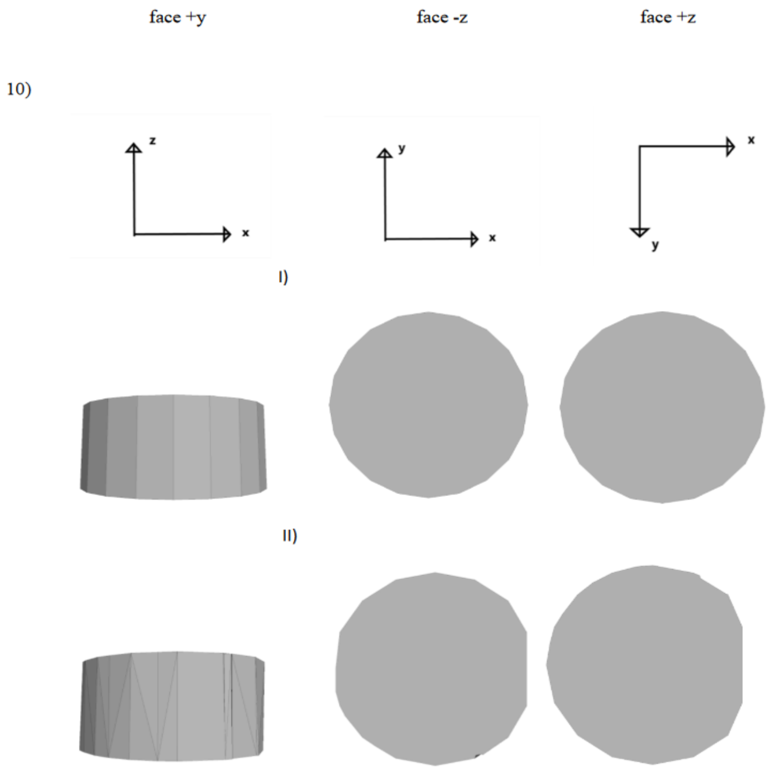



*Figure 85: Comparative presentation of the 10th column drum of the column of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

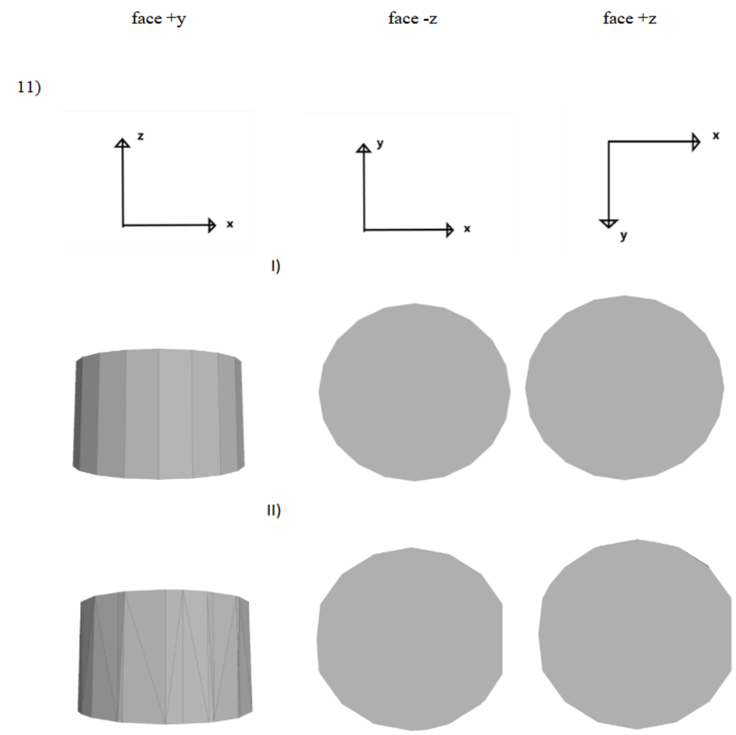



*Figure 86: Comparative presentation of the 11th column drum of the column of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

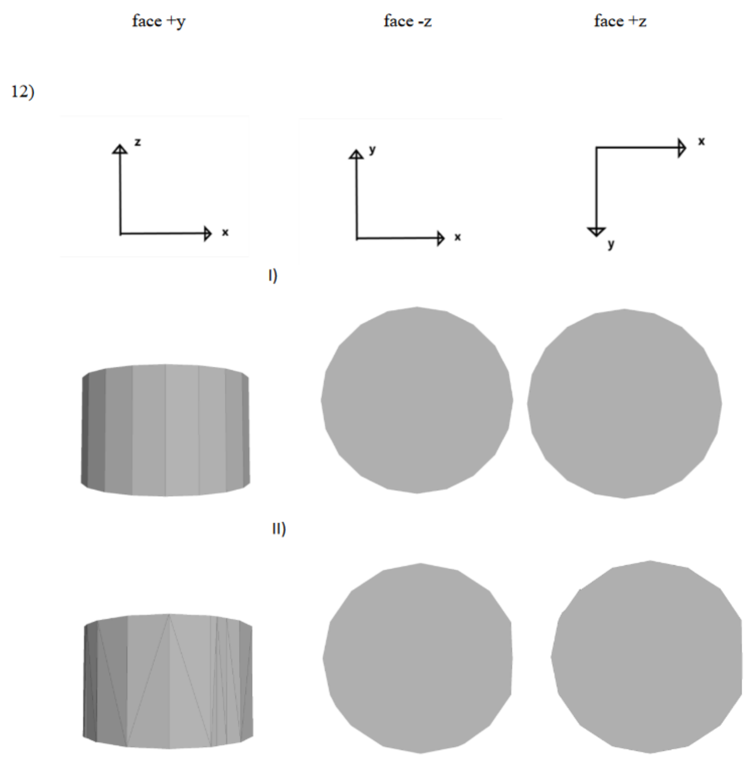



*Figure 87: Comparative presentation of the 12th column drum of the column of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

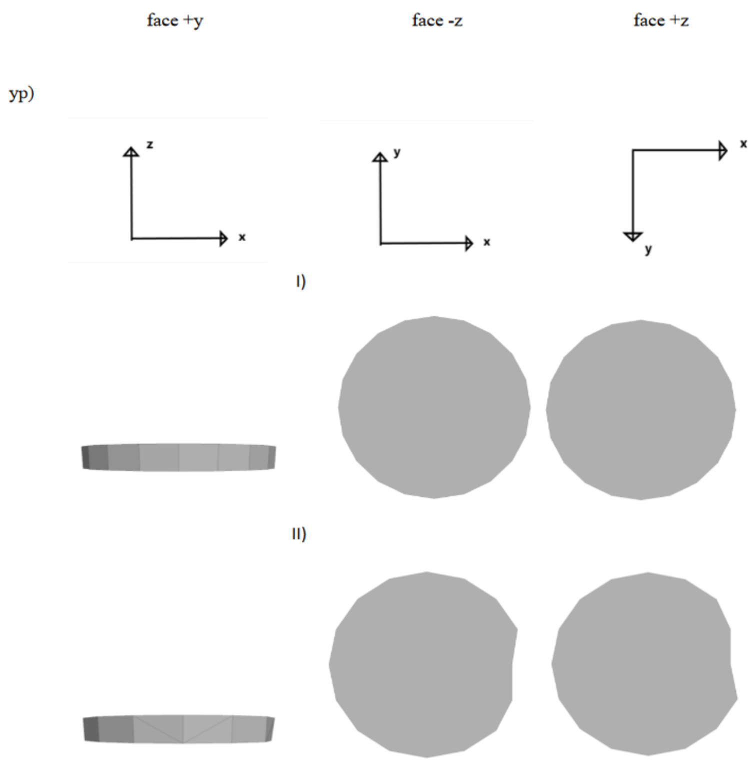



*Figure 88: Comparative presentation of the sub-capital of the column of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

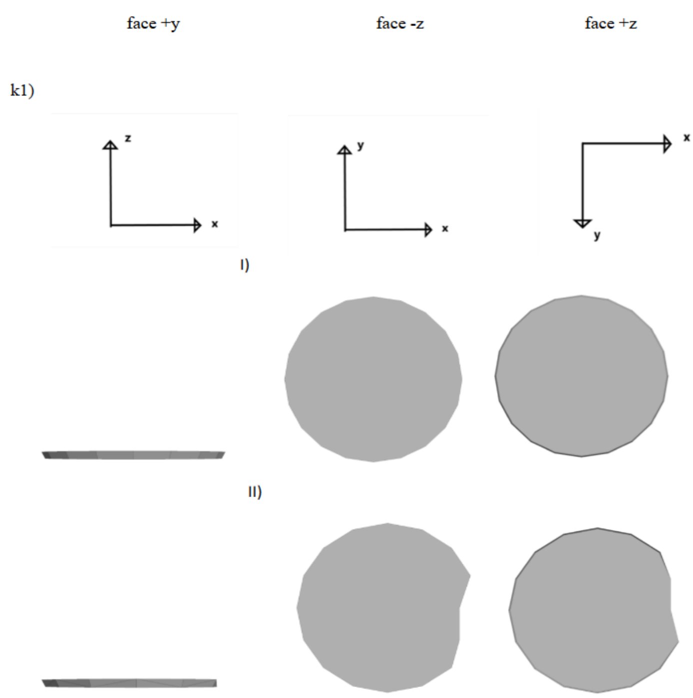



*Figure 89: Comparative presentation of part of the column capital of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

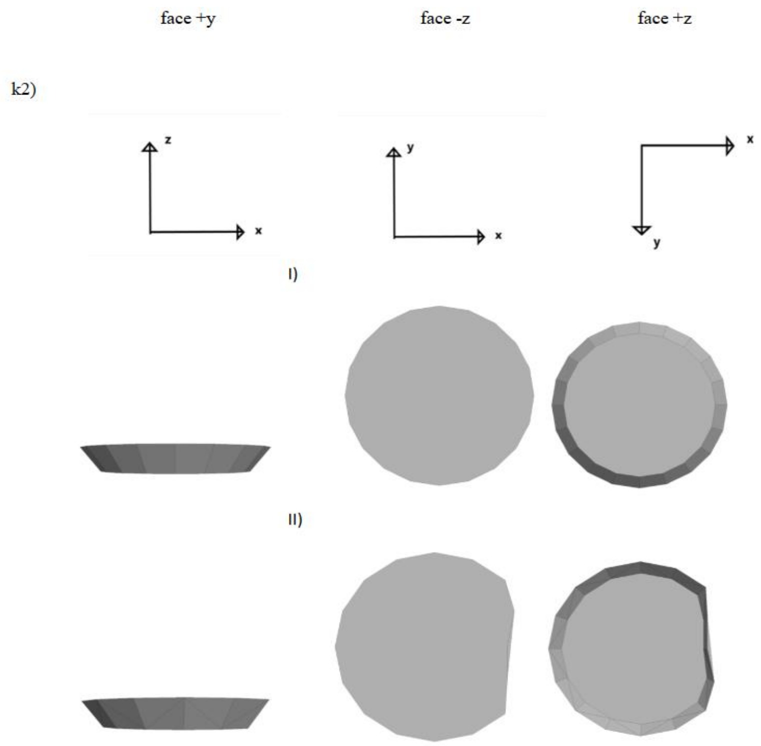



*Figure 90: Comparative presentation of part of the column capital of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

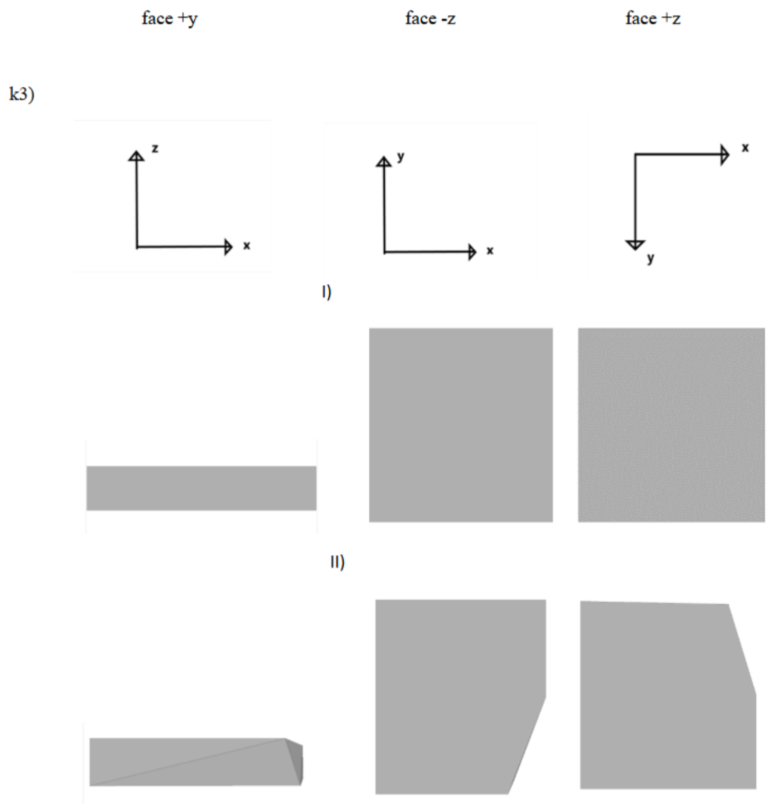



*Figure 91: Comparative presentation of part of the column capital of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

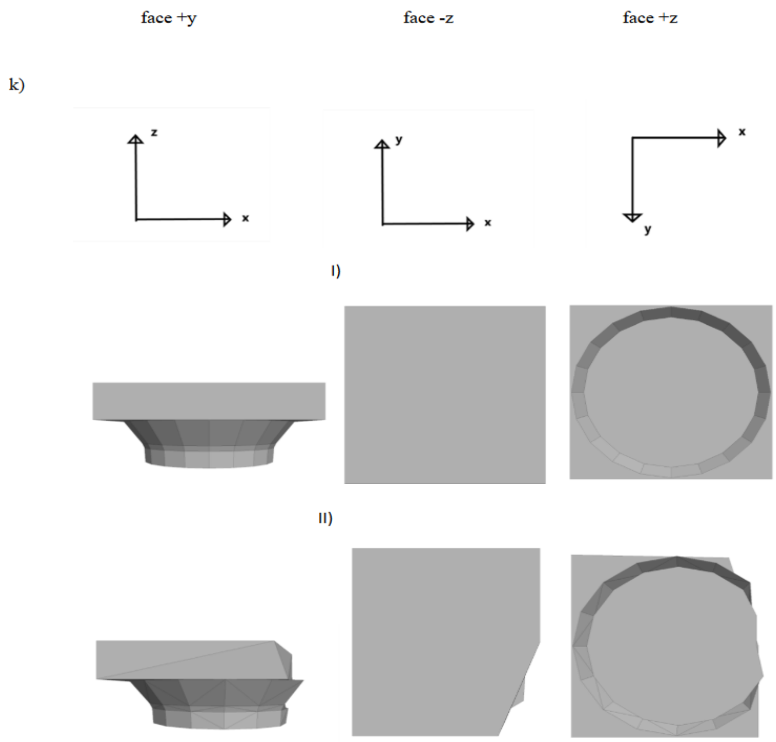



*Figure 92: Comparative presentation of the whole column capital of the intact model (I) and of the damaged model (II) in view, top view and bottom view*

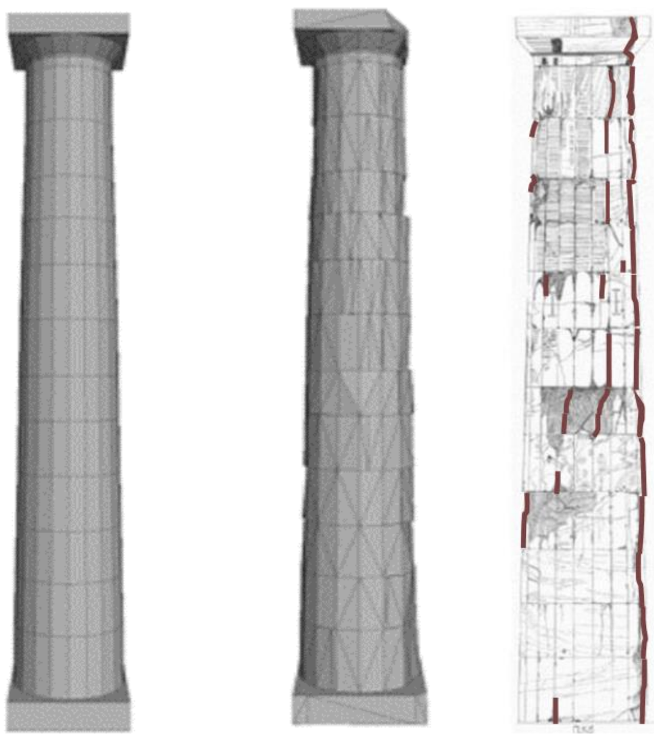


*Figure 93: Comparative presentation of the column of the intact model (I) and the damaged, according to the markings in the drawing on the right, model (II) in 3DEC*

### 3.2.2 Colonnade in a line arrangement

In this case, a colonnade consisting of three columns in a line arrangement and the respective epistyle (architrave) is modelled (Fig. 94-95). The axes of the columns are 4 m apart. The epistyle is simulated not as a single block but as three zones and analogous to the geometry presented in Figure 19 and given again below; giving a height of 1.35, a width of each block equal to the distance between the column axes, i.e., 4m, and thicknesses of 0.426, 0.491 and 0.443m, from the outer to the inner zone of the epistyle, respectively (Fig. 96-97).

Initially, the colonnade is simulated intact (without damages) following exactly the same geometry for the three columns, as noted for the intact single column in the previous section, but using "poly prism" in any case.

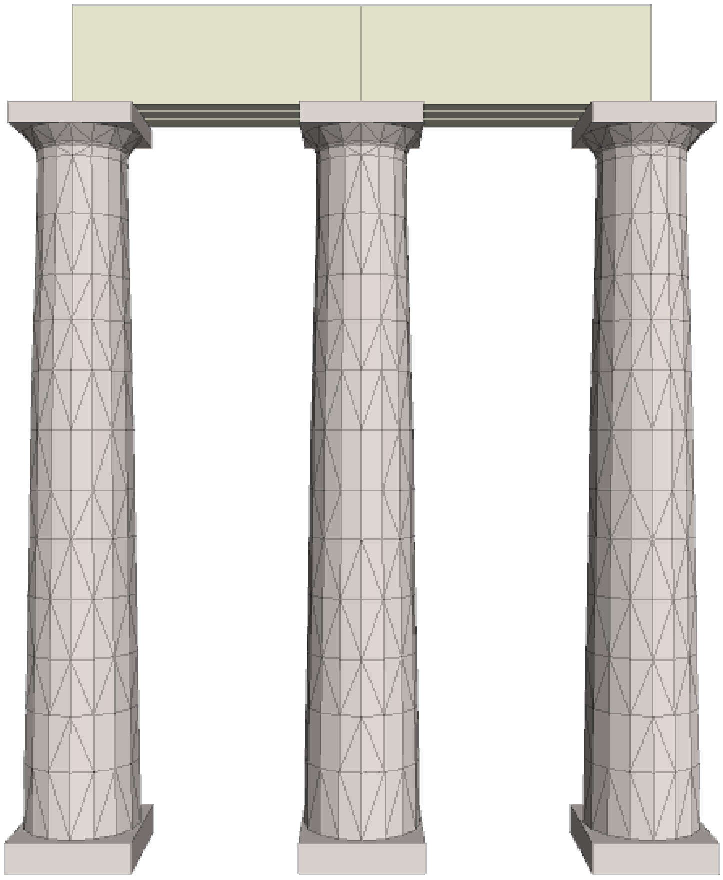


*Figure 94: Simulation of intact 3-column colonnade in a line arrangement with epistyles (architraves) in 3DEC*

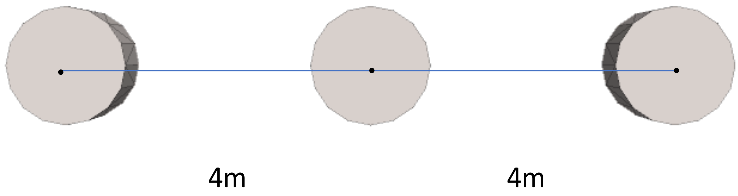



*Figure 95: Top view of column drums of the intact 3-column colonnade in a line arrangement in 3DEC*


*Figure 96: Top view of the 3-zone epistyle of the colonnade in a line arrangement in 3DEC*

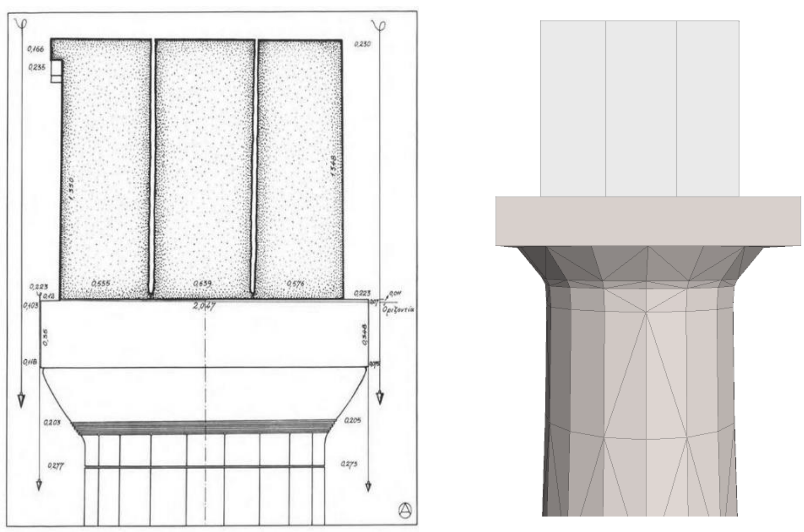


*Figure 97: (left) Section of an epistyle of the Parthenon, (right) View of the analogically dimensioned epistyle in 3DEC*

The same colonnade is then tested by applying damages. The central (middle) column is taken to be the column of the previous section, i.e., the SE column of the Pronaos with the damages already noted, while for the other two columns a random, same distribution of damages was assumed for both of them (Fig.98). Specifically, the 2$^{nd}$ and 7$^{th}$ column drums were considered intact, as well as the rectangular base, while, in the others, damages were considered, from 1 to 3 in number; i.e., there are indentations ranging from 0.015 to 0.200 m. As for the epistyle, it is considered intact (without any damage). The Figures 99-112 show in detail every drum of the colonnade with the damages that were applied.

Also, the code files for the geometry of the intact and damaged colonnade in a line arrangement are available in Appendix 1.

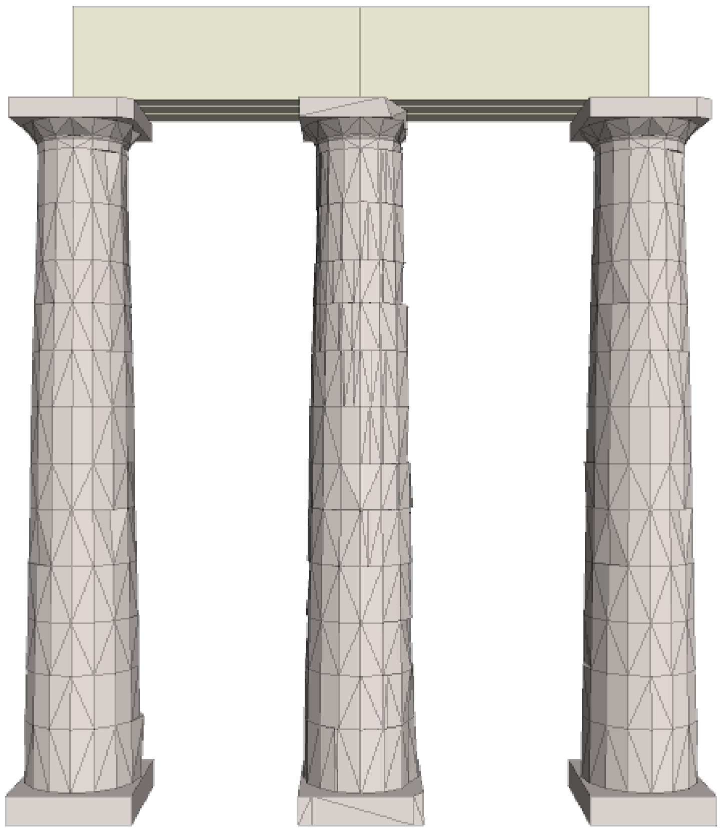


*Figure 98: Simulation of the damaged 3-column colonnade in a line arrangement with epistyles (architraves) in 3DEC*

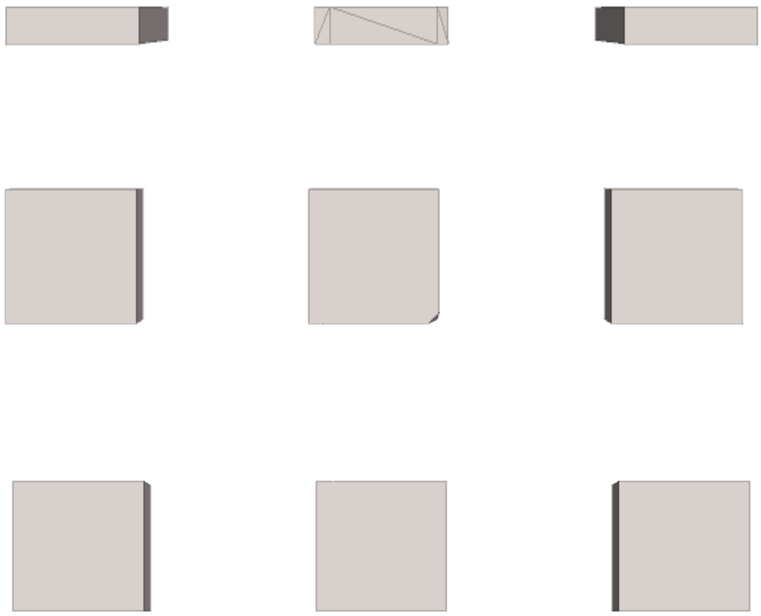


*Figure 99: Presentation of the rectangular base of the 3-column colonnade with damages, simulated in 3DEC, in view, top view and bottom view*

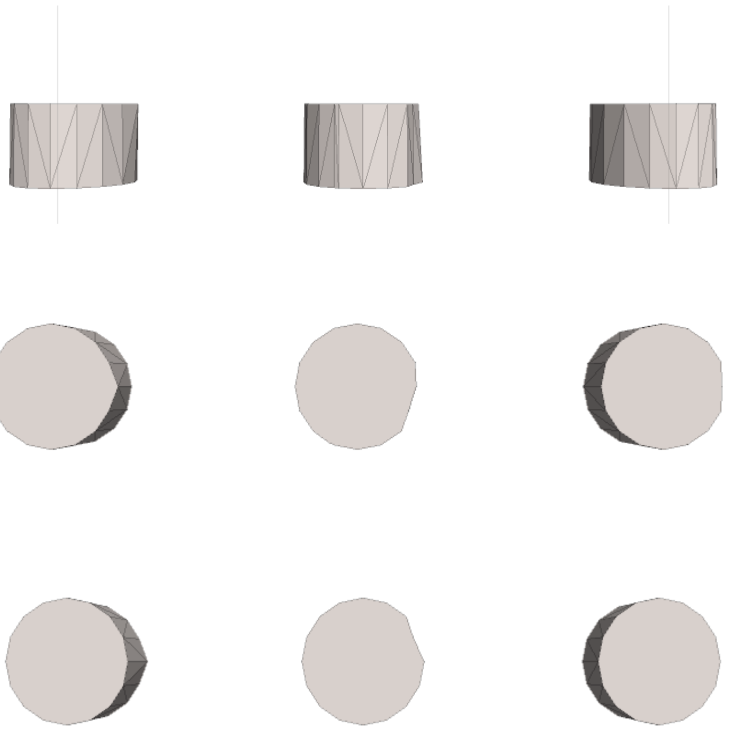


*Figure 100: Presentation of the 1st column drum of the 3-column colonnade with damages, simulated in 3DEC, in view, top view and bottom view*

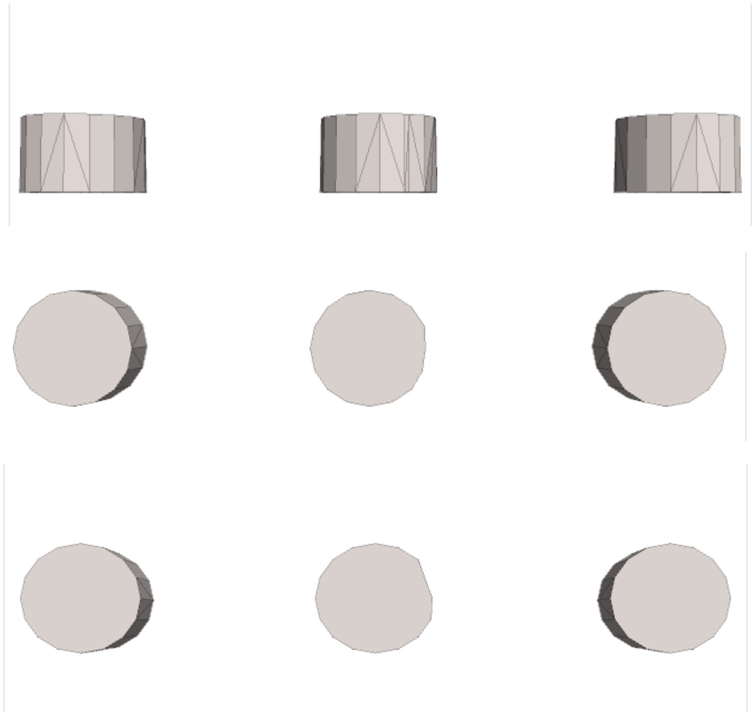


*Figure 101: Presentation of the 2nd column drum of the 3-column colonnade with damages, simulated in 3DEC, in view, top view and bottom view*

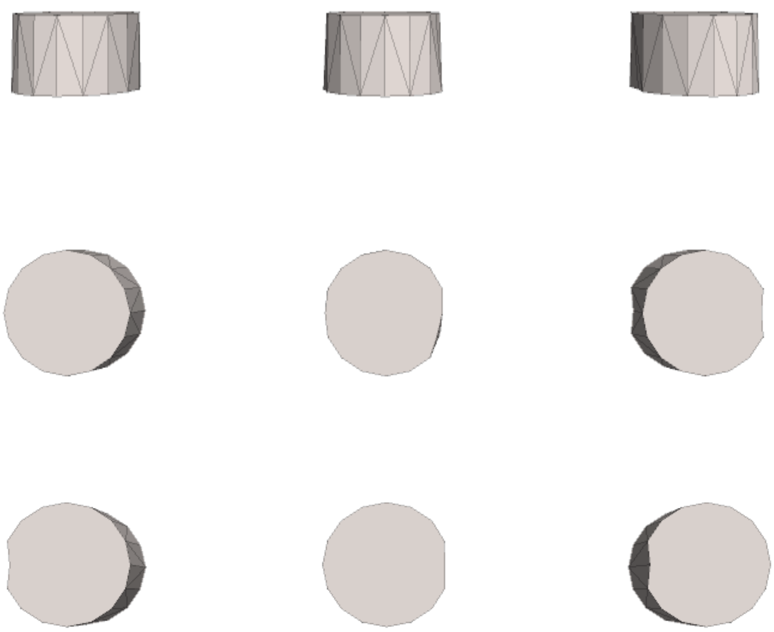


*Figure 102: Presentation of the 3rd column drum of the 3-column colonnade with damages, simulated in 3DEC, in view, top view and bottom view*

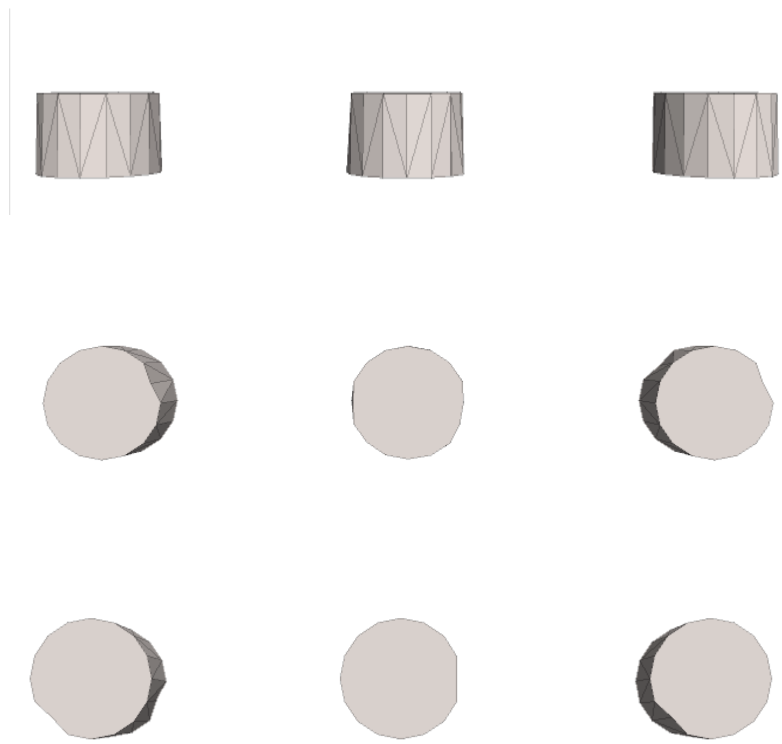


*Figure 103: Presentation of the $4^{th}$ column drum of the 3-column colonnade with damages, simulated in 3DEC, in view, top view and bottom view*

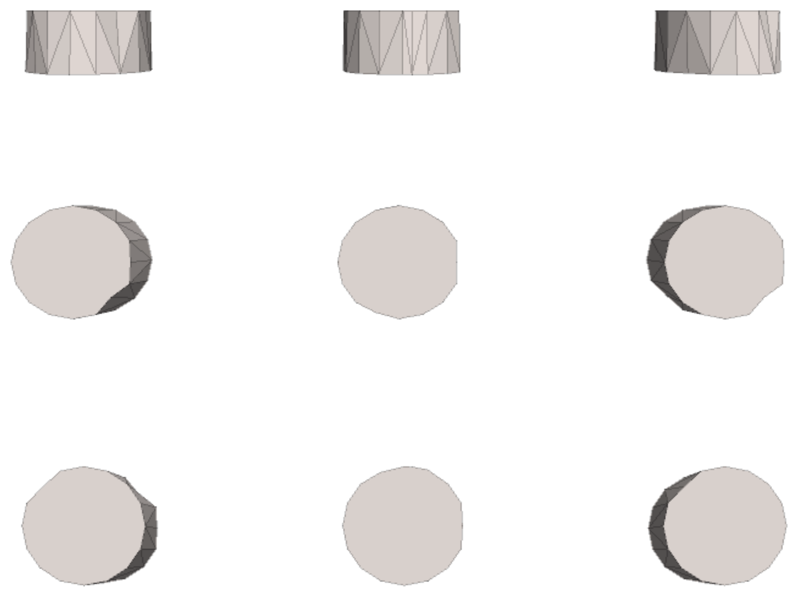


*Figure 104: Presentation of the $5^{th}$ column drum of the 3-column colonnade with damages, simulated in 3DEC, in view, top view and bottom view*

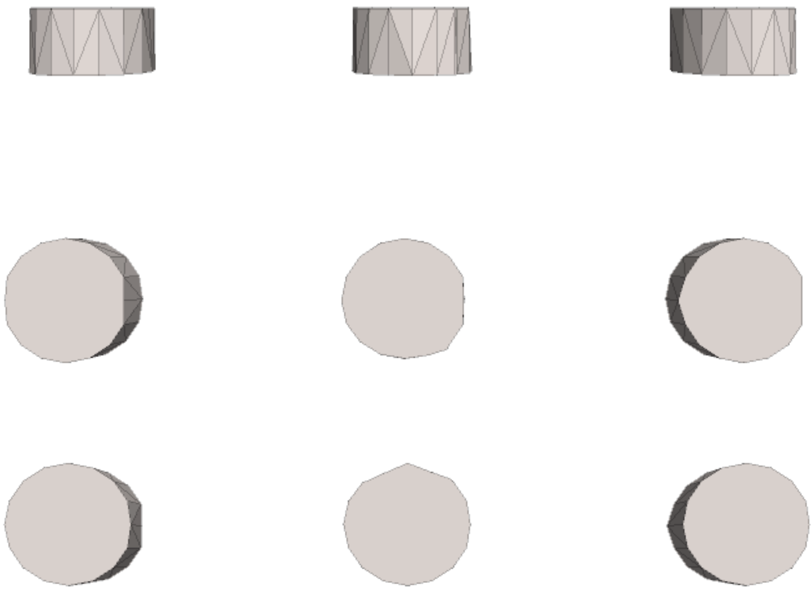


*Figure 105: Presentation of the 6th column drum of the 3-column colonnade with damages, simulated in 3DEC, in view, top view and bottom view*

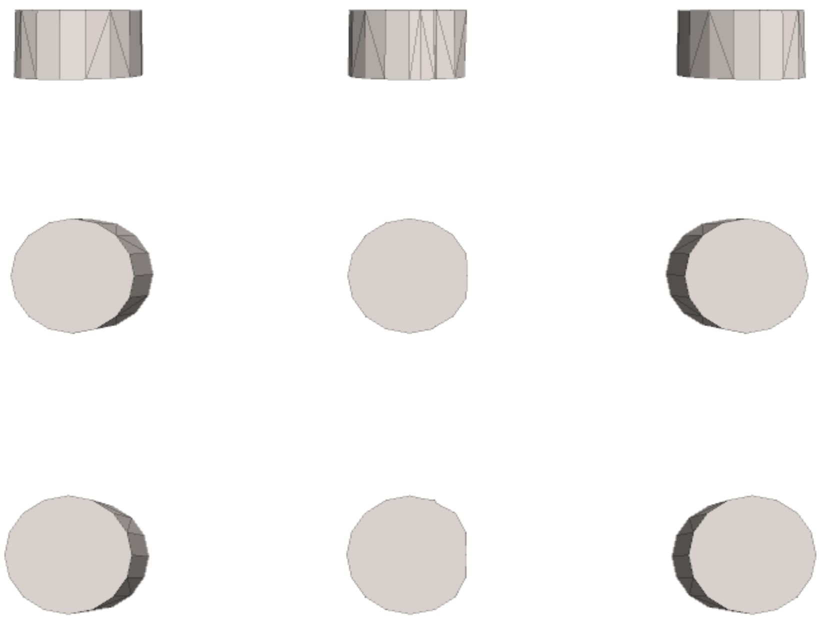


*Figure 106: Presentation of the 7th column drum of the 3-column colonnade with damages, simulated in 3DEC, in view, top view and bottom view*

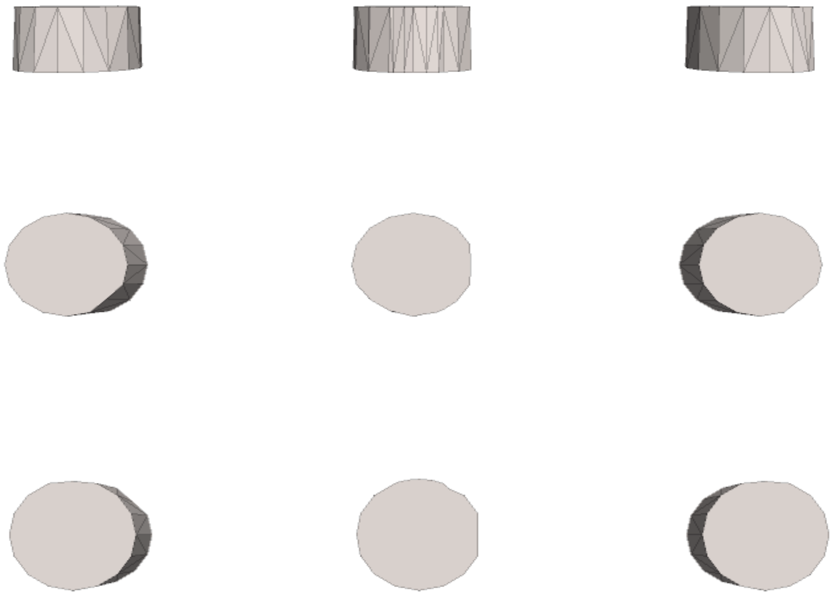


*Figure 107: Presentation of the 8th column drum of the 3-column colonnade with damages, simulated in 3DEC, in view, top view and bottom view*

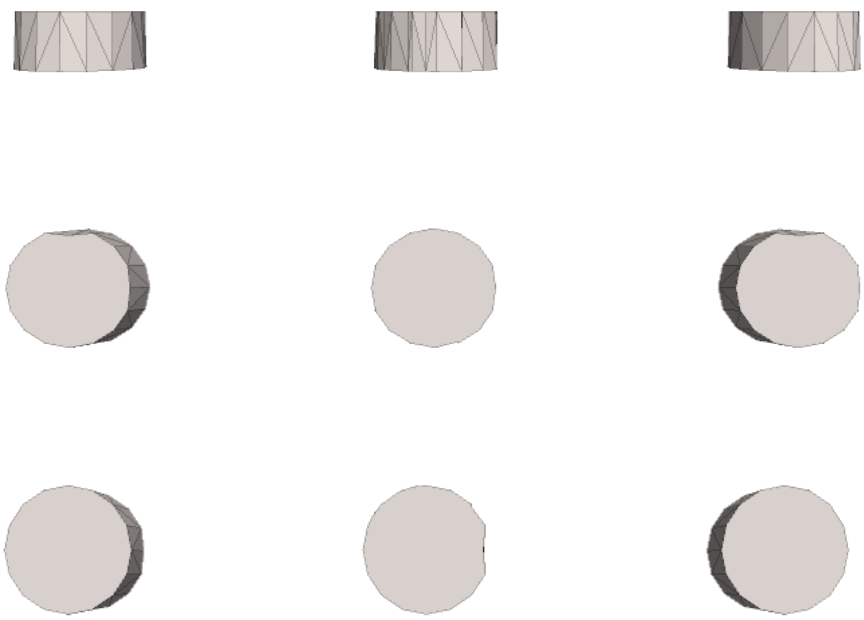


*Figure 108: Presentation of the 9th column drum of the 3-column colonnade with damages, simulated in 3DEC, in view, top view and bottom view*

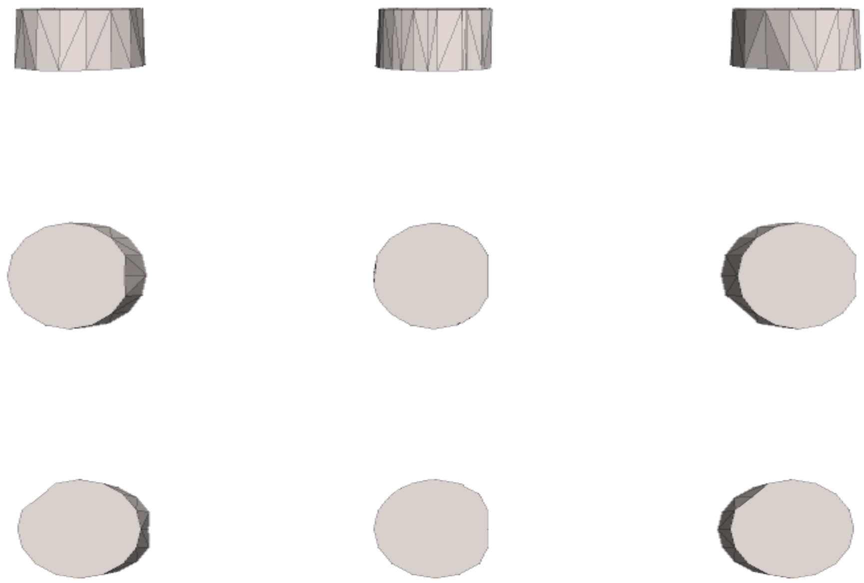


*Figure 109: Presentation of the 10$^{th}$ column drum of the 3-column colonnade with damages, simulated in 3DEC, in view, top view and bottom view*

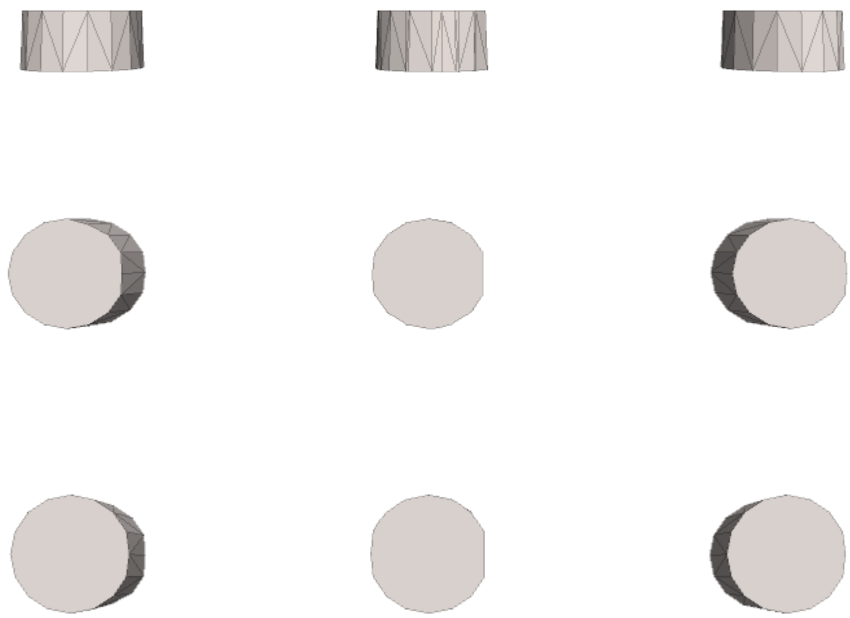


*Figure 110: Presentation of the 11$^{th}$ column drum of the 3-column colonnade with damages, simulated in 3DEC, in view, top view and bottom view*

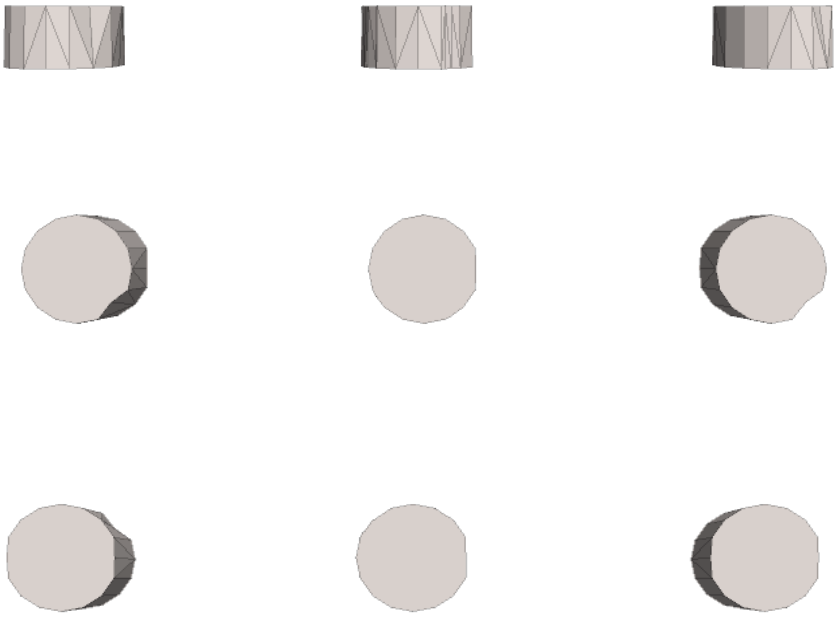


*Figure 111: Presentation of the 12th column drum of the 3-column colonnade with damages, simulated in 3DEC, in view, top view and bottom view*

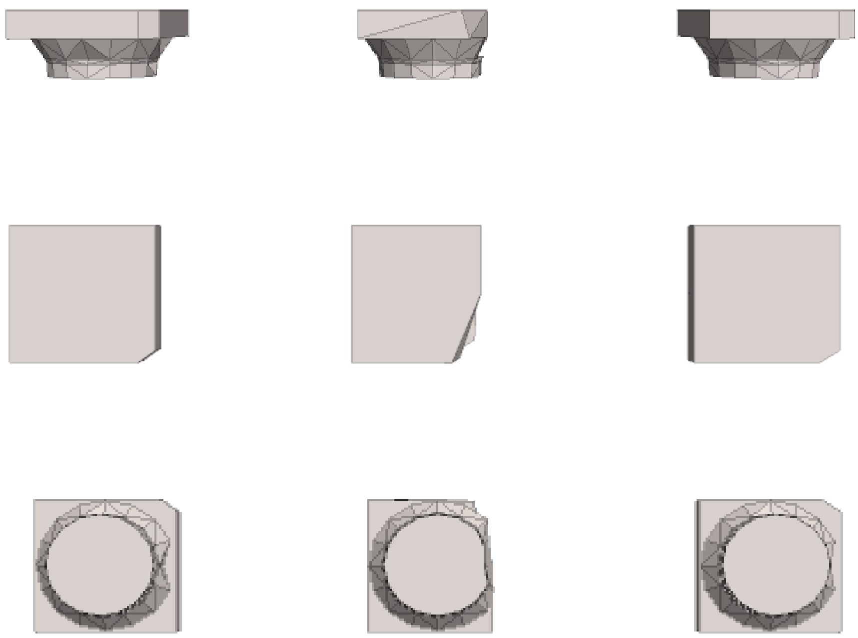


*Figure 112: Presentation of the column capitals of the 3-column colonnade with damages, simulated in 3DEC, in view, top view and bottom view*

### 3.3.3 Colonnade in a corner arrangement

Following the investigation, the colonnade consisting of three columns in a corner arrangement and the corresponding corner epistyle is modelled (Fig. 113-114). The axes of the columns are again 4m apart. The epistyle consists of three zones and the geometry is similar to previously, following a composition similar to that shown in Figure 20 and is given below. Therefore, the height of the epistyle is 1.35 m, the width of each piece such that the composition is achieved, and the thicknesses of the zones are 0.426, 0.491 and 0.443m, from the outer to the inner (Fig. 115-116).

Initially, the colonnade is simulated intact (without damages) following the same geometry for the three columns - as noted for the case of the colonnade in a line arrangement without damages (using intact "poly prisms").

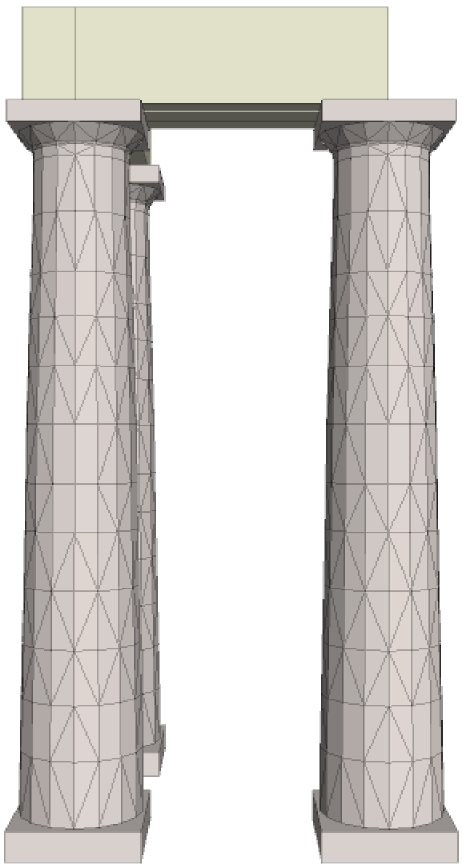


*Figure 113: Simulation of intact 3-column colonnade in a corner arrangement with epistyles (architraves) in 3DEC*

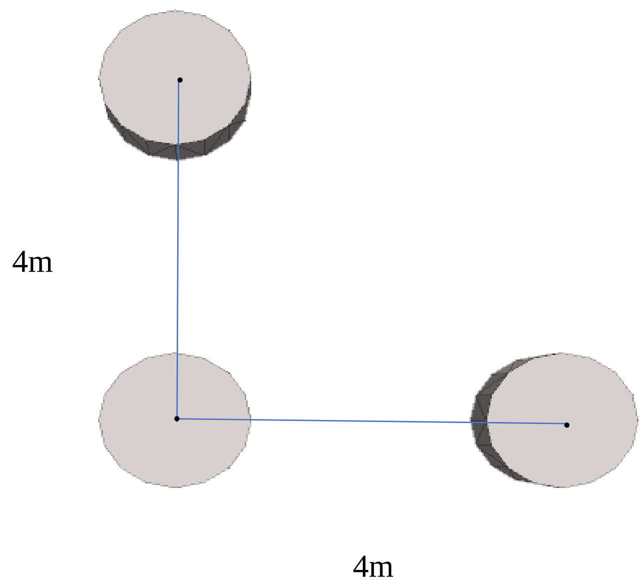



*Figure 114: Top view of column drums of the intact 3-column colonnade in a corner arrangement in 3DEC*

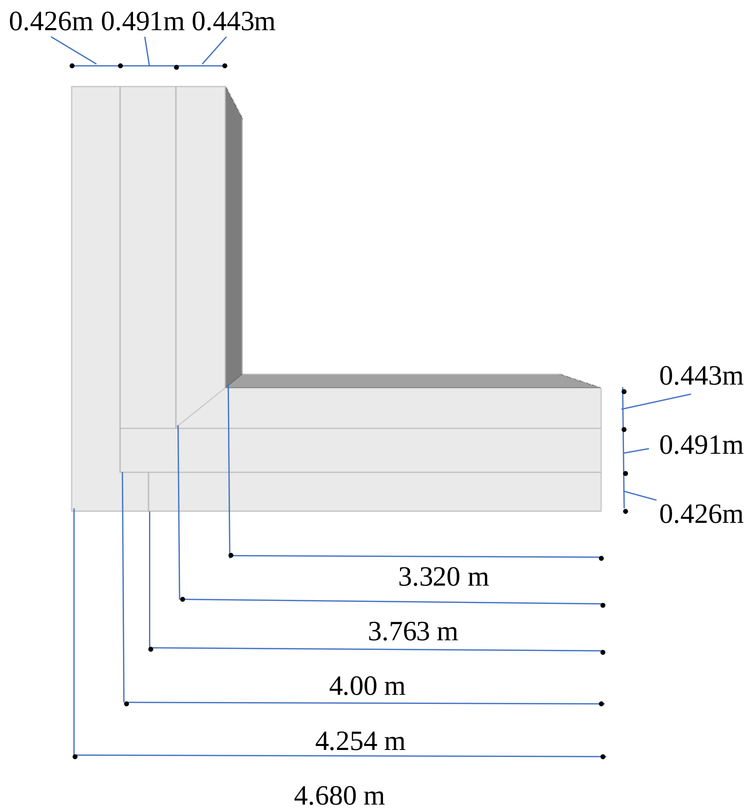



*Figure 115: Top view of the 3-zone epistyle of the colonnade in a corner arrangement in 3DEC*

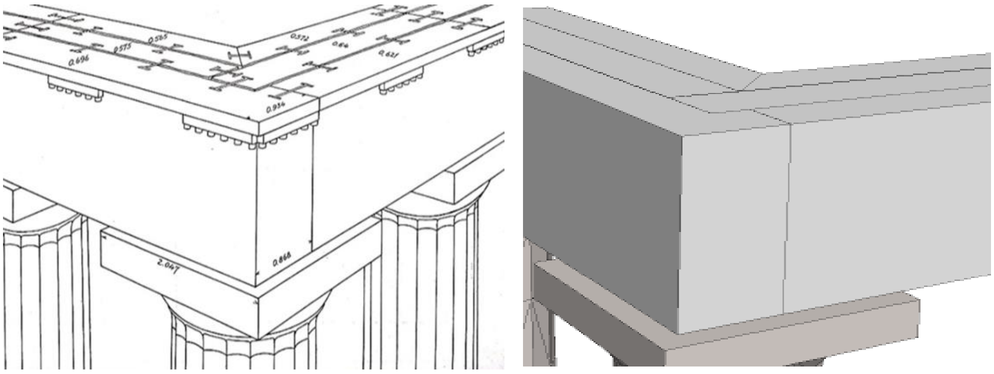


*Figure 116: (left) Composition of corner epistyles (Orlandos, 1977), (right) Composition of corner epistyles in 3DEC*

The same colonnade is then tested by applying damages. The corner column is taken to be the column of the previous section, i.e., the SE column of the Pronaos with the damages already noted, while for the other two columns a random, same distribution of damages was assumed for both of them (Fig. 117), exactly the same as the distribution assumed in the corresponding case of the damaged colonnade in a line arrangement. As for the epistyle, it is considered intact (without any damage).

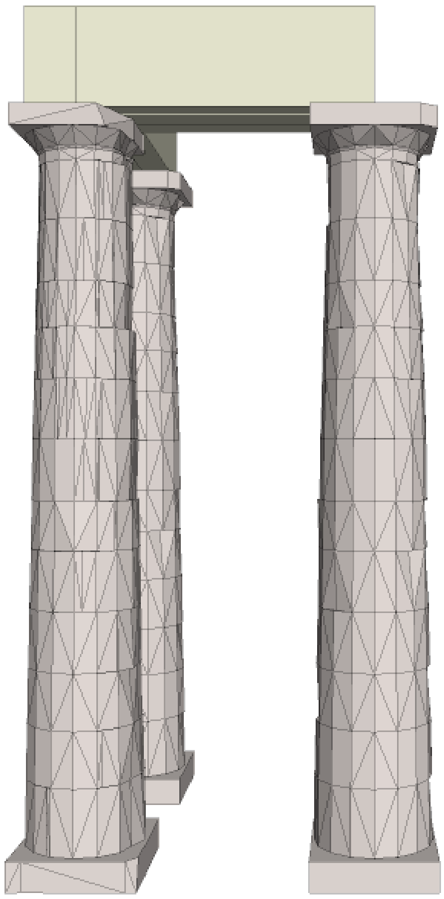


*Figure 117: Simulation of the damaged 3-column colonnade in a corner arrangement with epistyles (architraves) in 3DEC*

The code files for the geometry of the intact and damaged colonnade in a corner arrangement are also available in Appendix 1.

## 3.3 Simulation with 3DEC software

As mentioned above, for the simulation of the columns in 3DEC, data files with the appropriate geometry are created. Figures 118 and 119 show illustrative extracts from these files for the simulation of the 2nd column drum of the intact central/corner column and the model with damages, respectively.

The simulation models do not take into account the fasteners and fillers from the restorations. Also, for the damaged central/corner column model, any material losses on the inner side of the column have been ignored.

The respective geometric data file is called by the program after the type of analysis - dynamic - to be followed and the basic parameters have been defined. In this context, it has been defined, for the specific analyses, that the model update for the position and the contacts and sub-contacts is to be carried out in every single cycle, and that the general tolerance of the model (atol), e.g., for the minimum distance between grid points, is equal to 0.001. The tolerance for the contact distance is automatically defined as five times the general tolerance, i.e., here 0.005. If the distance from the common plane exceeds this value, then the contacts are deleted, and added if the part is within the value of the common plane. Then, after the geometry has been called and sets of blocks are defined as appropriate to facilitate the formulation of the requested data, the surfaces are "triangulated" to increase the number of vertices on them.

In addition, the analysis requires the definition of the basic mechanical properties describing the material, which are listed in Table 1.

The seismic excitations are applied to a fixed base ("Base"), the dimensions of which are chosen so that it can be assumed that they do not affect the problem.

```
;6th_2

poly drum 0.0 0.0 0.918 0.0 0.0 1.687 0.816 0.799 20 90
range name 6th_2 x -0.816 0.816 y -0.816 0.816 z 0.918 1.687
```

*Figure 118: Data for the simulation of the 2nd column drum of the single column of the intact model in 3DEC, using "poly drum". The centers of the lower and upper surface of the drum, the radii and the number of edges are defined, and the specified range of values is named.*

```
;6th_2

poly prism a 0.768,0.0,0.918 0.754,0.312,0.918 0.577,0.577,0.918 0.312,0.754,0.918 &
             0.0,0.816,0.918 -0.312,0.754,0.918 -0.577,0.577,0.918 -0.754,0.312,0.918 &
            -0.816,0.0,0.918 -0.754,-0.312,0.918 -0.577,-0.577,0.918 -0.312,-0.754,0.918 &
             0.0,-0.816,0.918 0.312,-0.754,0.918 0.367,-0.710,0.918 0.577,-0.577,0.918 &
             0.667,-0.312,0.918 &
           b 0.751,0.0,1.687 0.738,0.306,1.687 0.565,0.565,1.687 0.306,0.738,1.687 &
             0.0,0.799,1.687 -0.306,0.738,1.687 -0.565,0.565,1.687 -0.738,0.306,1.687 &
            -0.799,0.0,1.687 -0.738,-0.306,1.687 -0.565,-0.565,1.687 -0.306,-0.738,1.687 &
             0.0,-0.799,1.687 0.306,-0.738,1.687 0.367,-0.700,1.687 0.565,-0.565,1.687 &
             0.712,-0.306,1.687
range name 6th_2 x -0.816 0.816 y -0.816 0.816 z 0.918 1.687
```

*Figure 119: Data for the simulation of the 2nd column drum of the single/central/corner column of the damaged in 3DEC. 16+ points are defined on the lower (a) and upper surface (b), and, similarly, the given range of values is named.*

*Table 1: Mechanical properties of the material (Pentelic marble) of the ancient columns, as defined for the 3DEC analysis*

| | |
|---|---|
| Density: | den = 2700 kg/m$^3$ |
| Stiffness: | k = 5.8 x 10$^7$ N/m |
| Shear modulus: | G = 2.2 x 10$^7$ N/m$^2$ |
| Axial stiffness coefficient: | $jk_n$ = 5.0 x 10$^9$ |
| Shear stiffness coefficient: | $jk_s$ = 1.0 x 10$^9$ |
| Friction angle: | $jf_r$ = 37° |

```
;materials
prop mat=1 den=2700 k=58000000 g=22000000 jkn=5000000000 jks=1000000000 jfri=37
```

*Figure 120: Defining mechanical properties in 3DEC*

It should be noted that due to the modular construction, the dynamic behaviour of ancient monuments is strongly non-linear and highly sensitive to even insignificant changes in the geometry or movement characteristics of the base.

# 4 DISCUSSION OF RESULTS

## 4.1 Selection of seismic excitations

Due to the specific nature of the analyses as explained in section 3.1, which implies the sensitivity of the response to the characteristics of the seismic motion, the use of appropriate accelerometers plays a very important role. These should be compatible with the wider seismotectonic environment - in this case, that of the historic centre of Athens and the expected magnitude of possible earthquakes. Otherwise, it is likely that the studies will lead to incorrect results, underestimating or overestimating the response.

In general, the response of classical monuments to seismic excitations (and therefore the risk of collapse) is fundamentally affected by the dominant period of seismic motion, namely the response increases almost exponentially as the period increases. Thus, while a monument may have very little deformation in a high-period earthquake, it is likely to collapse in a very long-period earthquake with the same or less maximum acceleration. In the first case, the deformation is mainly due to sliding of the individual structural elements, while in the second case, rocking prevails (Psycharis, 2015).

In the present work, accelerograms are selected that are compatible with the seismotectonic environment of the Acropolis area and cover a wide range of frequency content, which significantly affects the seismic response of modular structures, as selected in the Psycharis' report on the selection of suitable accelerographs for dynamic analyses of the Acropolis monuments (2015), which notes that the influence of the dynamic response of the Acropolis rock on the seismic motion at the top of the hill has been taken into account approximately, through the topographic amplification factor of Eurocode 8.

In Ambraseys' seismic hazard study for the Athens area (2010), it is shown that the ground acceleration that can occur with an annual probability of exceeding $5.0\times10^{-5}$ is about 0.19 g, i.e., an acceleration that does not correspond to a very strong earthquake.

Taking into account parameters that have a decisive impact on the response of ancient monuments, such as the maximum ground velocity and the dominant period of ground motion as well as directivity effects in cases of proximity to active seismic faults, nine seismic excitations of surface earthquakes of normal faults were selected from the European Strong Motion Data Base and NGA Strong Motion Data Base databases, with magnitude $5.9 < Mw < 7.0$ and recorded in bedrock or rocky/stiff ground.

Table 2 shows the characteristics of the nine seismic excitations selected. These include the recording of the 1999 Athens earthquake at the Syntagma Metro Station, less than 1 km from the Acropolis; between the two recordings at the Metro Station of Syntagma, recording B was chosen, which was made at a depth of 11 m and must not have been affected by the dynamic response of the station, as it is possible that recording A was affected.

Although in the case of the Acropolis there are no indications of seismic faults at a distance of up to 10 km, in the selection of the accelerograms for the dynamic analyses of the Acropolis monuments, seismic movements recorded at shorter distances from the fault (Cascia and Bagnoli-Irpino records) were taken into account, because it was considered that similar ground motions with strong directivity effects could occur in Athens due to earthquakes caused by faults located at distances greater than 10 km and containing directional pulses.

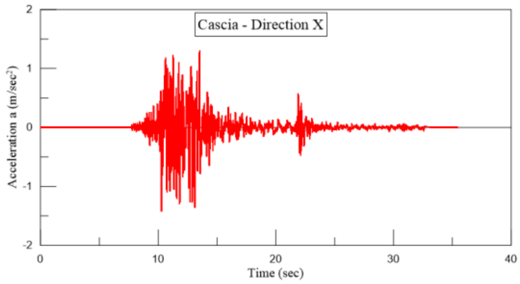
*Table 2: Characteristics of seismic excitations (Psycharis, 2015).*

| **No.** | **Earth-quake** | **Date** | ***Mw*** | **Record** | **Symb.** | **Distance from fault (km)** | **Ground** | ***pga* (g)** | ***pgv* (cm/s)** | ***Tp(1)* (sec)** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Valnerina, Italy | 19/09/1979 | 5.9 | Cascia | CSC | 1 | A | L: 0.145<br>T: 0.203<br>V: 0.147 | L: 8.1<br>T: 10.9<br>V: 4.7 | 0.64<br>0.75<br>0.29 |
| 2 | Campano Lugano, Italy | 23/11/1980 | 6.9 | Bisaccia | BSC | 19 | Rock | L: 0.079<br>T: 0.092<br>V: 0.055 | L: 14.7<br>T: 16.3<br>V: 9.9 | 1.02<br>2.02<br>3.51 |
| 3 | Campano Lugano, Italy | 23/11/1980 | 6.9 | Bagnoli-Irpino | BGI | 6 | Rock | L: 0.139<br>T: 0.181<br>V: 0.104 | L: 20.5<br>T: 30.6<br>V: 14.6 | 1.26<br>1.58<br>1.50 |
| 4 | Northridge, California, USA | 17/01/1994 | 6.7 | Lake Hughes #9 | L09 | 27 | A | L: 0.165<br>T: 0.217<br>V: 0.079 | L: 8.4<br>T: 10.1<br>V: 3.6 | 0.19<br>0.18<br>6.00 |
| 5 | Northridge, California, USA | 17/01/1994 | 6.7 | San Gabriel E. Grand Ave. | GRN | 42 | A | L: 0.141<br>T: 0.256<br>V: 0.073 | L: 9.6<br>T: 9.8<br>V: 3.7 | 0.42<br>0.54<br>1.79 |
| 6 | Northridge, California, USA | 17/01/1994 | 6.7 | Los Angeles Wonderland Ave. | WON | 23 | A | L: 0.112<br>T: 0.172<br>V: 0.106 | L: 8.7<br>T: 11.8<br>V: 3.6 | 1.17<br>0.84<br>0.70 |
| 7 | Kozani, Greece | 13/05/1995 | 6.5 | Kozani Prefecture Blg. | KOZ | 14 | A | L: 0.208<br>T: 0.143<br>V: 0.084 | L: 8.6<br>T: 6.6<br>V: 4.5 | 0.23<br>0.39<br>1.30 |
| 8 | Umbria Marche, Italy | 26/09/1997 | 6.0 | Assisi Stallone | AS010 | 14 | A | L: 0.188<br>T: 0.167<br>V: 0.078 | L: 10.3<br>T: 7.7<br>V: 2.9 | 0.35<br>0.27<br>0.22 |
| 9 | Athens, Greece | 07/09/1999 | 5.9 | Syntagma Metro B | SGMB | 10 | Stiff soil | L: 0.109<br>T: 0.086<br>V: 0.087 | L: 9.8<br>T: 10.6<br>V: 3.5 | 0.89<br>0.52<br>1.71 |

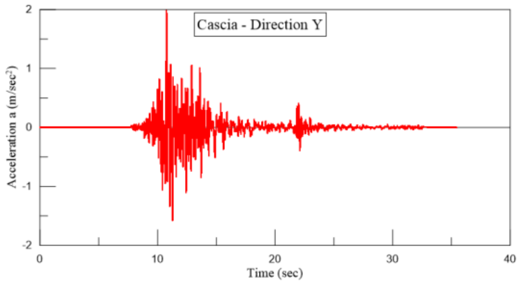
*(1) Tp: dominant period; corresponds to the peak of the pseudo-velocity spectrum for 5% damping.*

The analyses apply each record in the X direction and also in X+Y.

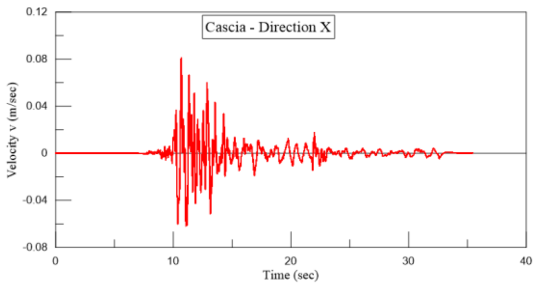
Figures 121-129 show the time histories of acceleration, velocity and displacement for the X-direction and for the Y-direction of each of the above records.



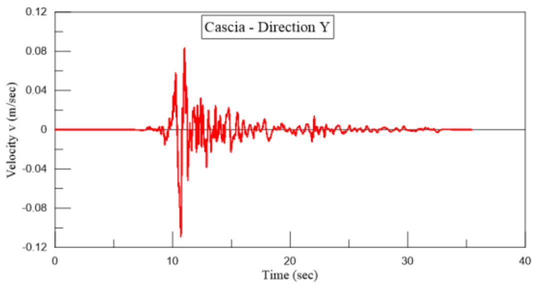

(a)



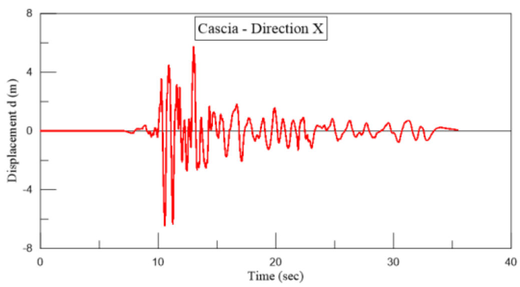

(b)



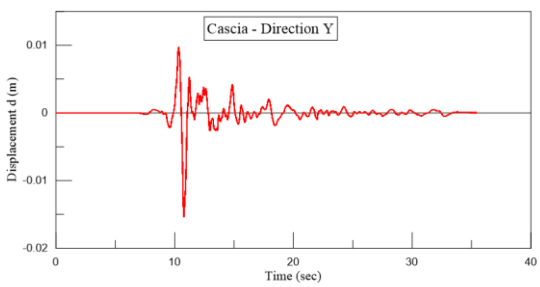

(c)




(d)




(e)




(f)

*Figure 121: Time histories of (a, b) acceleration (m/sec$^2$), (c, d) velocity (m/sec) and (e, f) displacement (m) for the direction X (a, c, e) and Y (b, d, f), respectively, of Cascia record.*

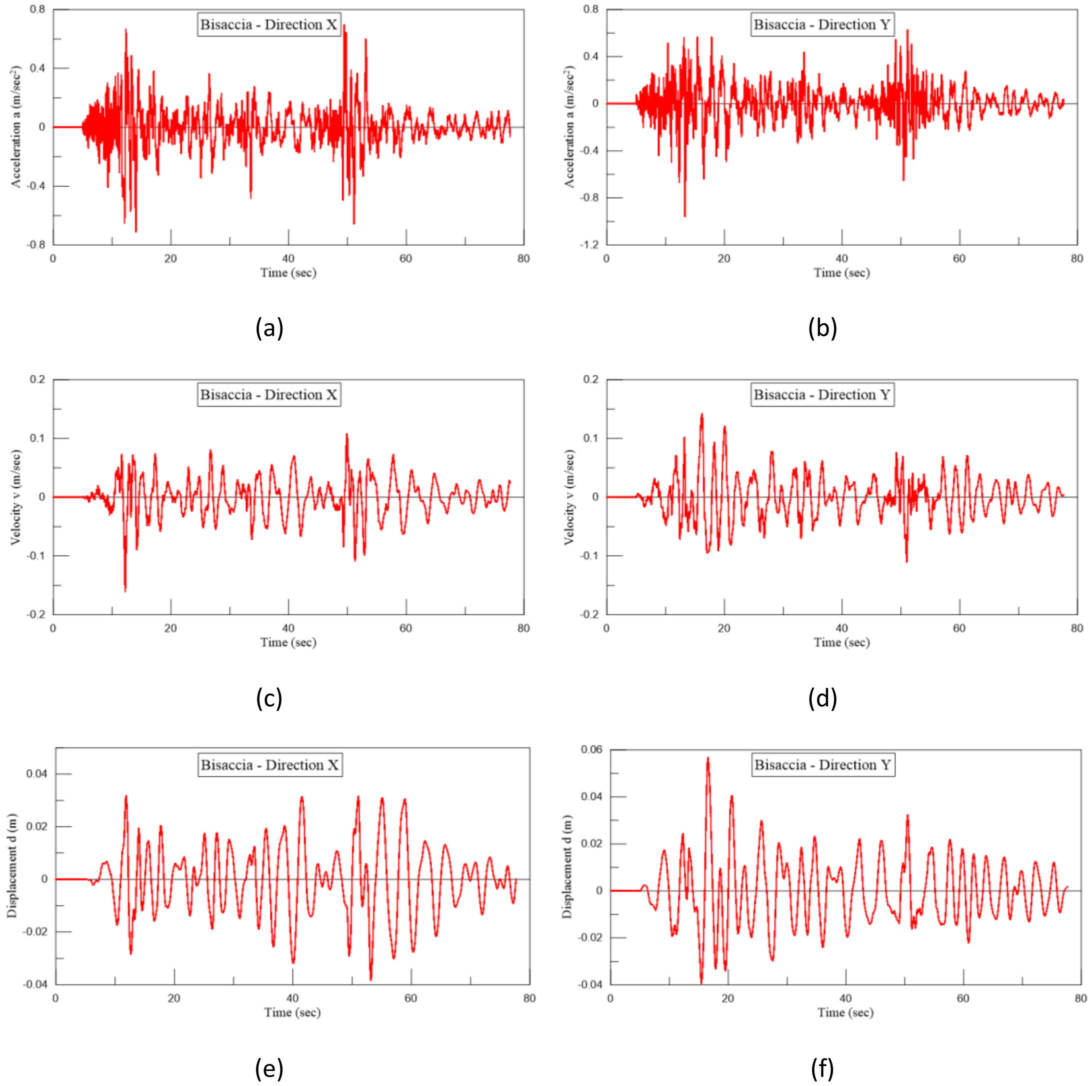



*Figure 122: Time histories of (a, b) acceleration (m/sec²), (c, d) velocity (m/sec) and (e, f) displacement (m) for the direction X (a, c, e) and Y (b, d, f), respectively, of Bisaccia record.*

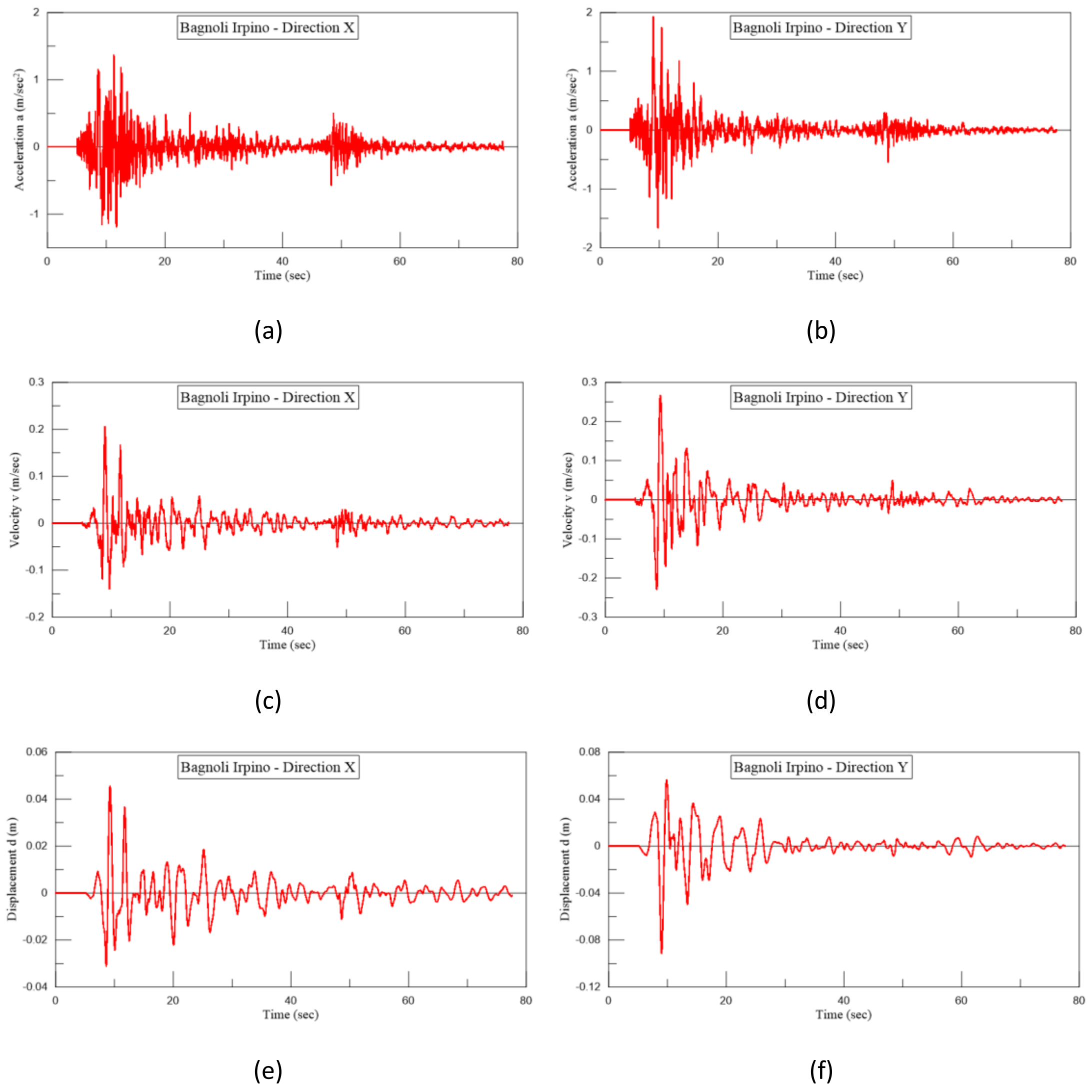



*Figure 123: Time histories of (a, b) acceleration (m/sec$^2$), (c, d) velocity (m/sec) and (e, f) displacement (m) for the direction X (a, c, e) and Y (b, d, f), respectively, of Bagnoli Irpino record.*

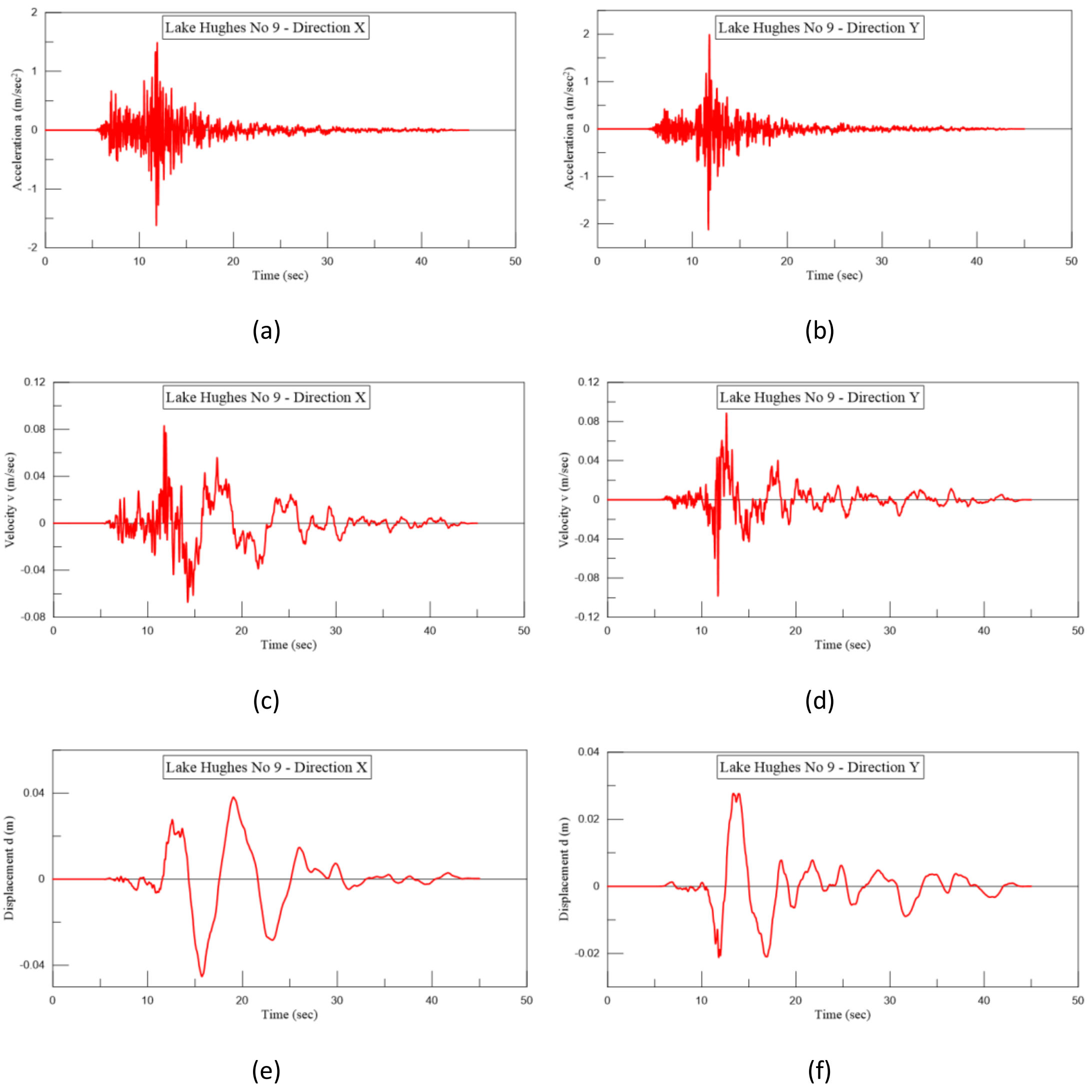



*Figure 124: Time histories of (a, b) acceleration (m/sec$^2$), (c, d) velocity (m/sec) and (e, f) displacement (m) for the direction X (a, c, e) and Y (b, d, f), respectively, of Lake Hughes No 9 record.*

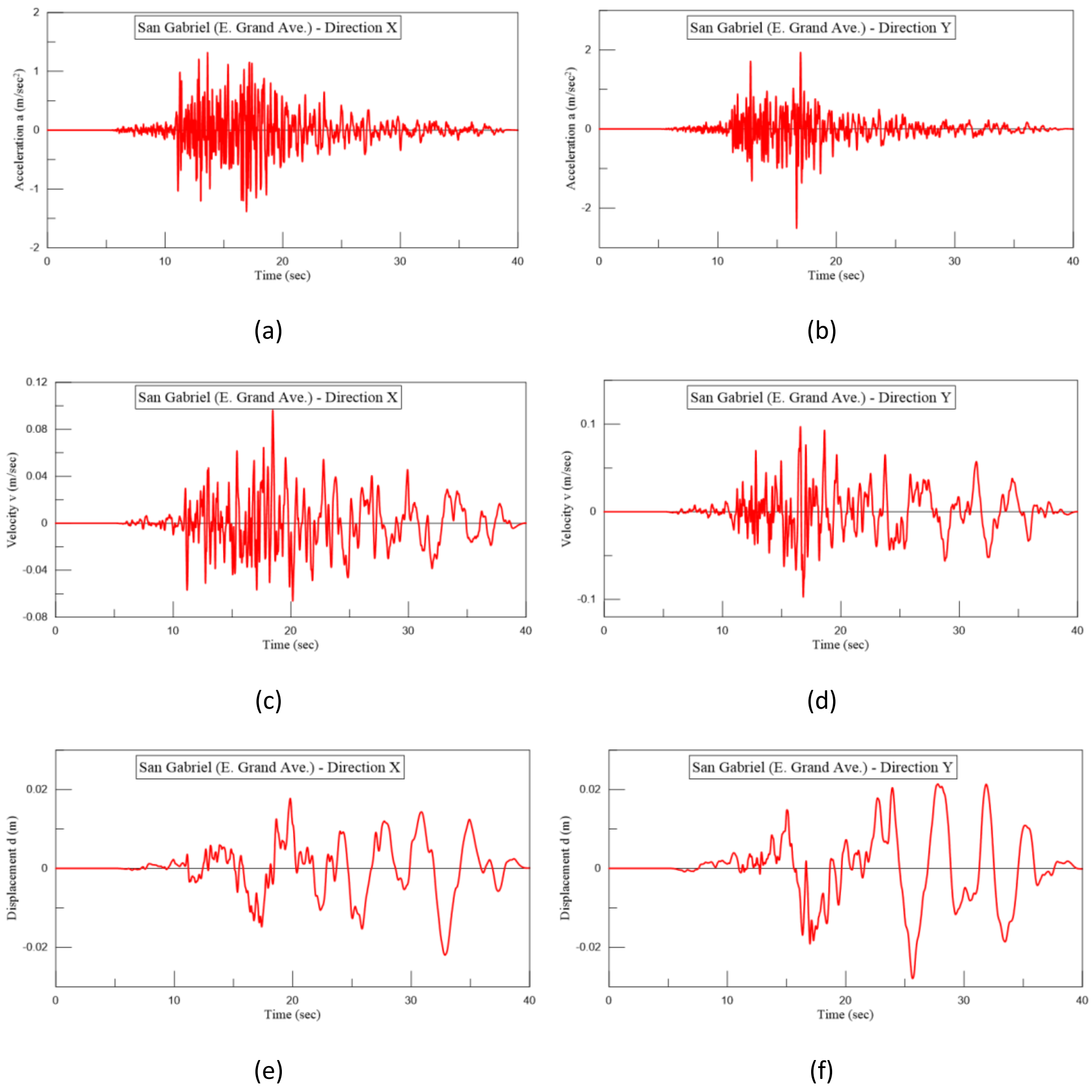



*Figure 125: Time histories of (a, b) acceleration (m/sec$^2$), (c, d) velocity (m/sec) and (e, f) displacement (m) for the direction X (a, c, e) and Y (b, d, f), respectively, of San Gabriel (E. Grand Ave.) record.*

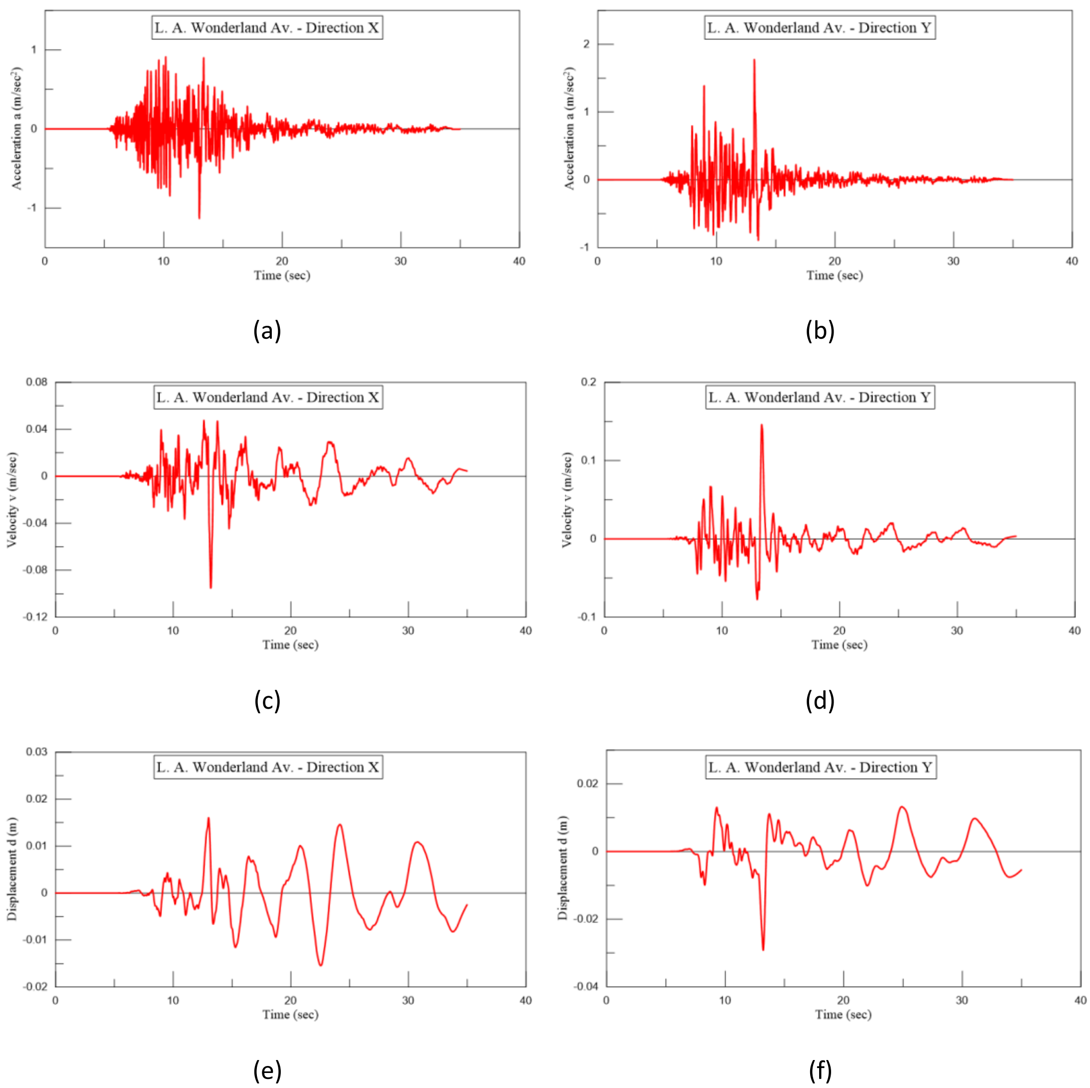



*Figure 126: Time histories of (a, b) acceleration (m/sec$^2$), (c, d) velocity (m/sec) and (e, f) displacement (m) for the direction X (a, c, e) and Y (b, d, f), respectively, of L. A. Wonderland Av. record.*

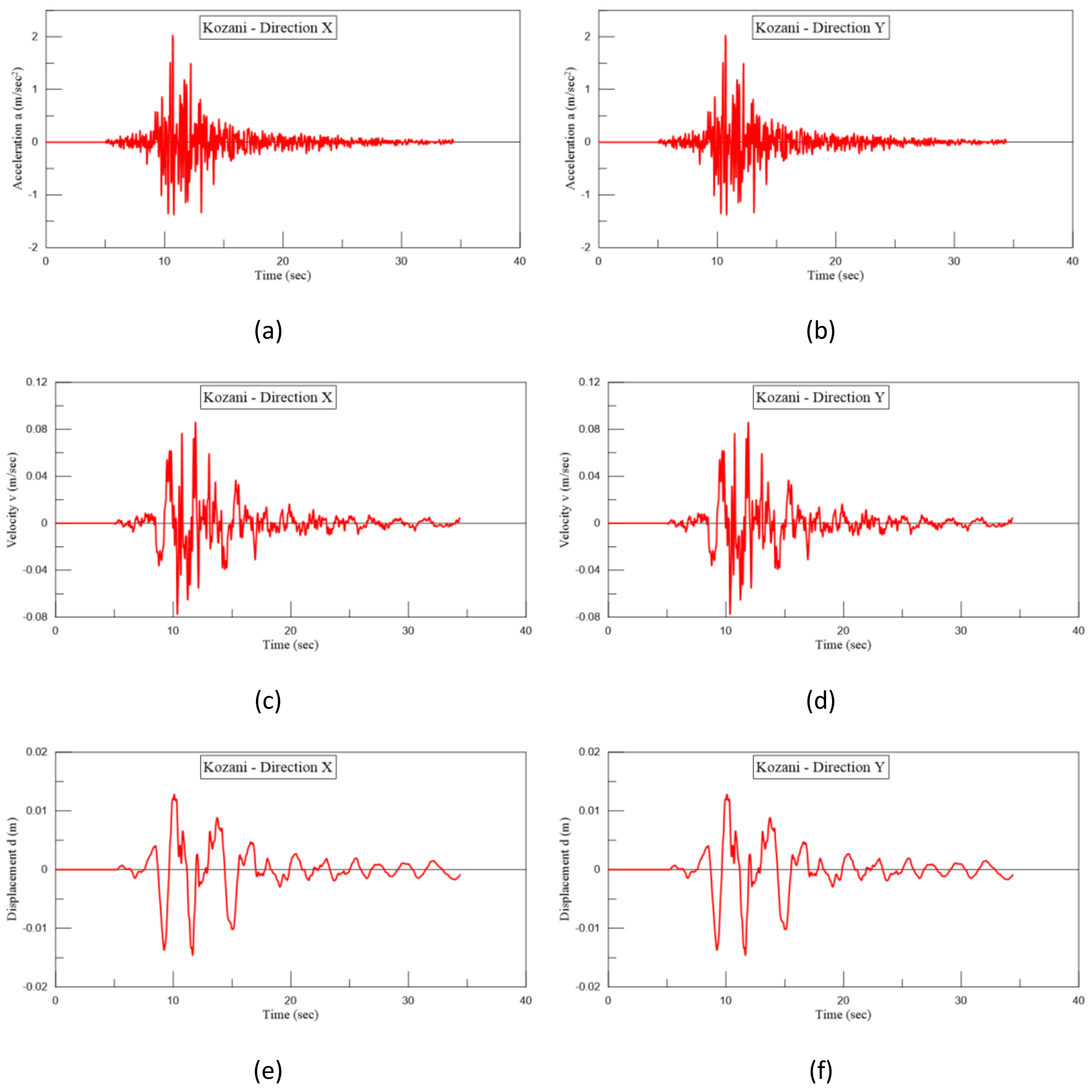
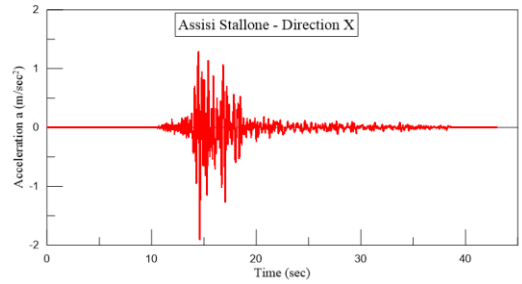
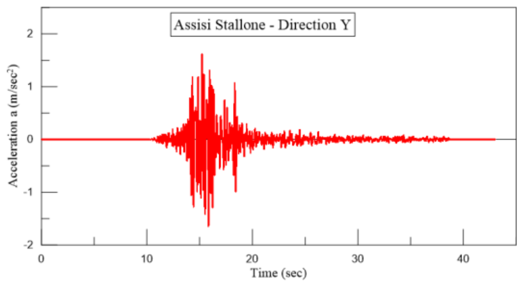


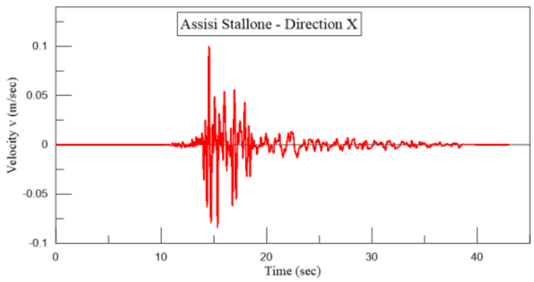

*Figure 127: Time histories of (a, b) acceleration (m/sec$^2$), (c, d) velocity (m/sec) and (e, f) displacement (m) for the direction X (a, c, e) and Y (b, d, f), respectively, of Kozani record.*



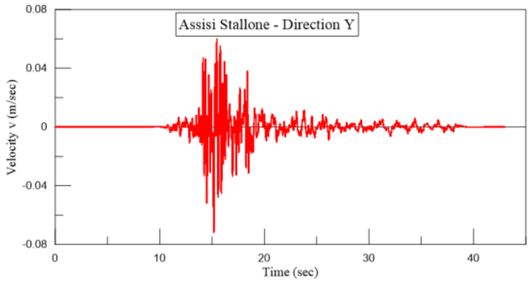

(a)



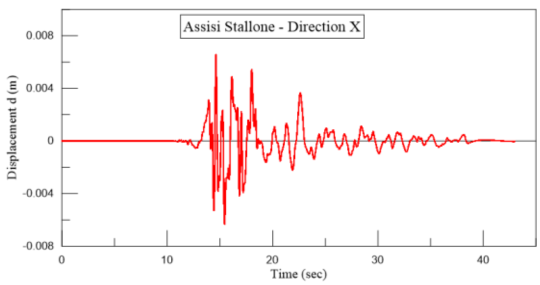

(b)



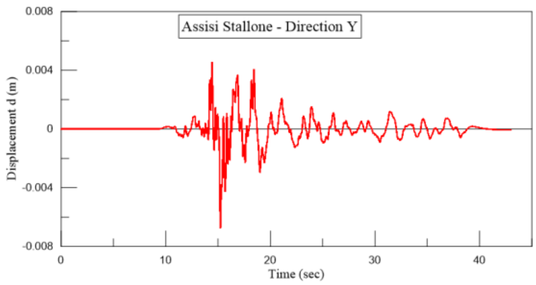

(c)




(d)




(e)




(f)

*Figure 128: Time histories of (a, b) acceleration (m/sec$^2$), (c, d) velocity (m/sec) and (e, f) displacement (m) for the direction X (a, c, e) and Y (b, d, f), respectively, of Assisi Stallone record.*

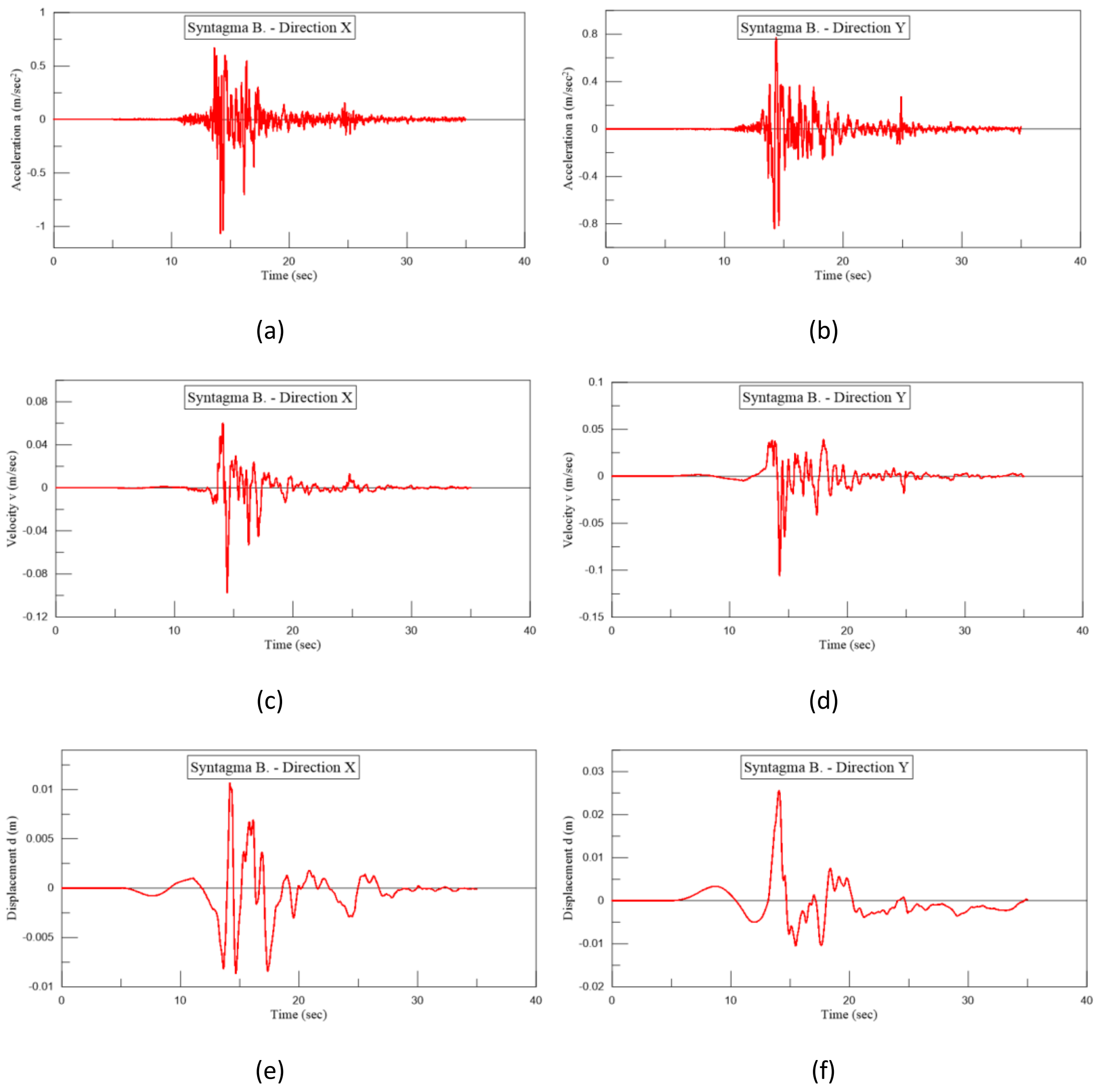



*Figure 129: Time histories of (a, b) acceleration (m/sec$^2$), (c, d) velocity (m/sec) and (e, f) displacement (m) for the direction X (a, c, e) and Y (b, d, f), respectively, of Syntagma B. record.*

## 4.2 Numerical results

This section presents the results of the analyses. First, comparative plots of absolute maximum displacements in x and y, as well as the geometric mean, between the intact model and the model with damages for each arrangement (single column, 3-column colonnade in a line arrangement, 3-column colonnade in a corner arrangement) for the central/corner column, are presented. Then, the effect of each arrangement is also compared for each condition (intact or damaged) by using corresponding diagrams.

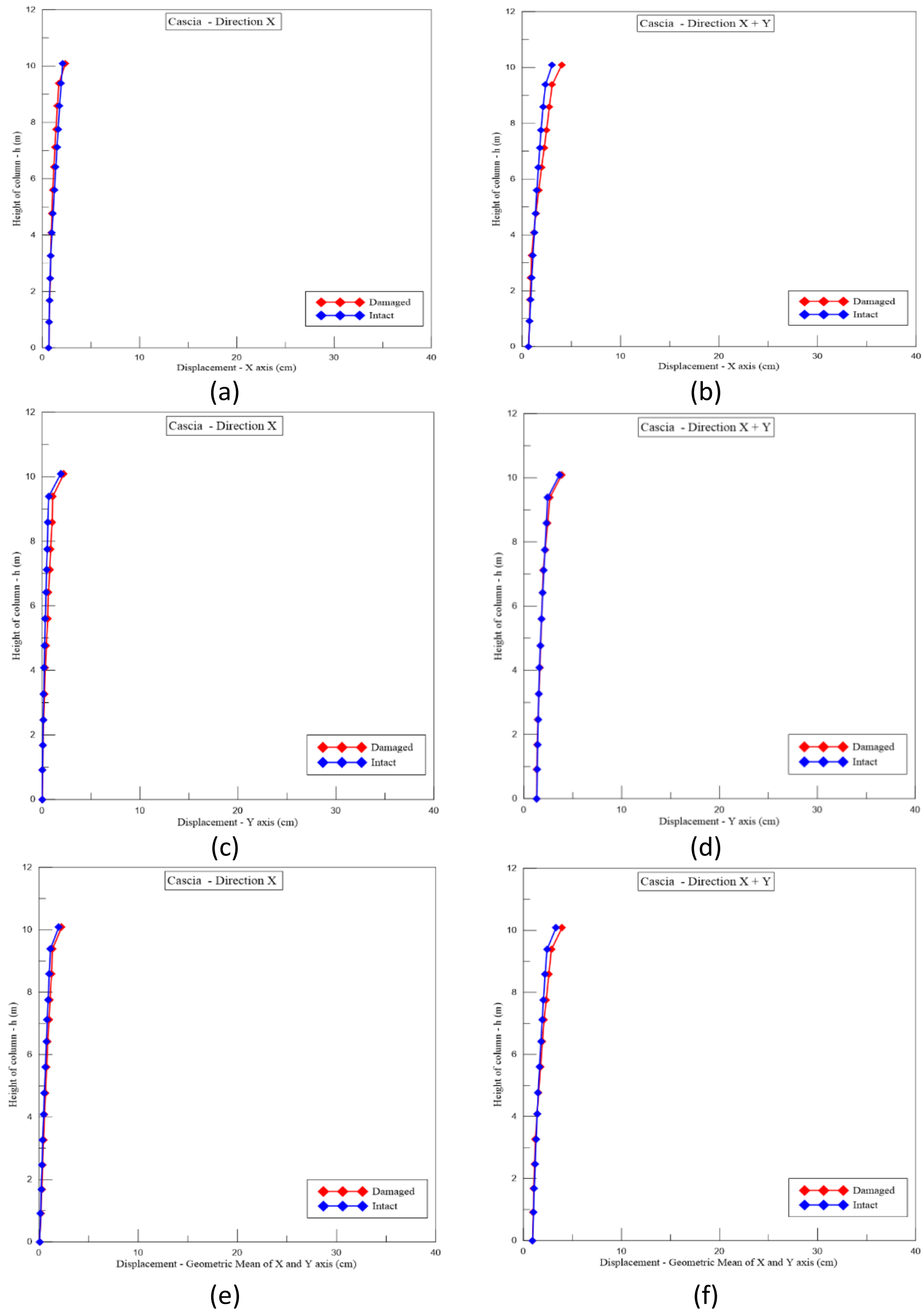



*Figure 130: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the single column in height of the column for x (a, c, e) and x + y (b, d, f) components of Cascia record.*

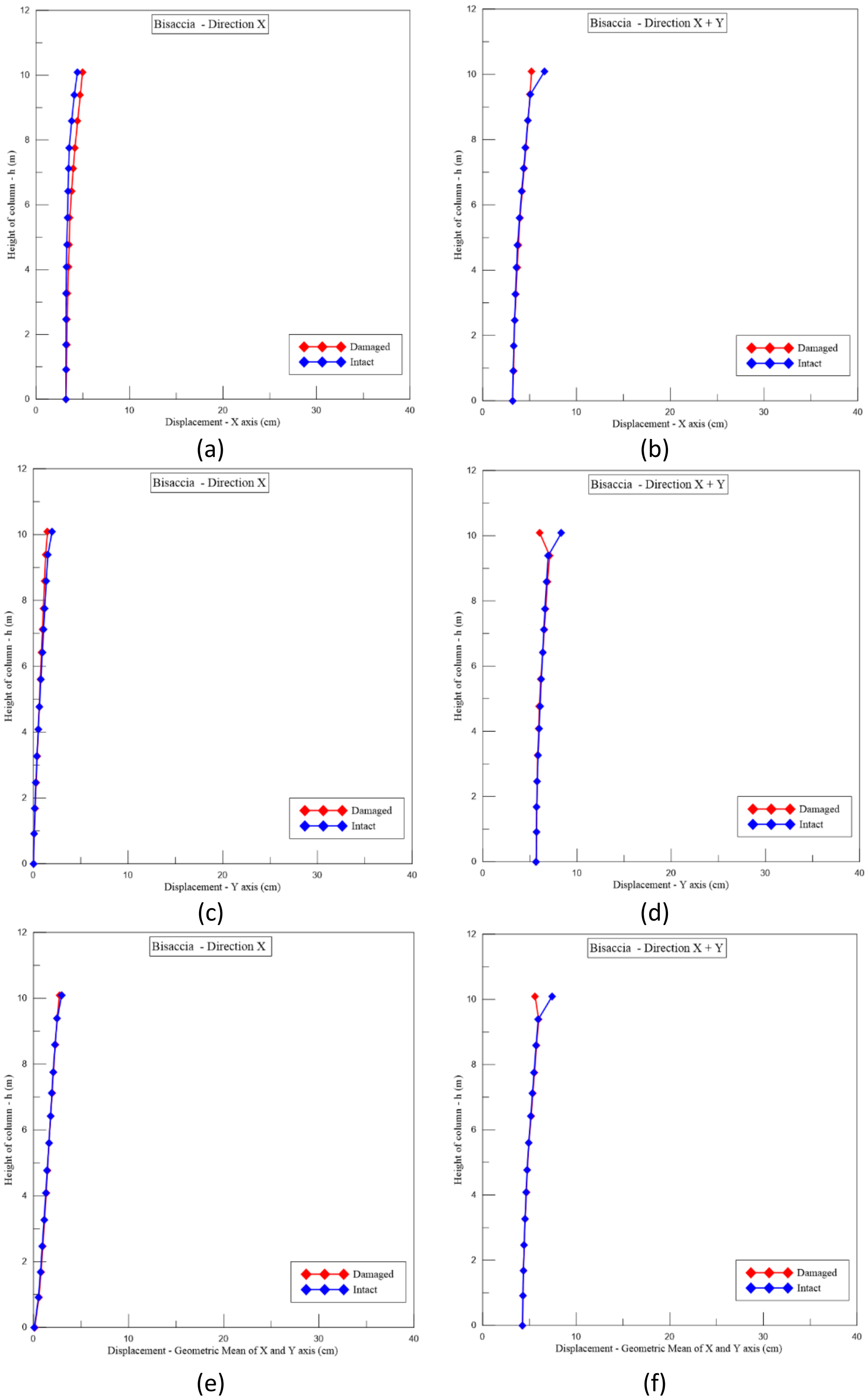



*Figure 131: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the single column in height of the column for x (a, c, e) and x + y (b, d, f) components of Bisaccia record.*

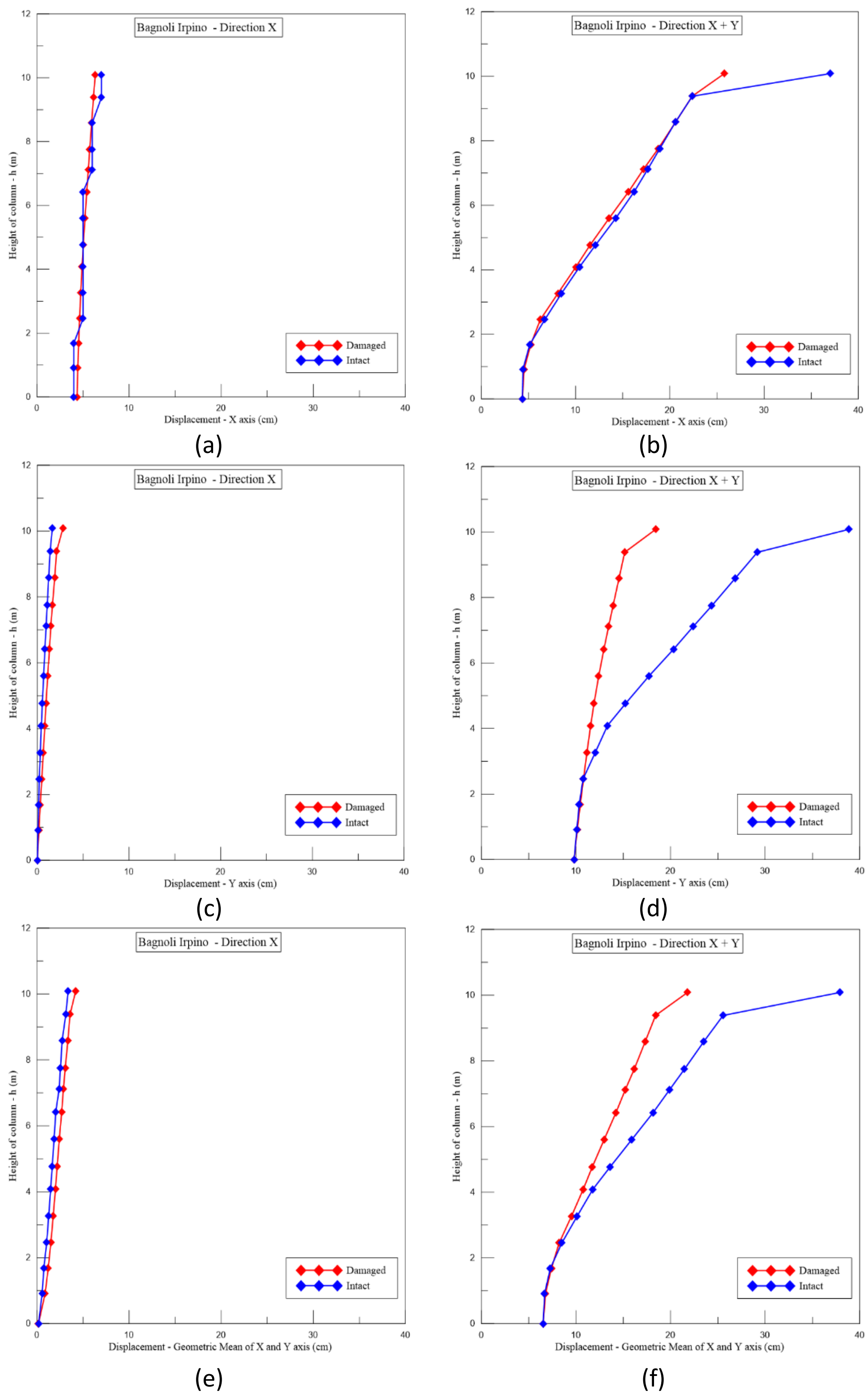



*Figure 132: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the single column in height of the column for x (a, c, e) and x + y (b, d, f) components of Bagnoli Irpino record.*

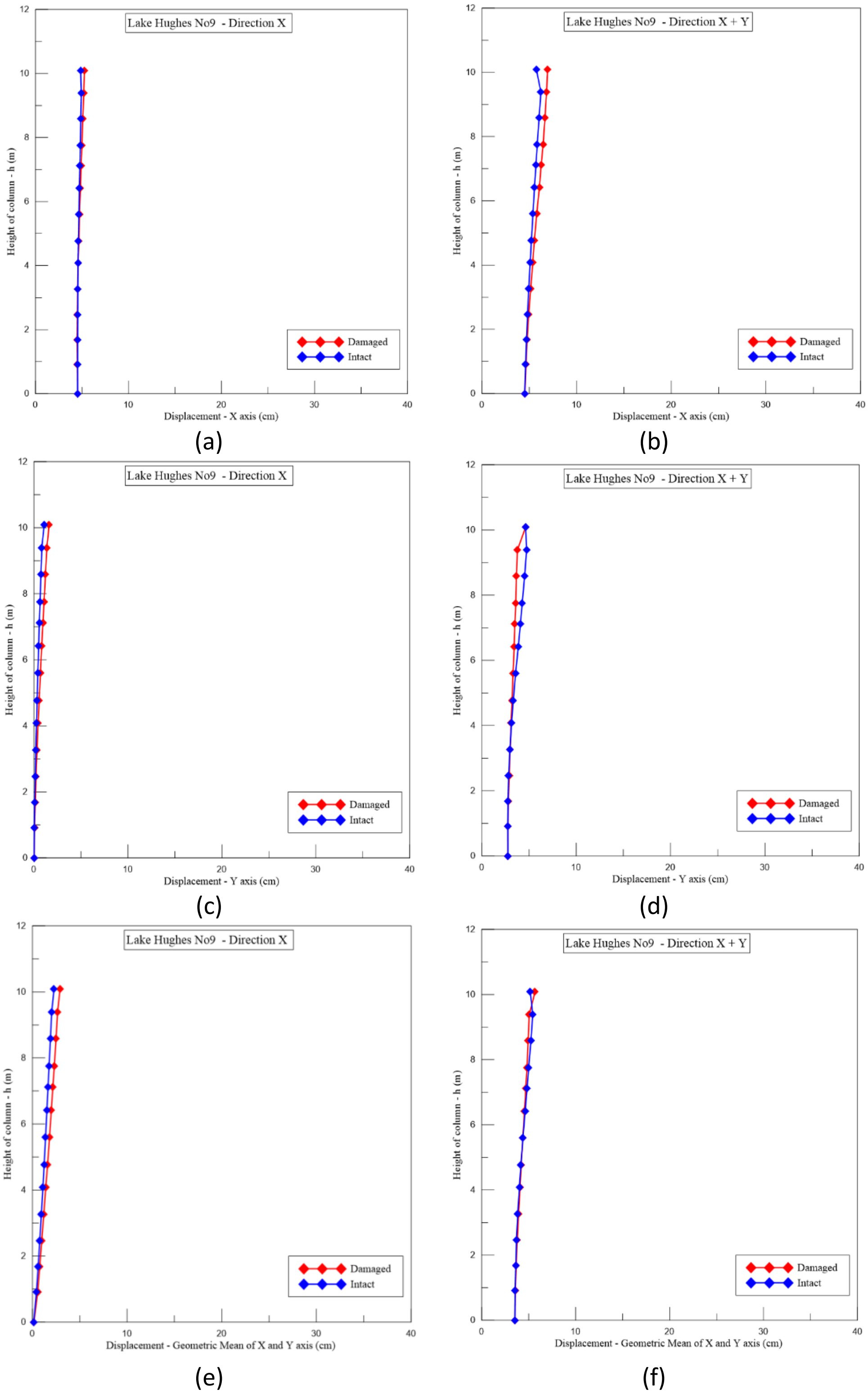



*Figure 133: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the single column in height of the column for x (a, c, e) and x + y (b, d, f) components of Lake Hughes No9 record.*

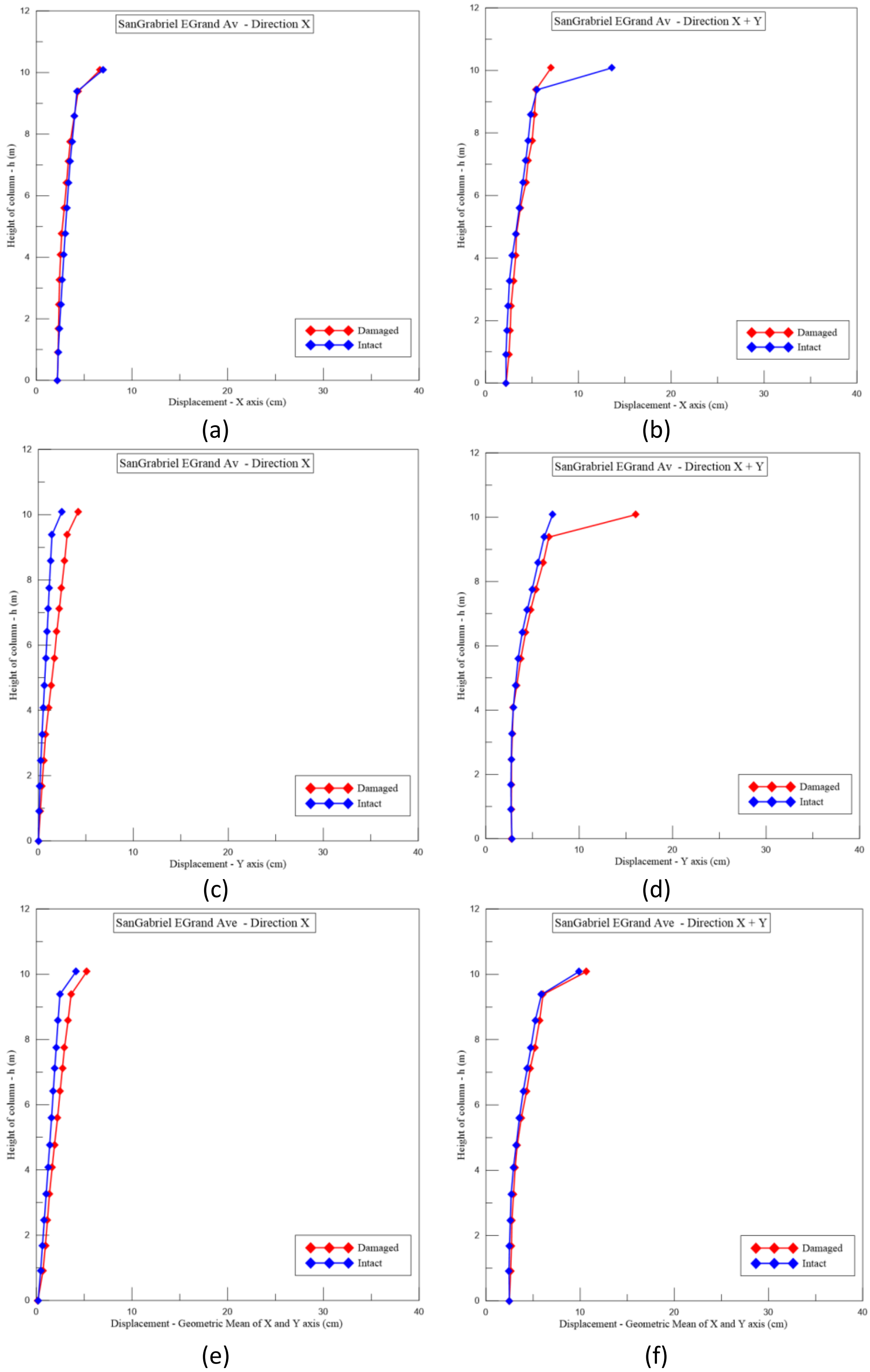



*Figure 134: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the single column in height of the column for x (a, c, e) and x + y (b, d, f) components of San Gabriel (E. Grand Ave.) record.*

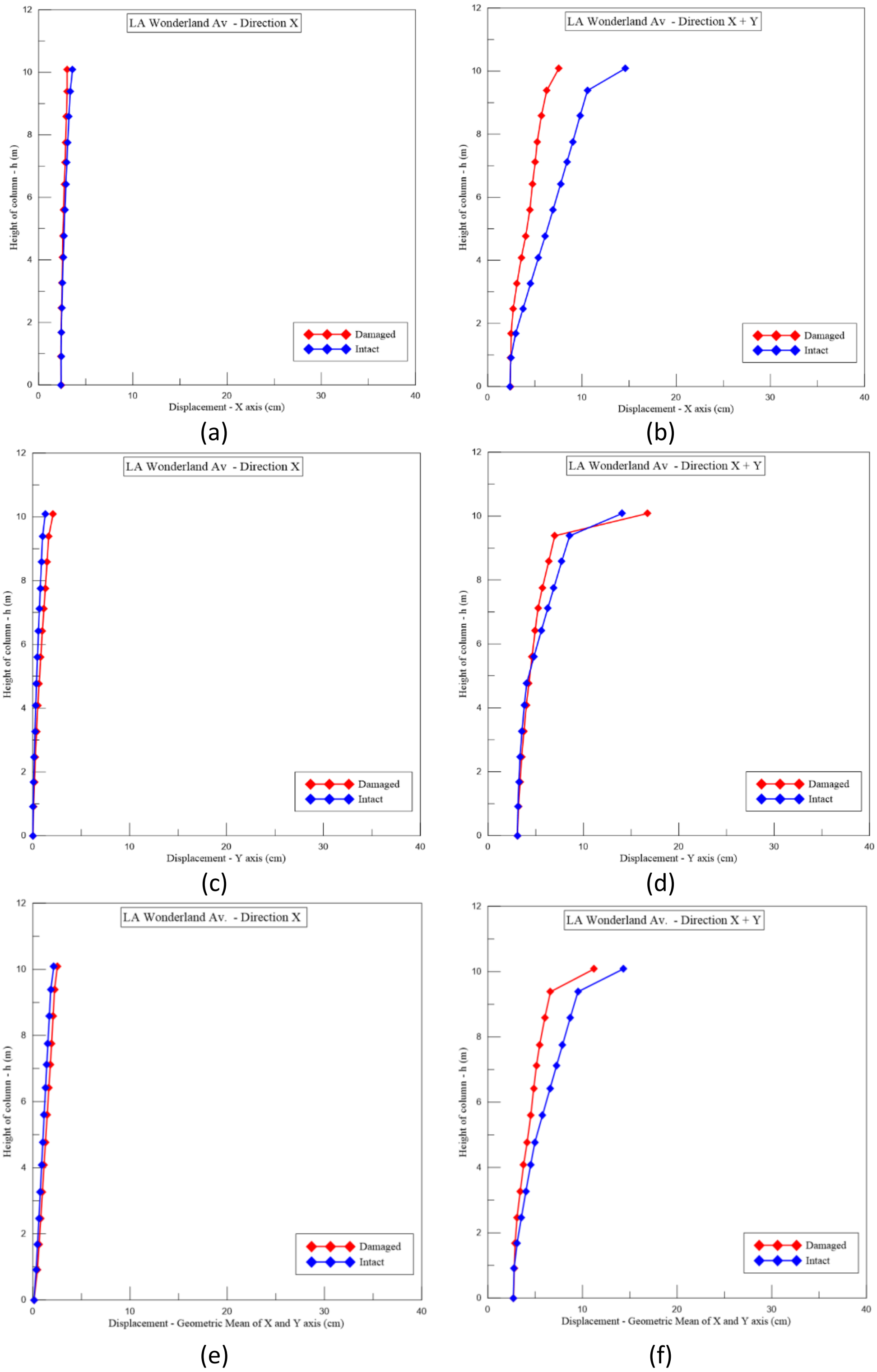



*Figure 135: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the single column in height of the column for x (a, c, e) and x + y (b, d, f) components of L.A. Wonderland Av. record.*

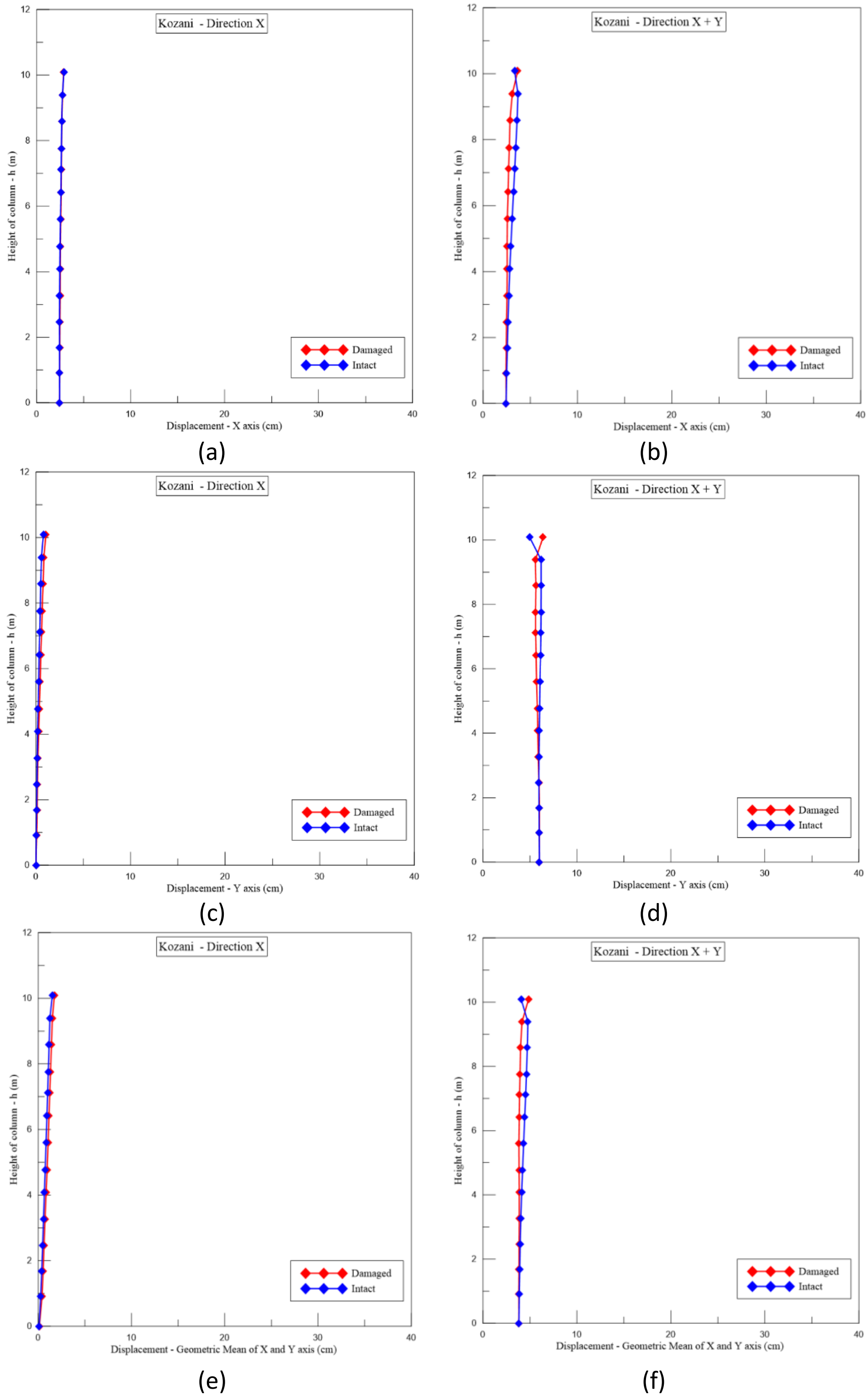



*Figure 136: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the single column in height of the column for x (a, c, e) and x + y (b, d, f) components of Kozani record.*

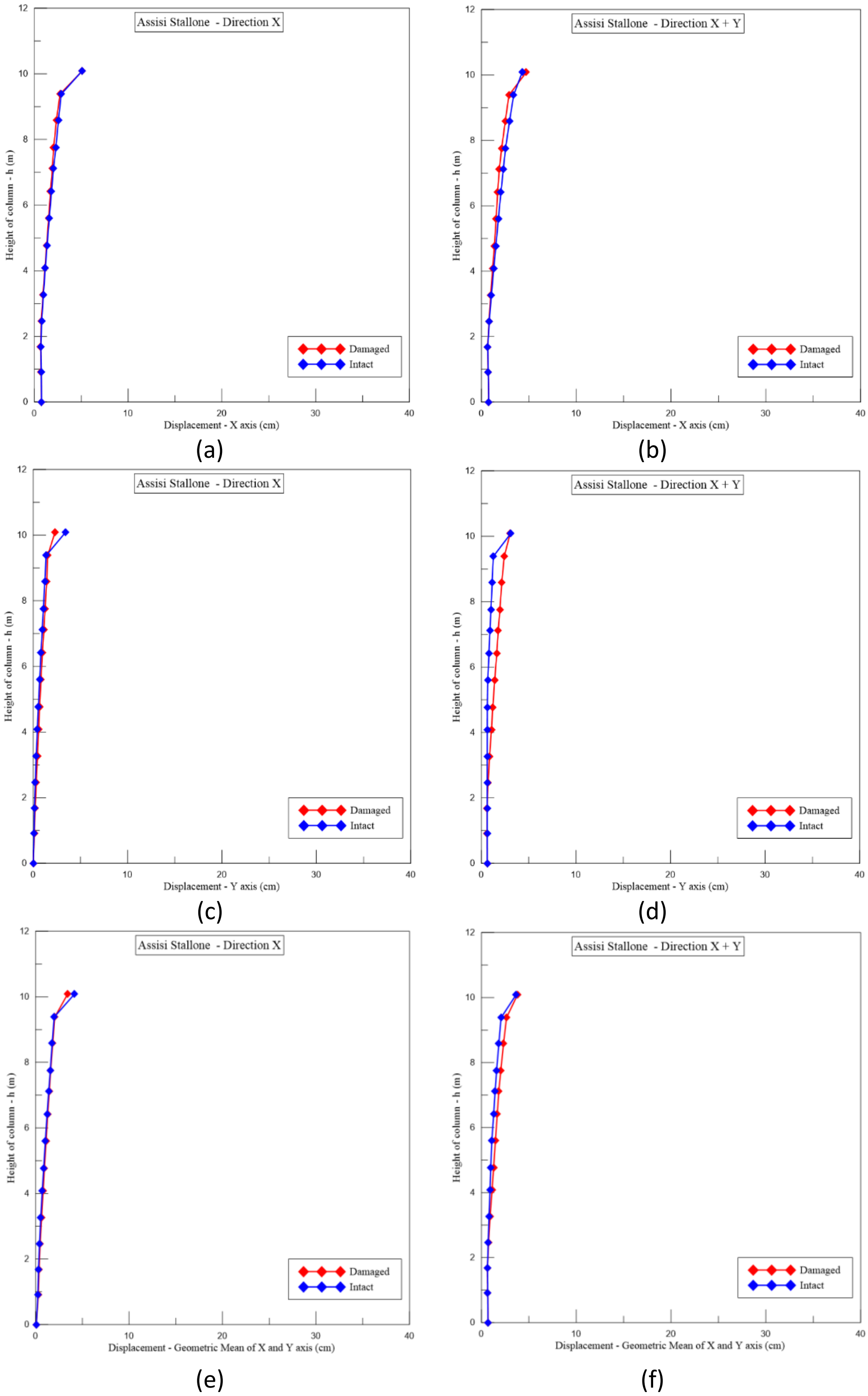



*Figure 137: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the single column in height of the column for x (a, c, e) and x + y (b, d, f) components of Assisi Stallone record.*

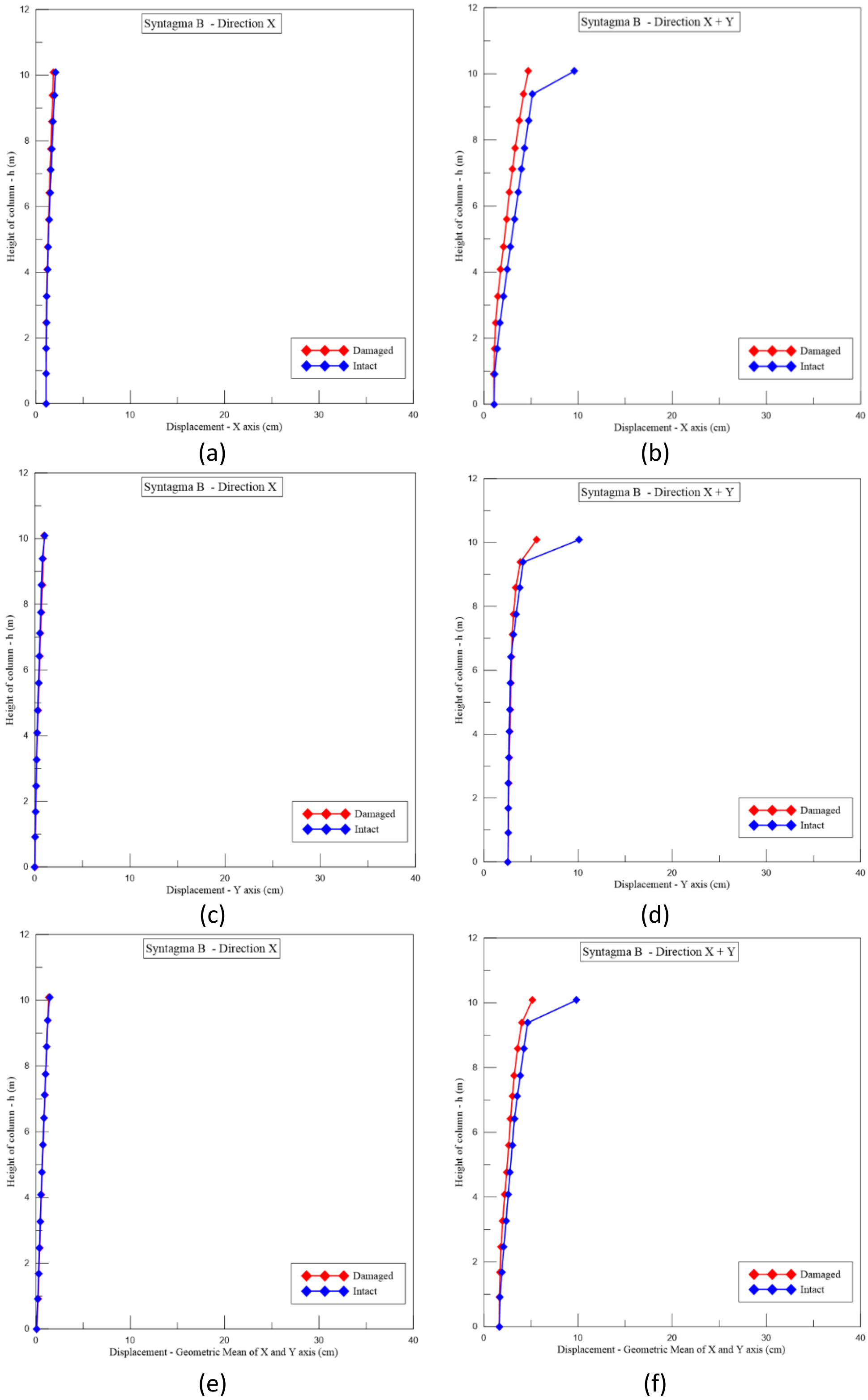



*Figure 138: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the single column in height of the column for x (a, c, e) and x + y (b, d, f) components of Syntagma B record.*

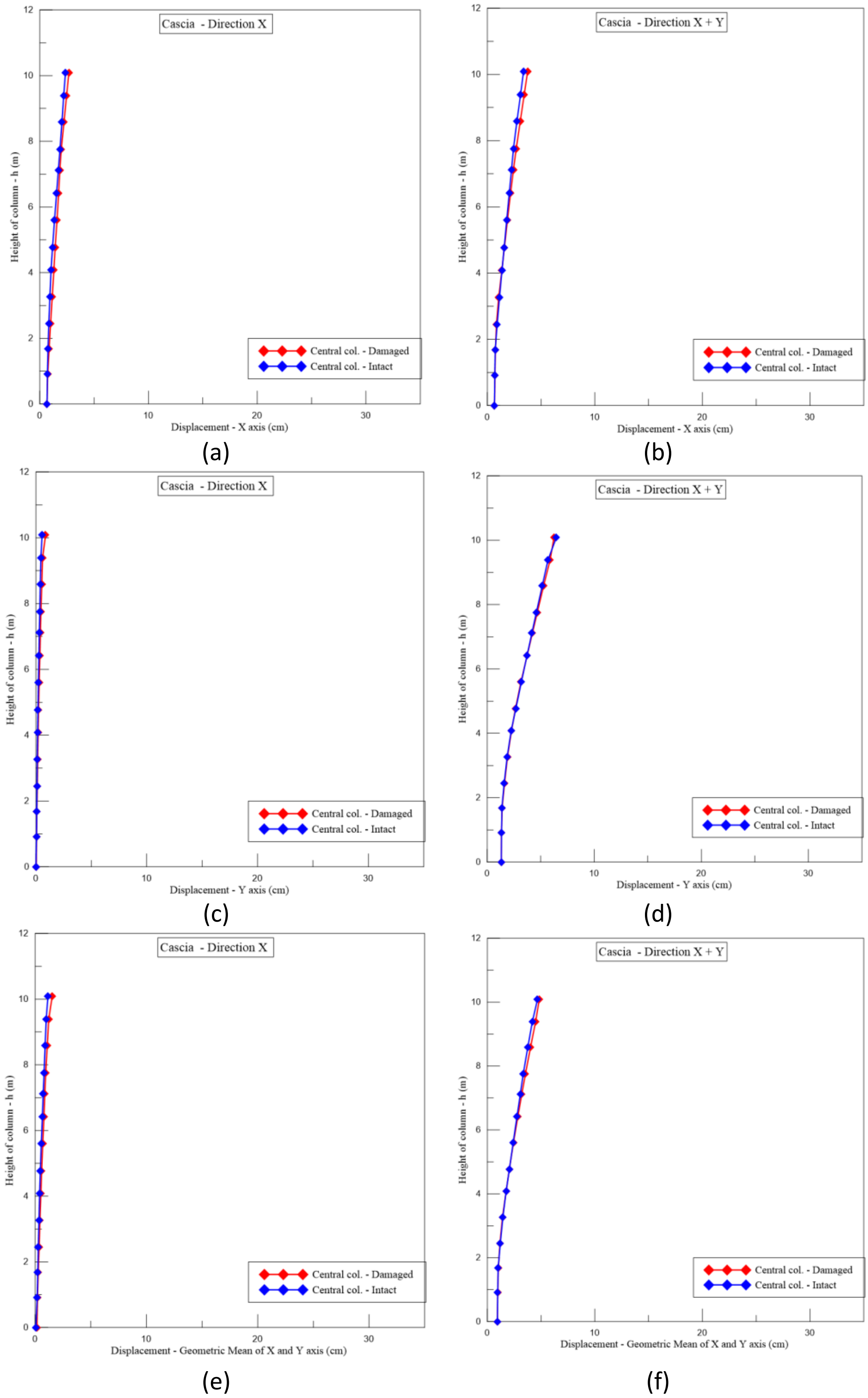



*Figure 139: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the central column of the colonnade in a line arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Cascia record.*

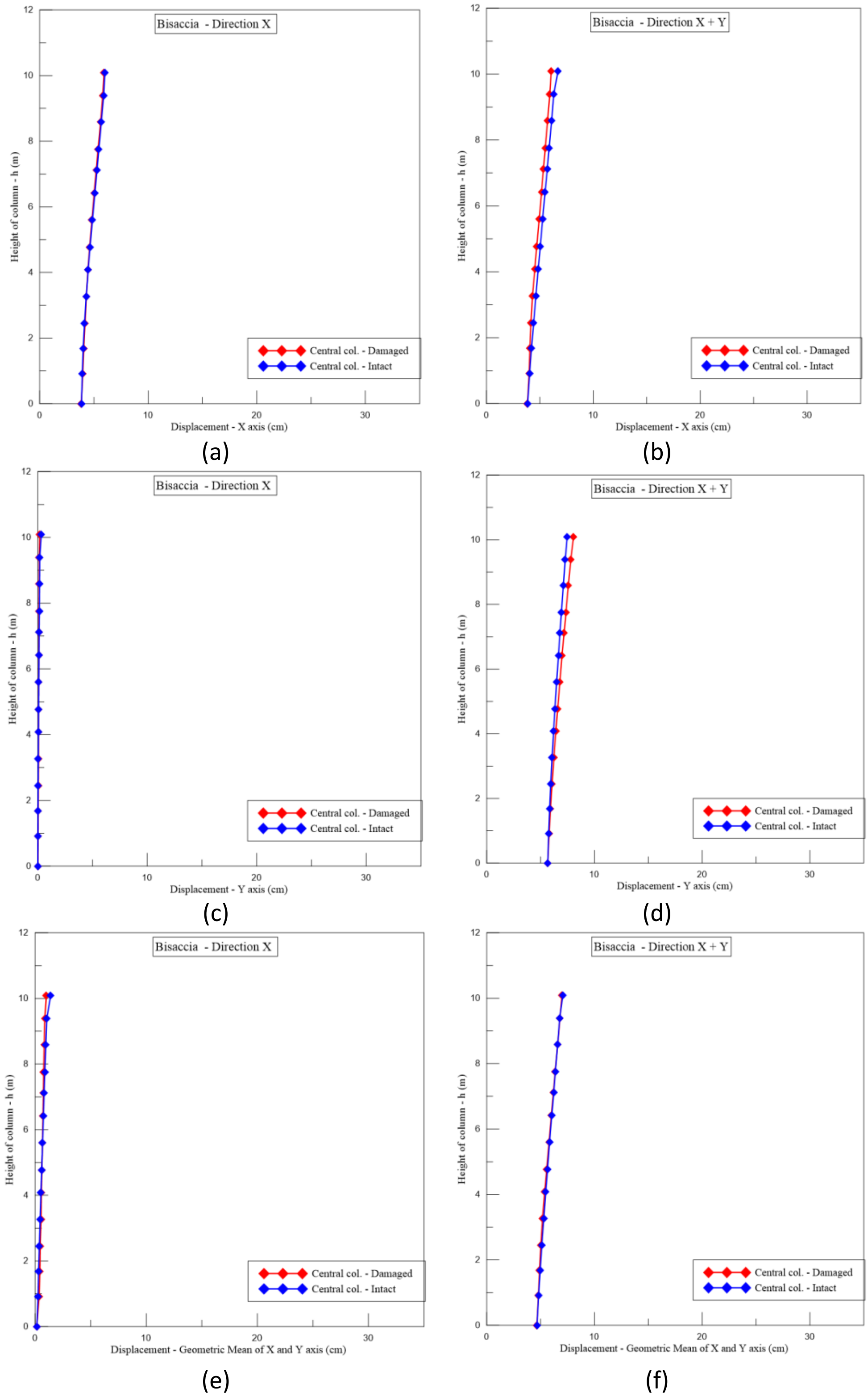



*Figure 140: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the central column of the colonnade in a line arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Bisaccia record.*

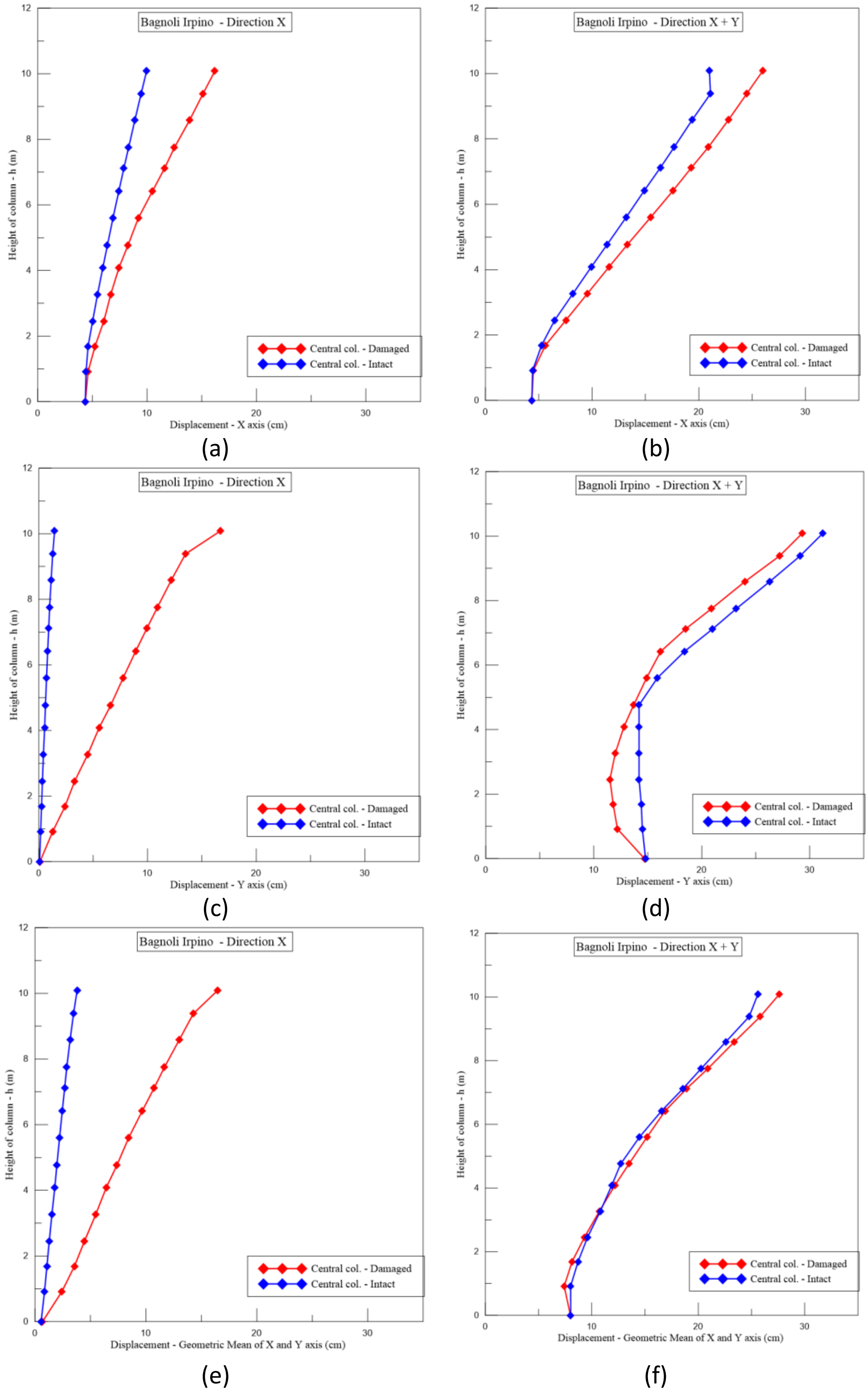



*Figure 141: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the central column of the colonnade in a line arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Bagnoli Irpino record.*

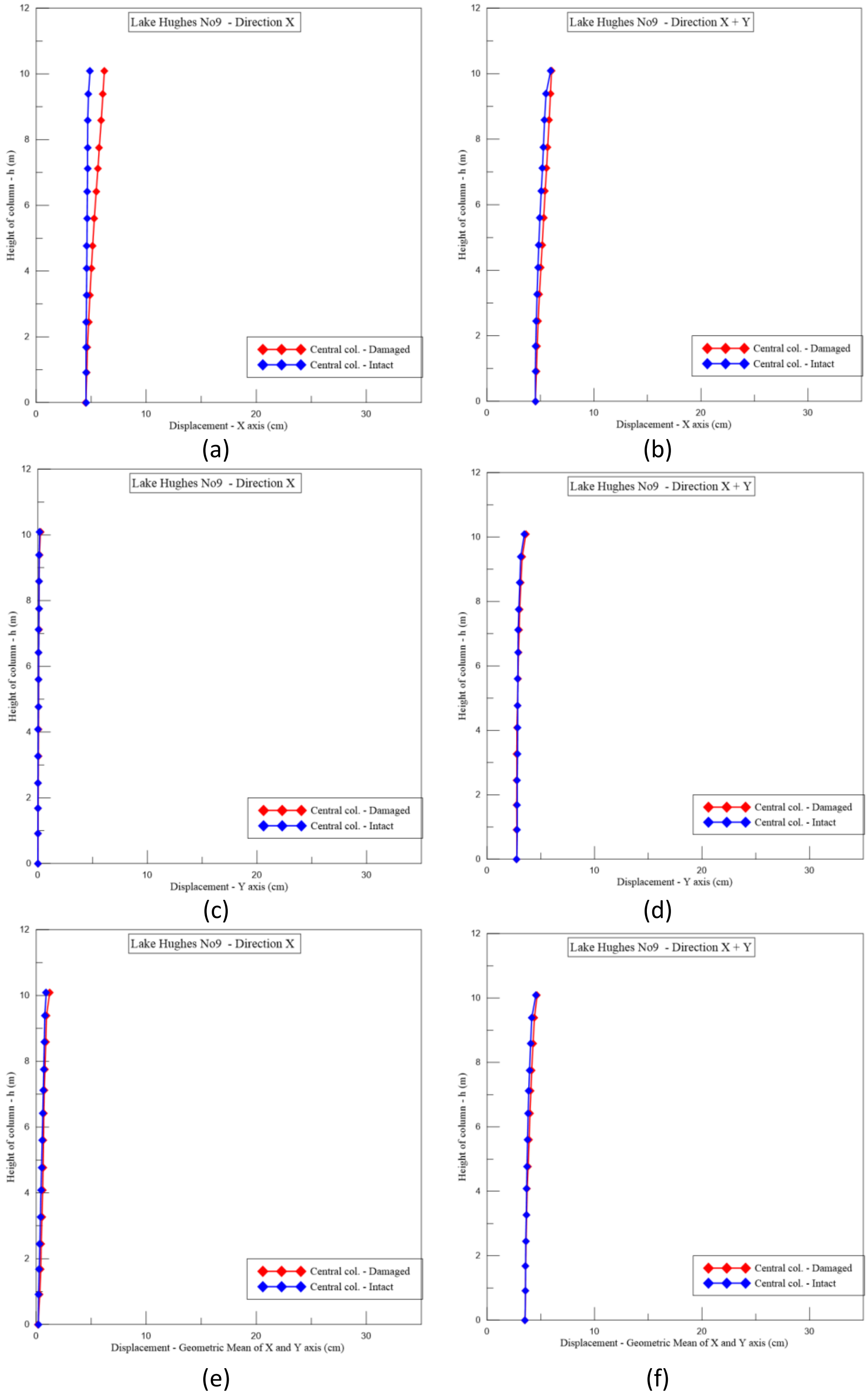



*Figure 142: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the central column of the colonnade in a line arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Lake Hughes No9 record.*

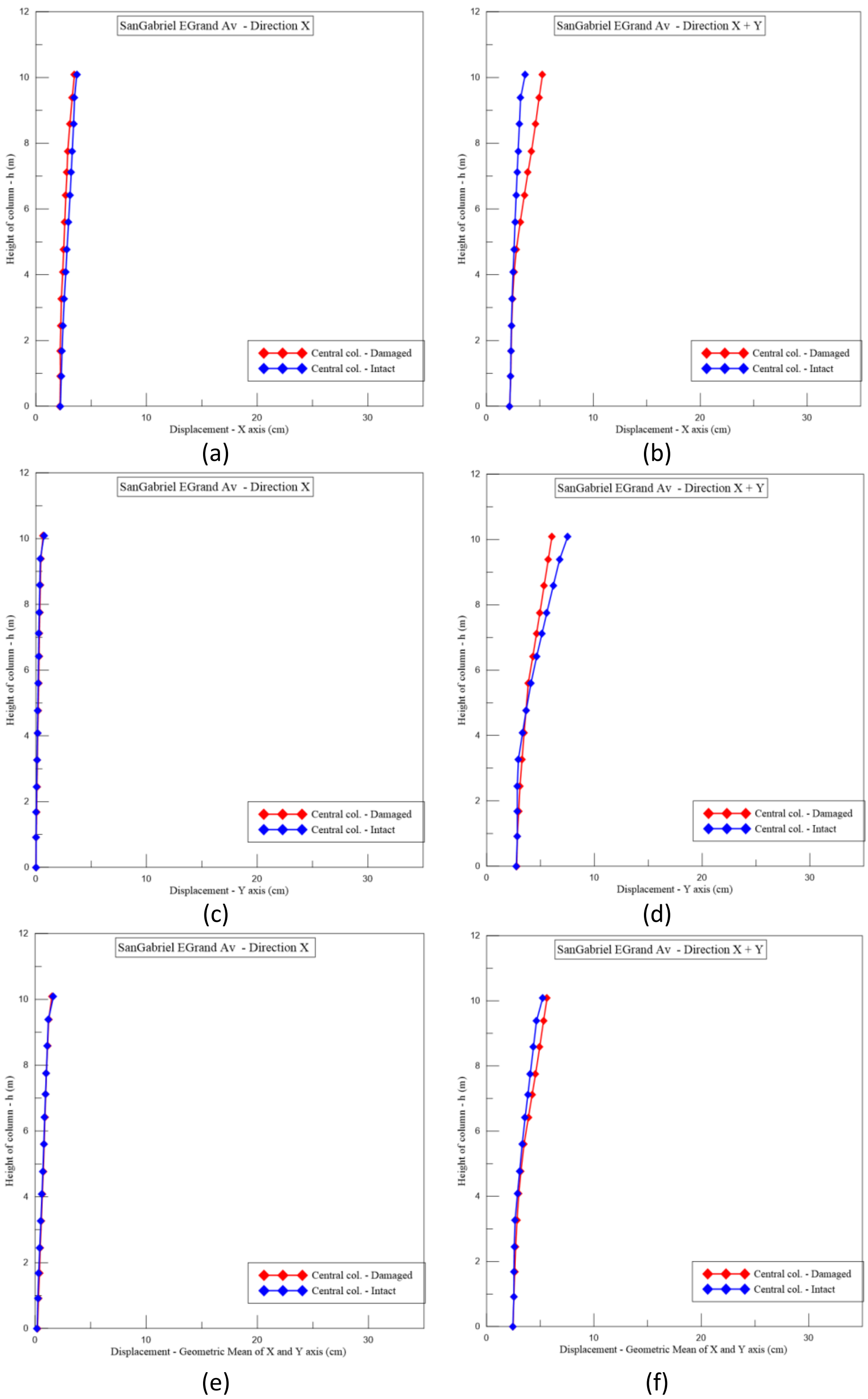



*Figure 143: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the central column of the colonnade in a line arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of San Gabriel (E. Grand Ave.) record.*

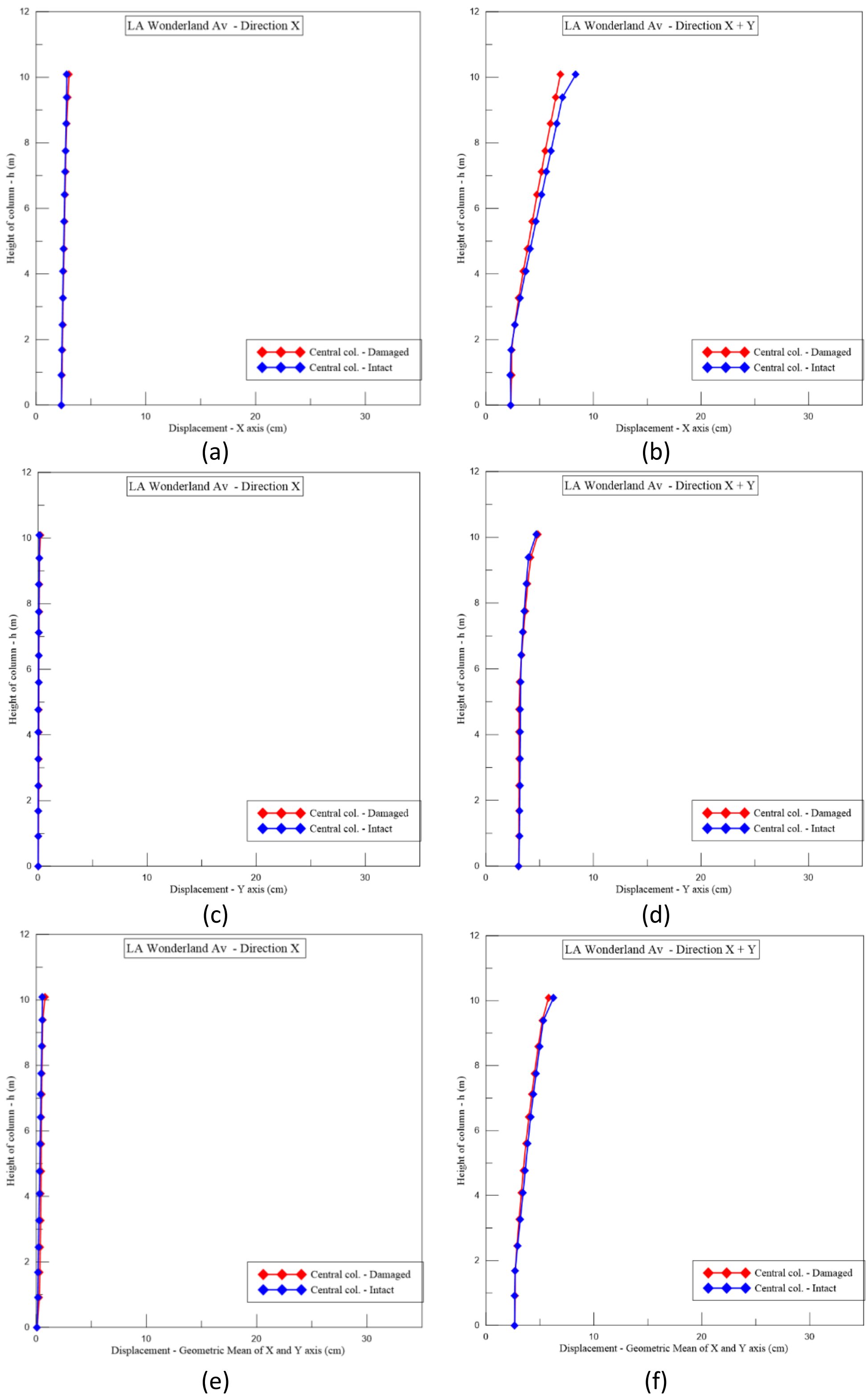



*Figure 144: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the central column of the colonnade in a line arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of L.A. Wonderland Av. record.*

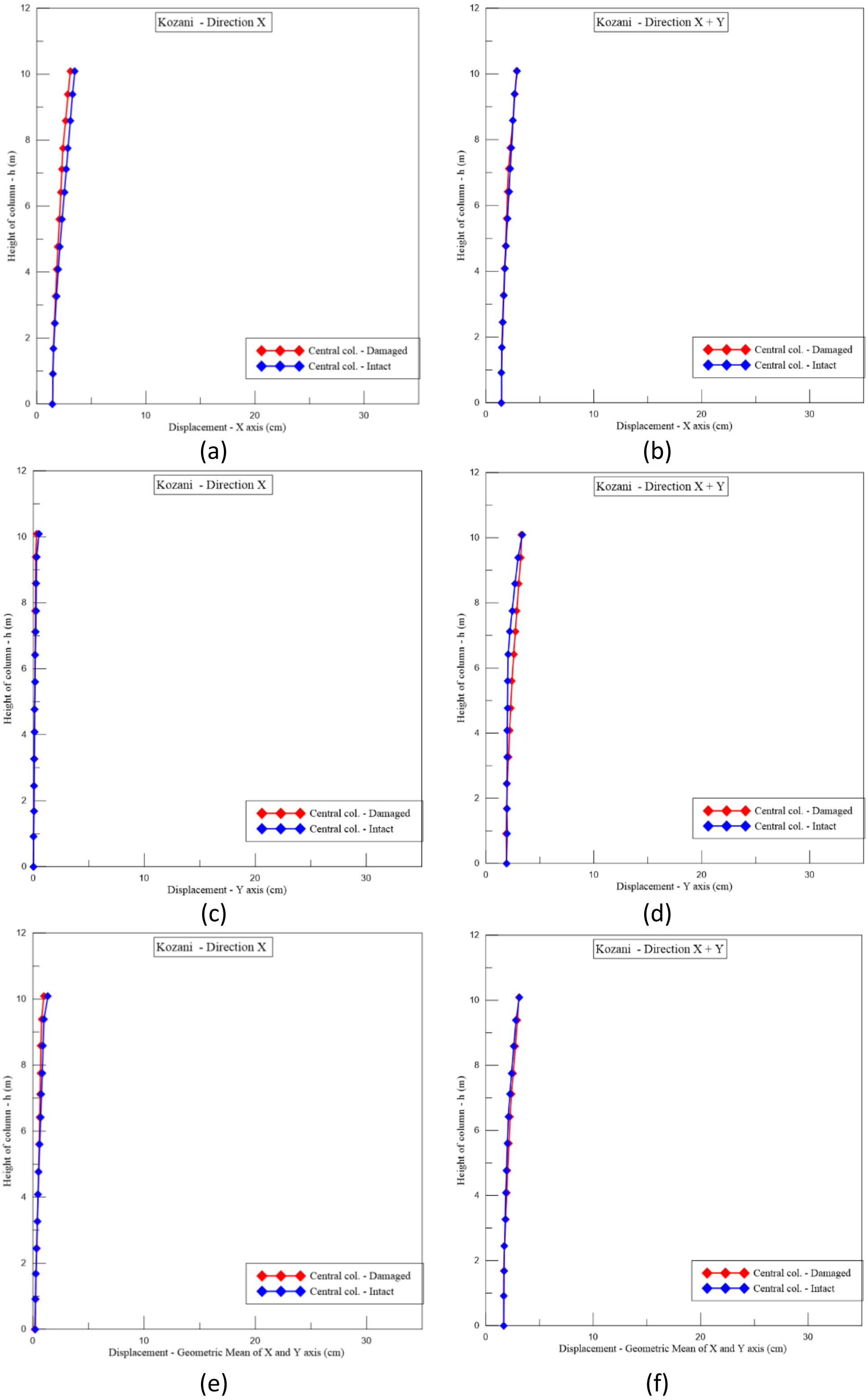



*Figure 145: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the central column of the colonnade in a line arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Kozani record.*

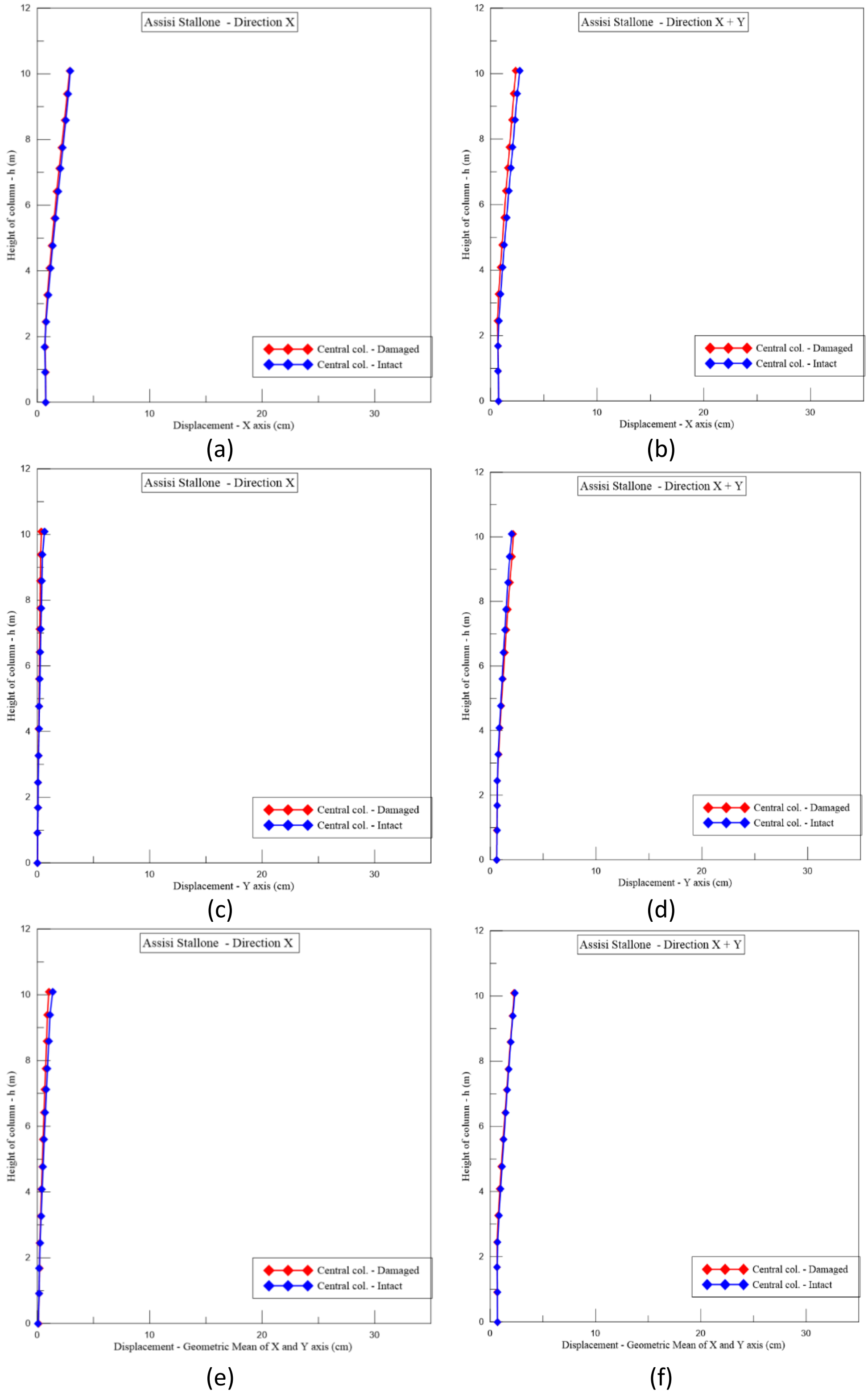



*Figure 146: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the central column of the colonnade in a line arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Assisi Stallone record.*

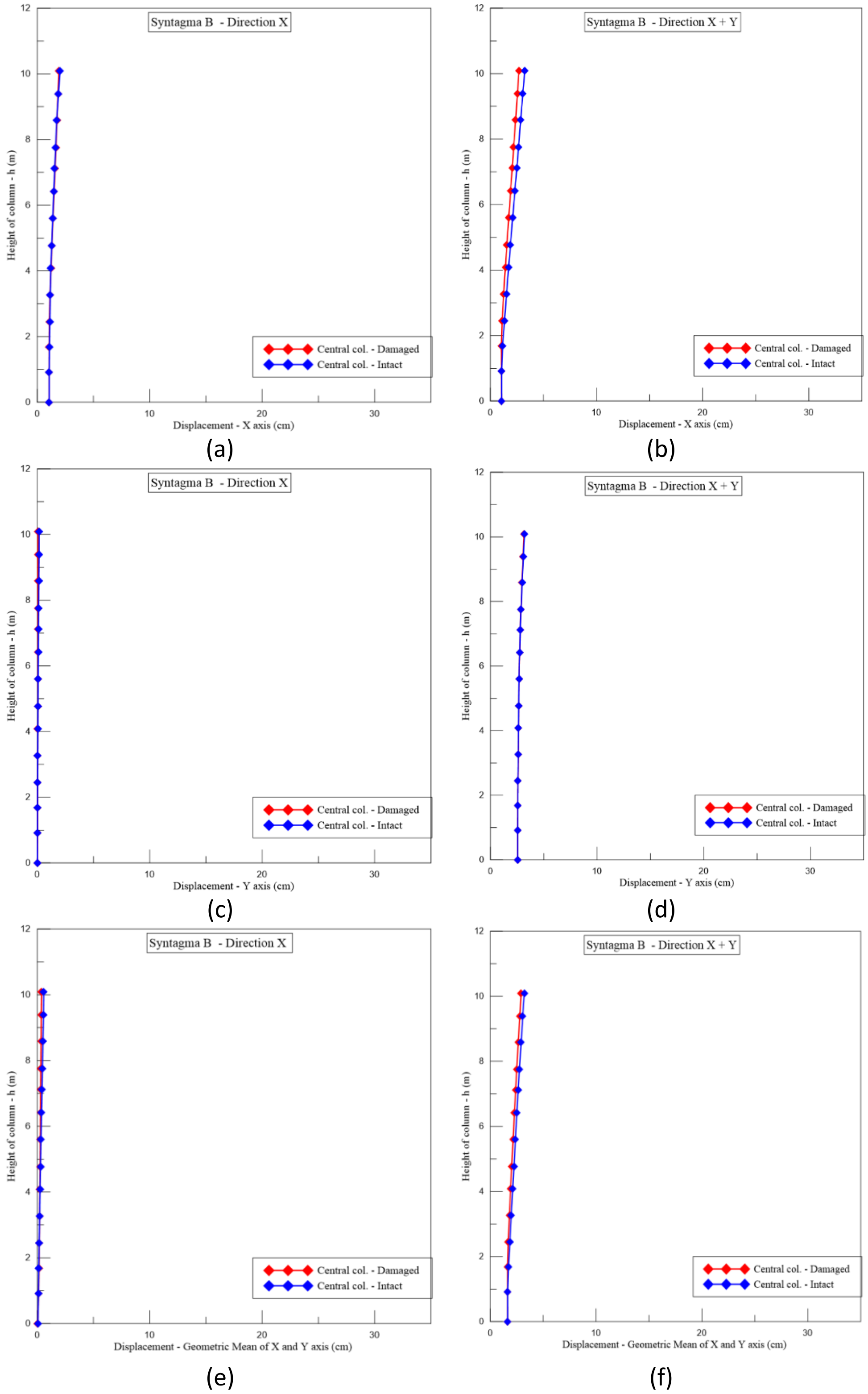



*Figure 147: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the central column of the colonnade in a line arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Syntagma B record.*

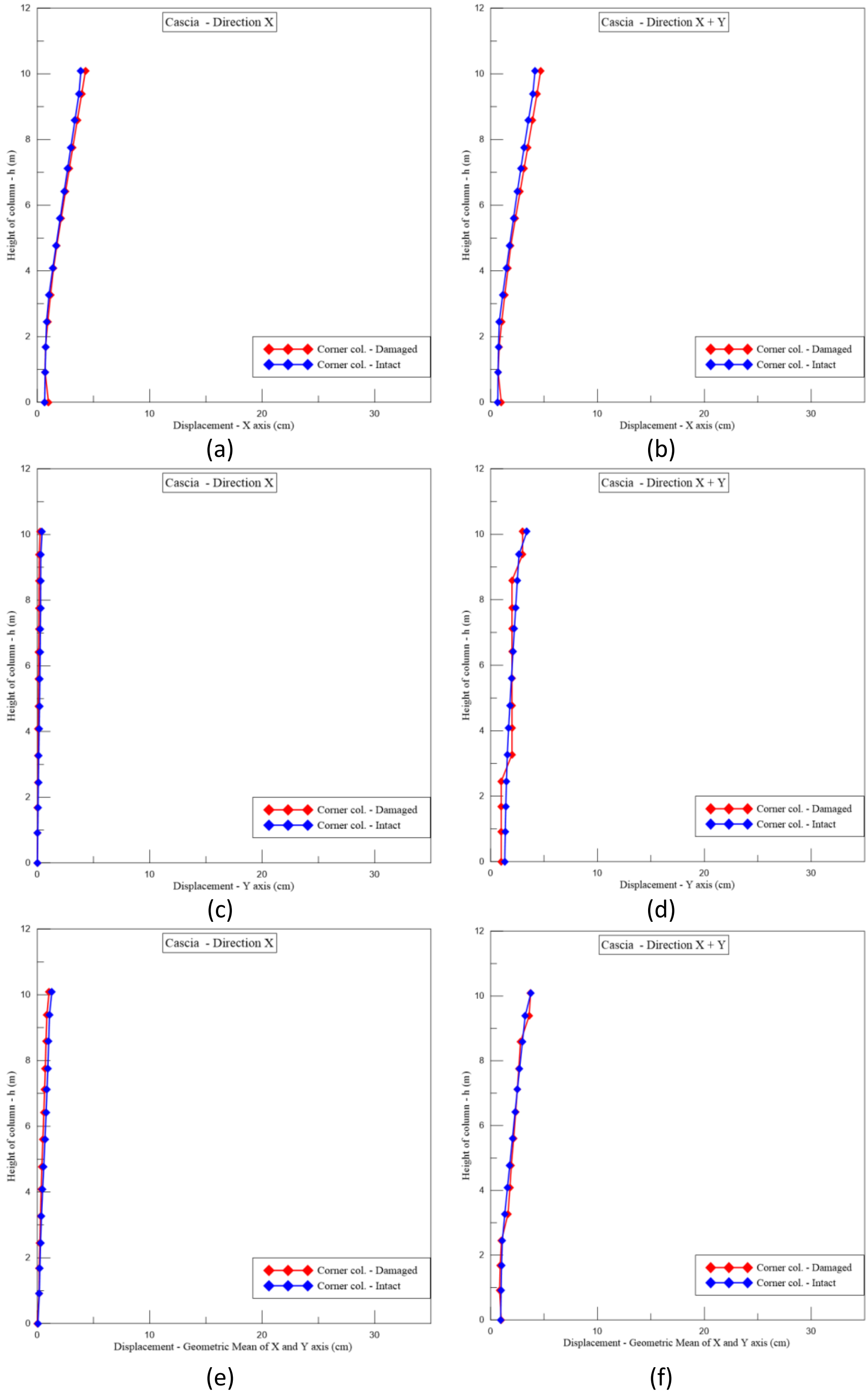



*Figure 148: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Cascia record.*

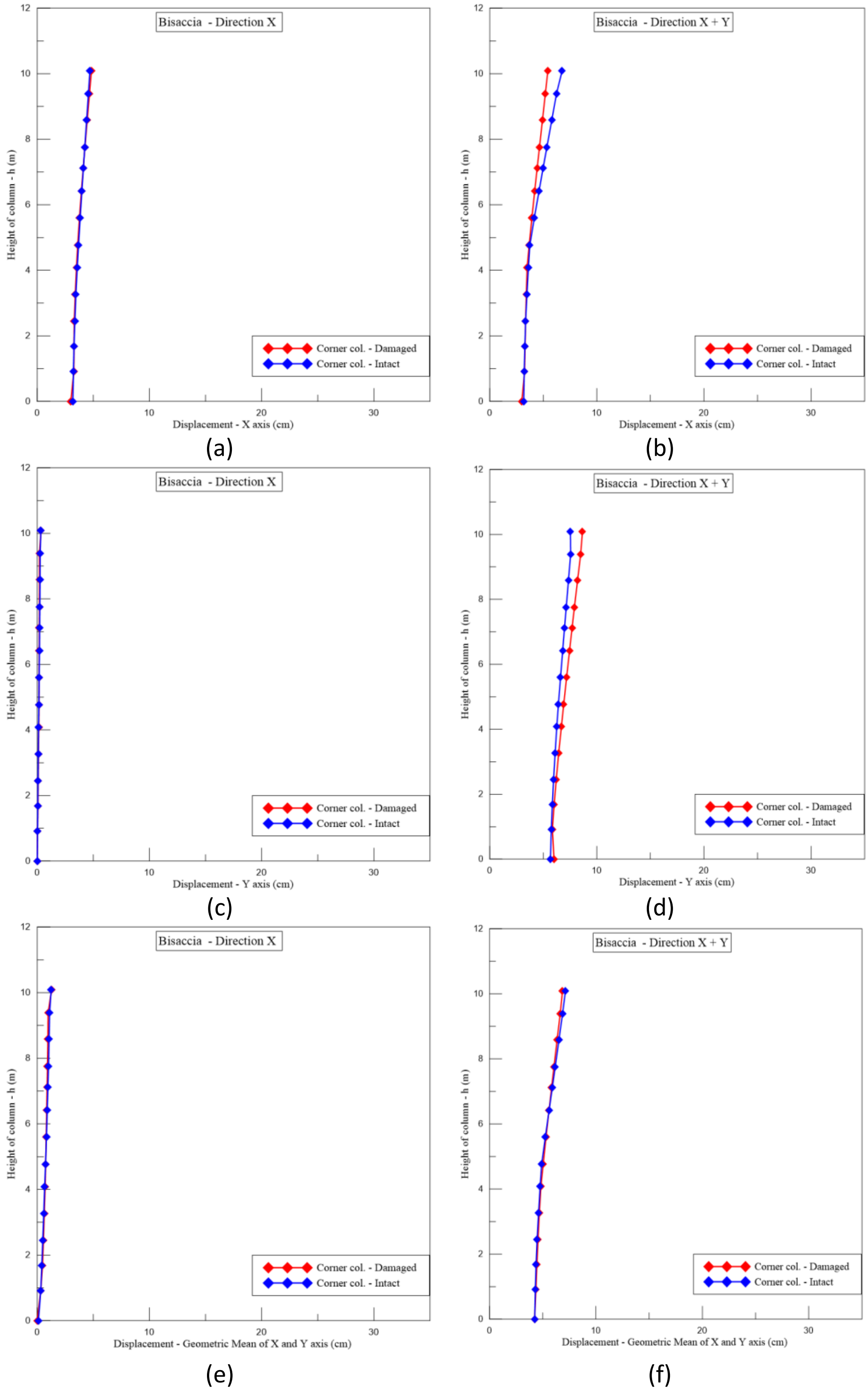



*Figure 149: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Bisaccia record.*

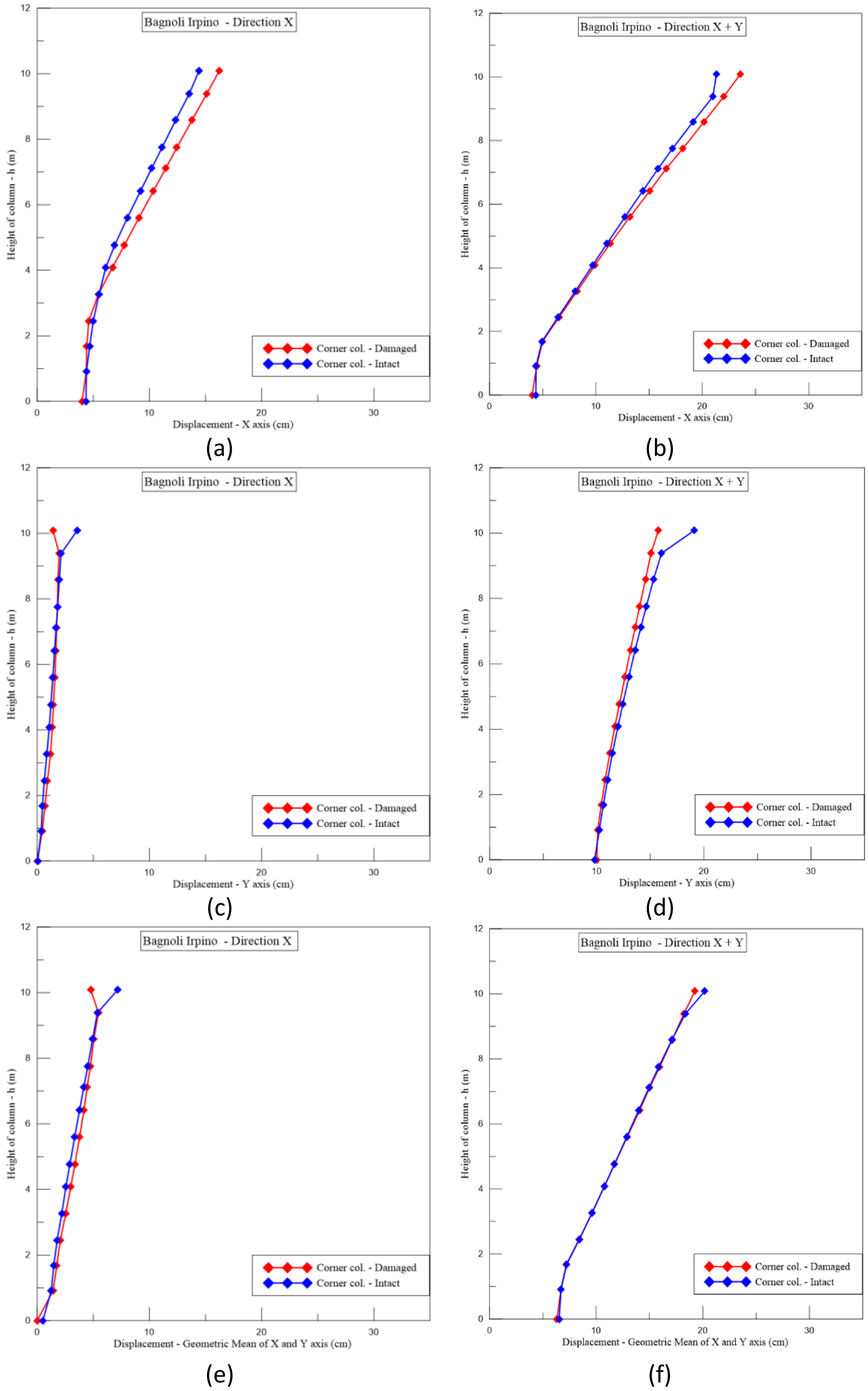



*Figure 150: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Bagnoli Irpino record.*

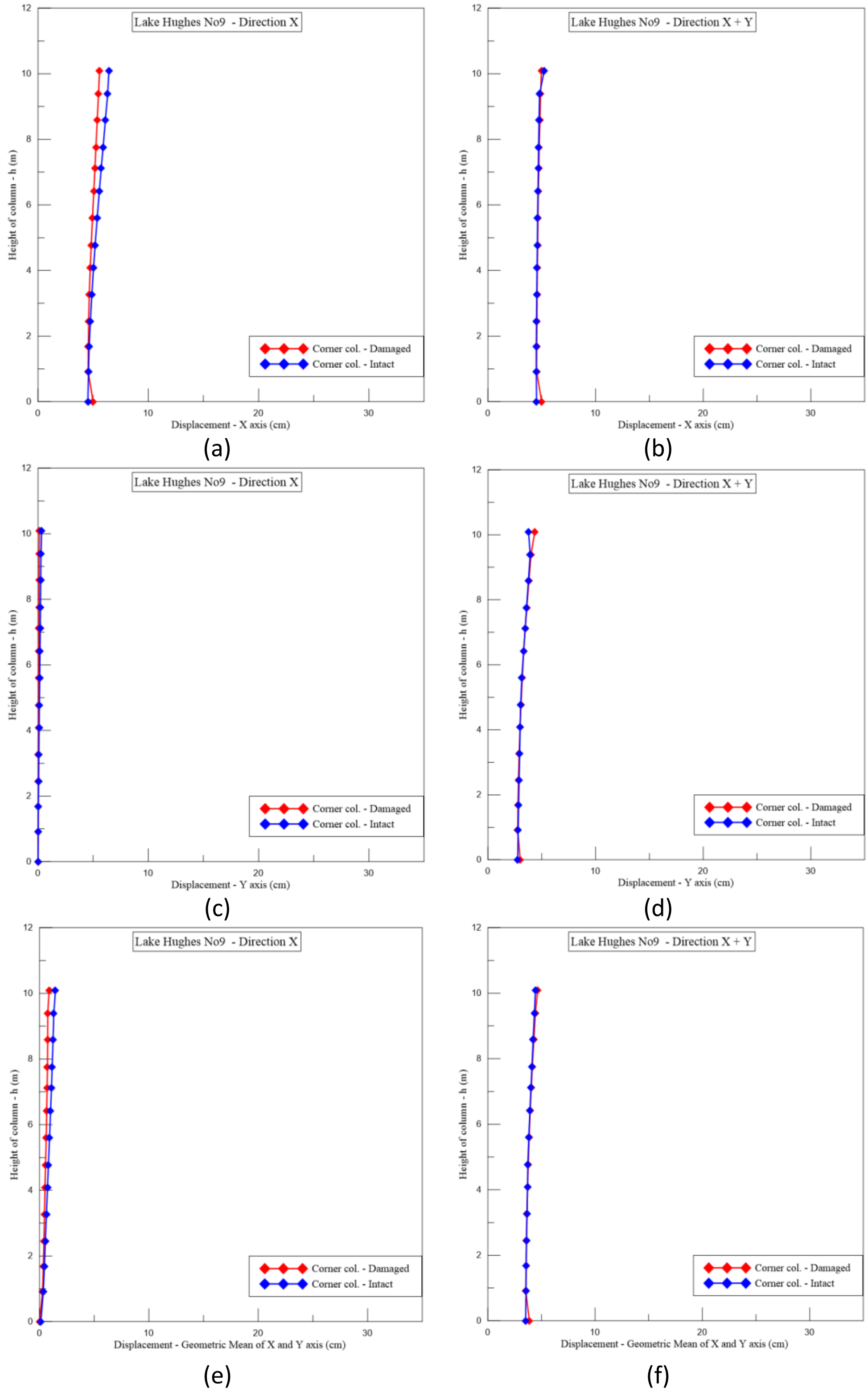



*Figure 151: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Lake Hughes No9 record.*

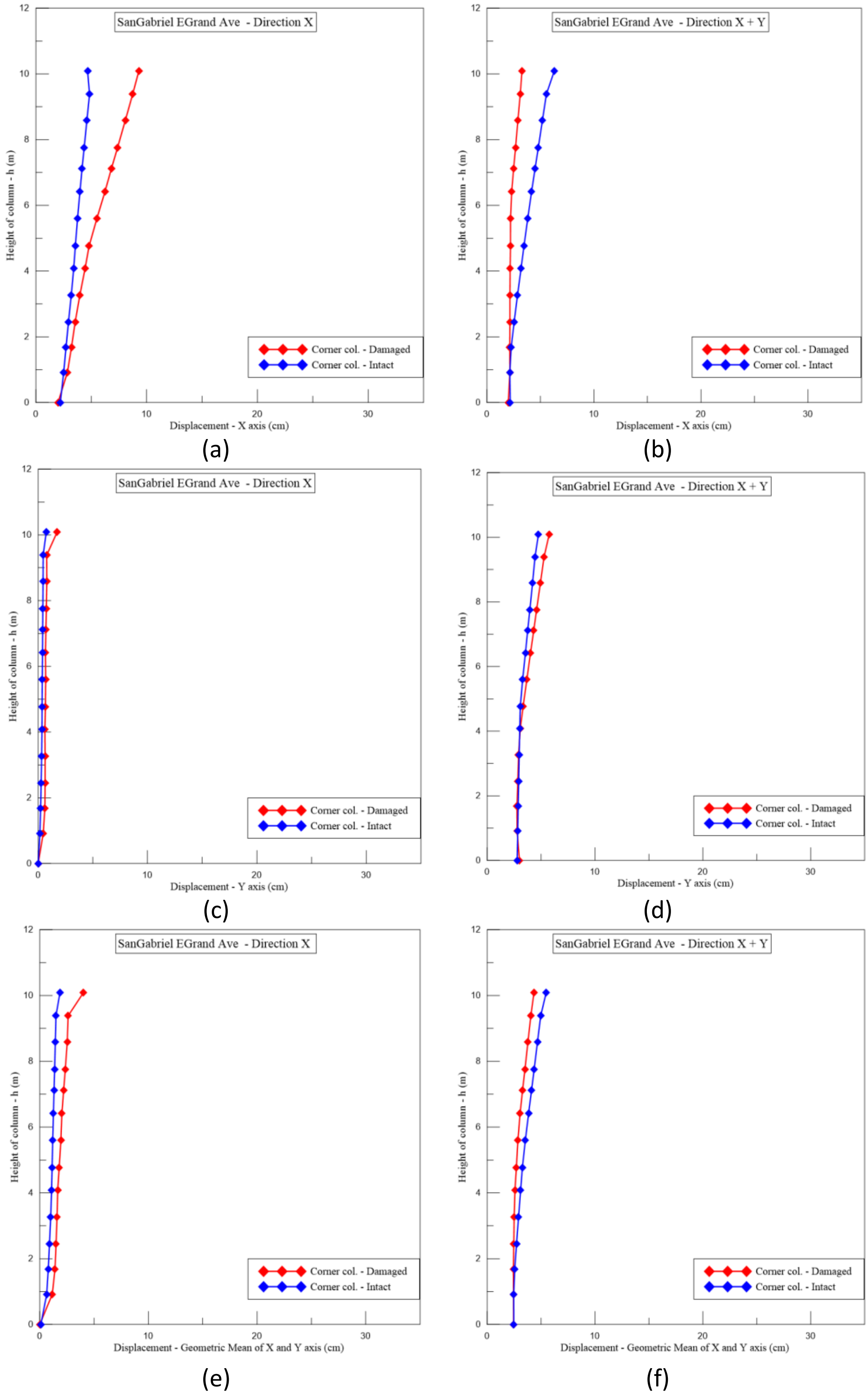



*Figure 152: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of San Gabriel (E. Grand Ave.) record.*

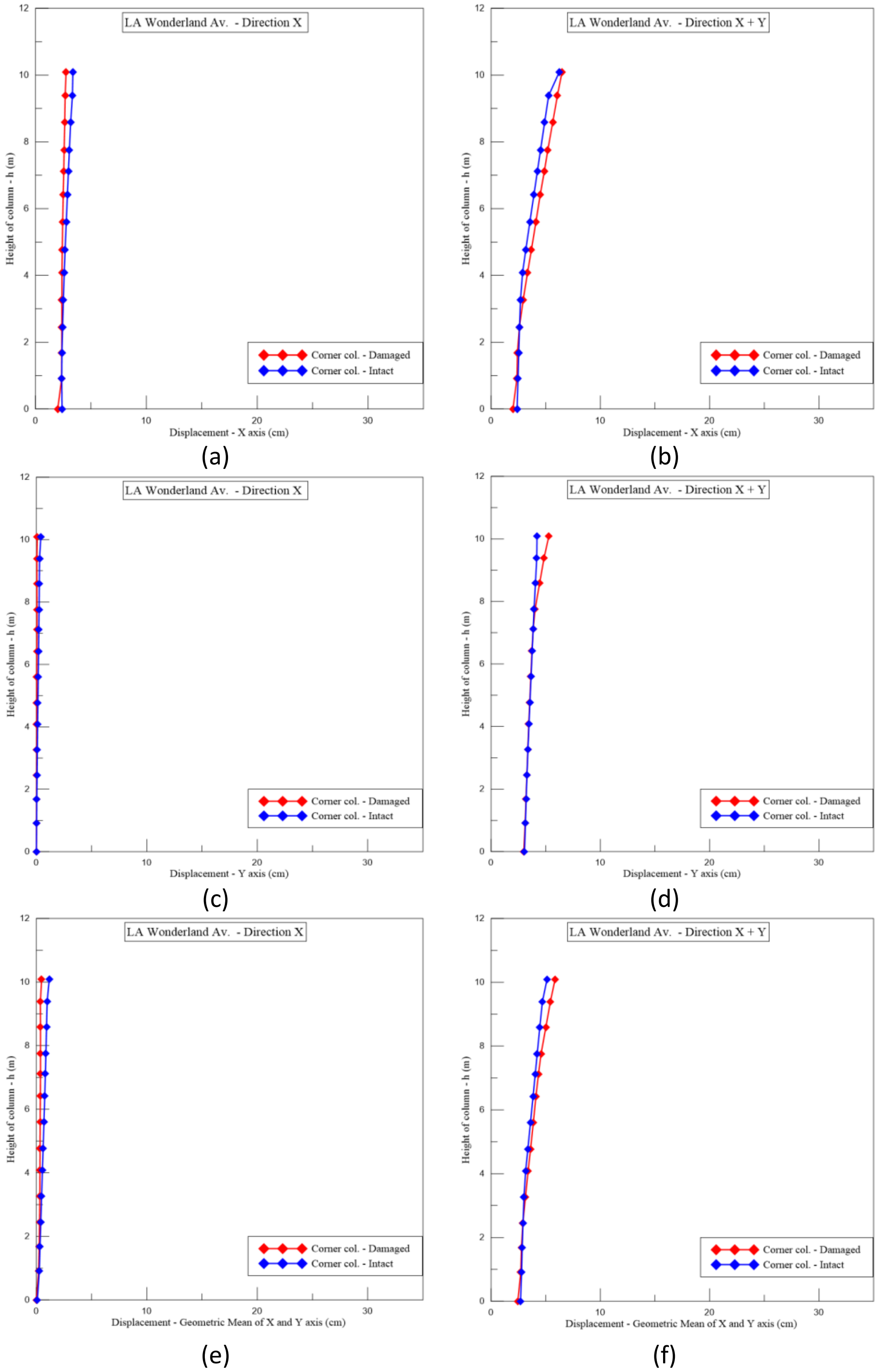



*Figure 153: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of L.A. Wonderland Av. record.*

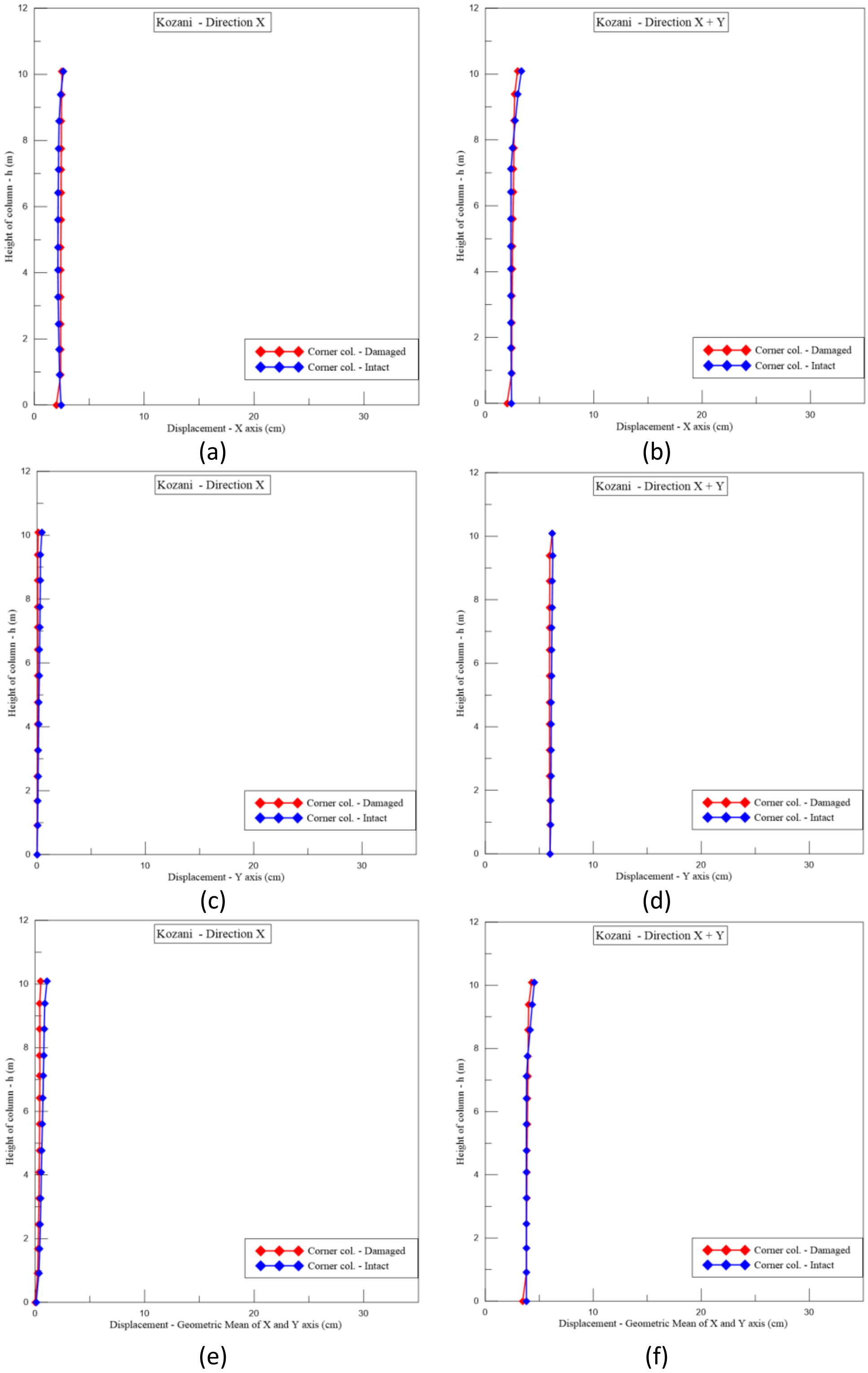



*Figure 154: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Kozani record.*

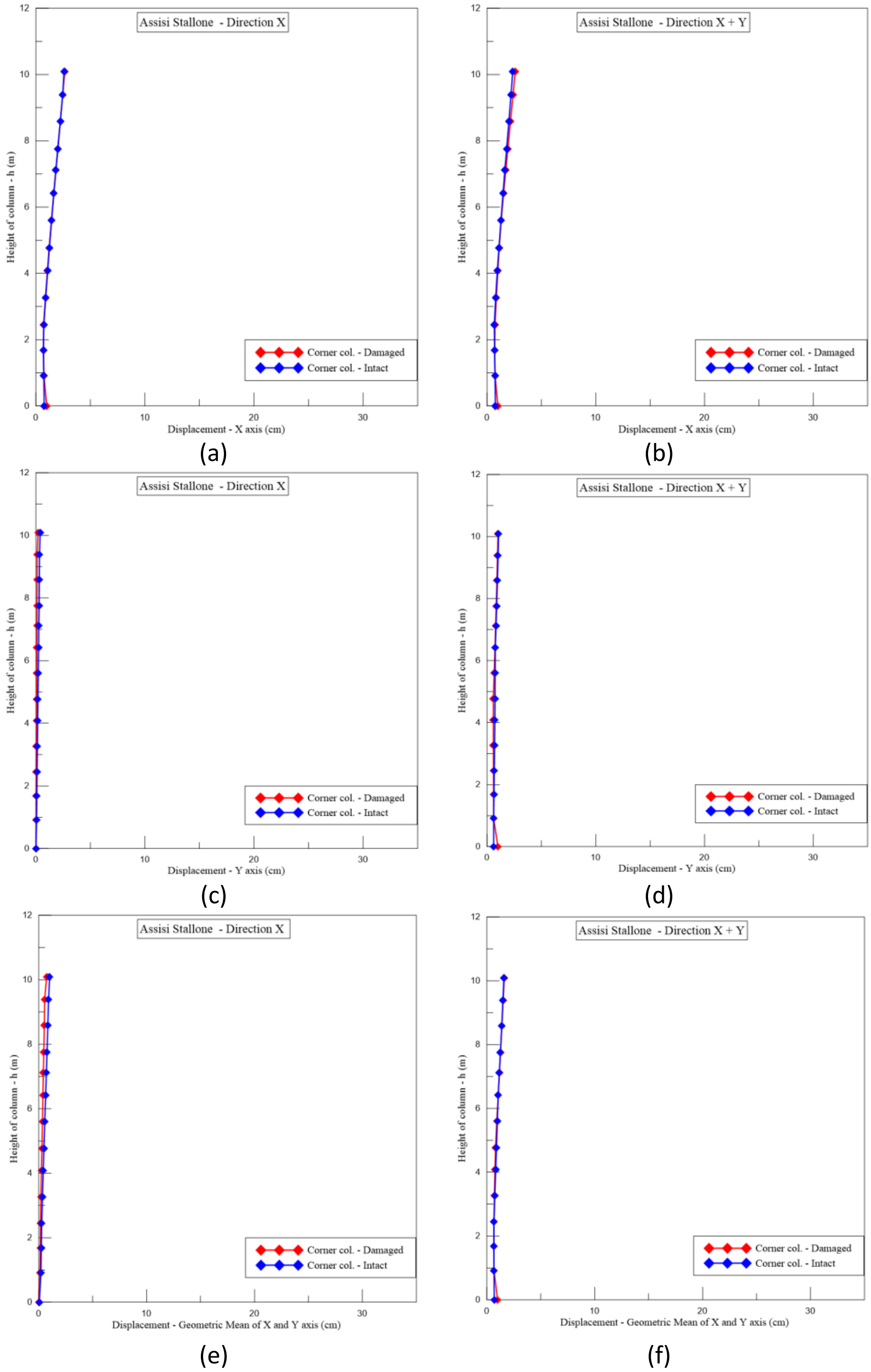



*Figure 155: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Assisi Stallone record.*

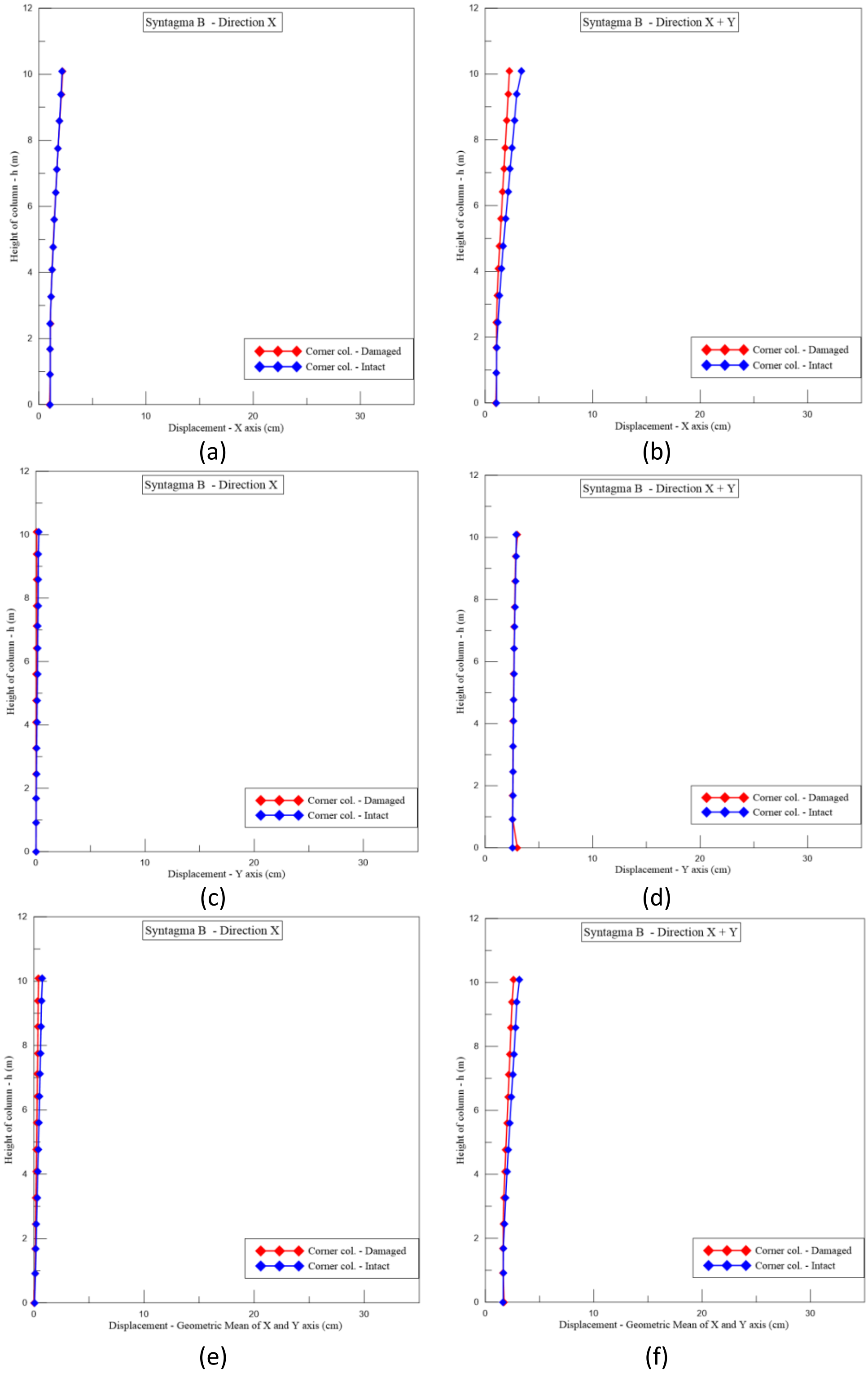



*Figure 156: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged and intact model of the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Syntagma B record.*

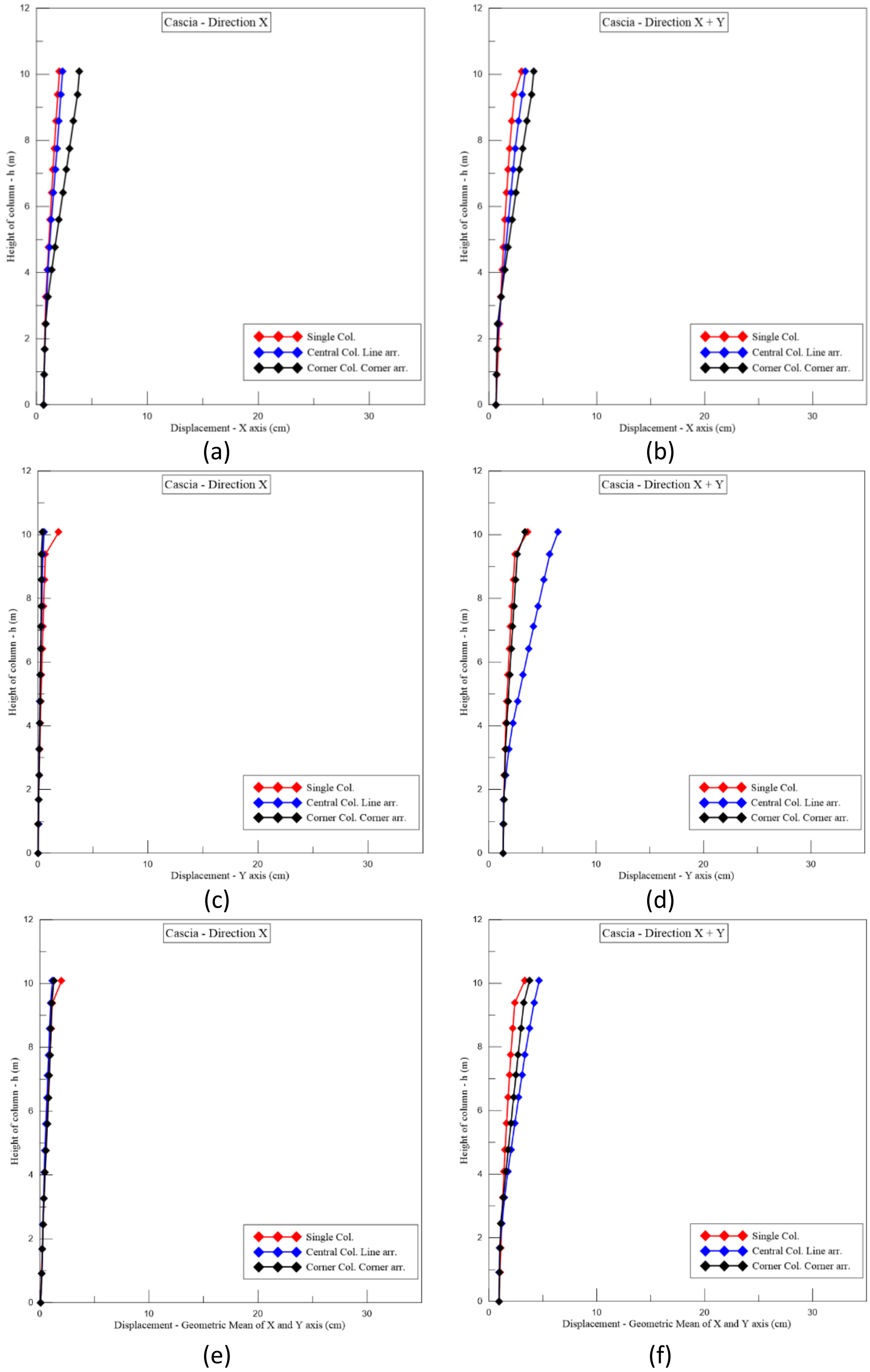



*Figure 157: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the intact model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Cascia record.*

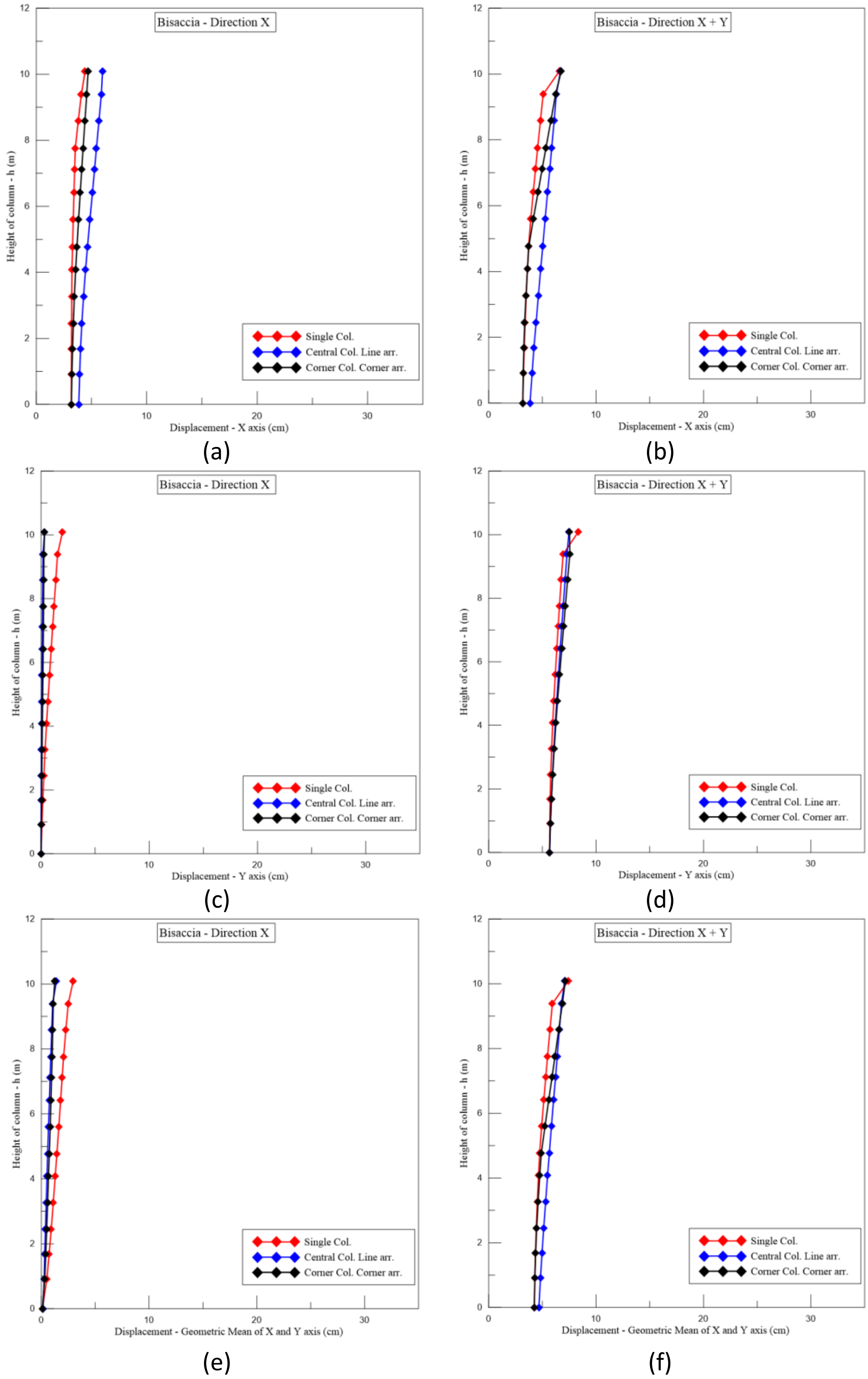



*Figure 158: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the intact model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Bisaccia record.*

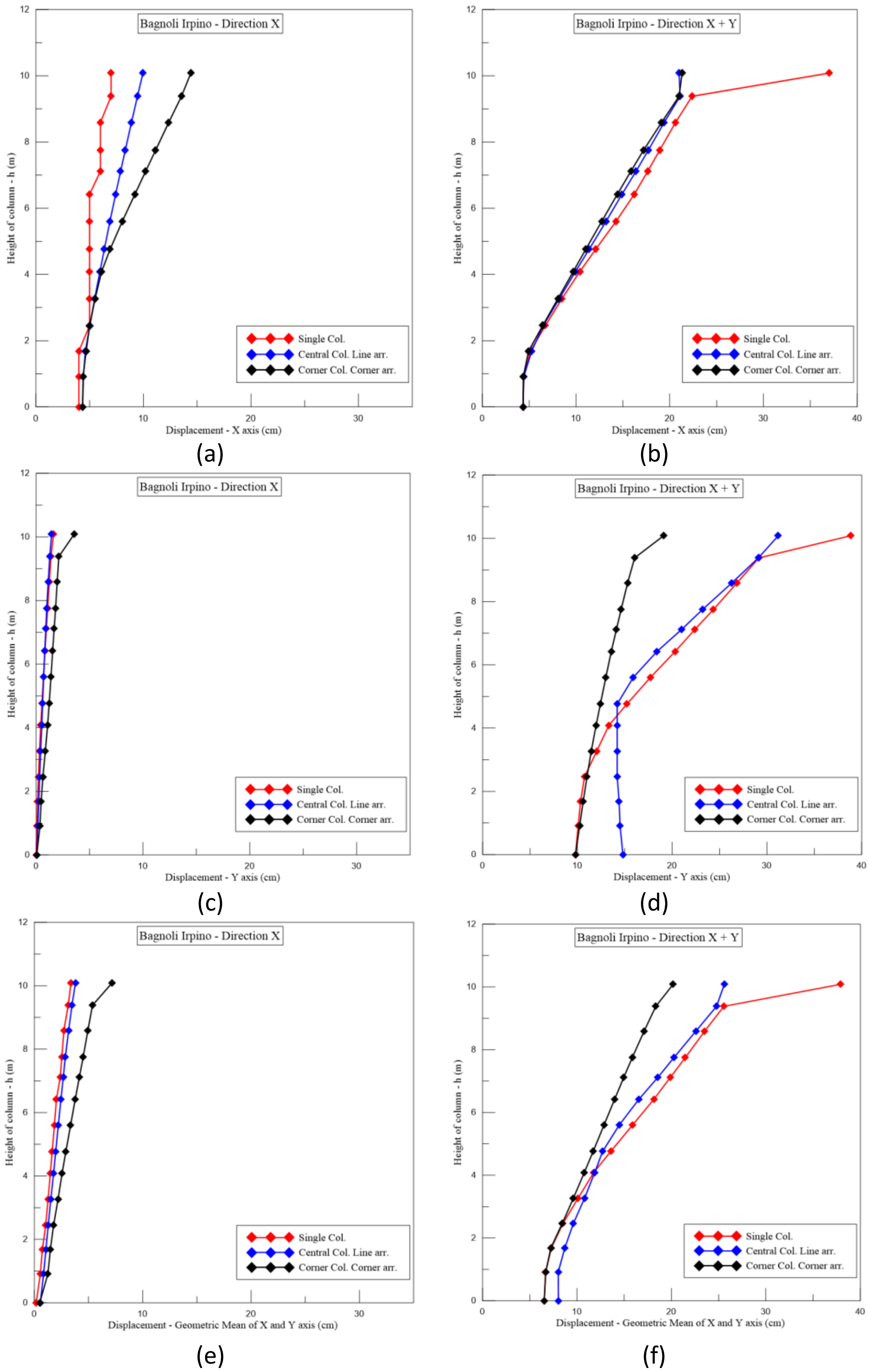



*Figure 159: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the intact model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Bagnoli Irpino record.*

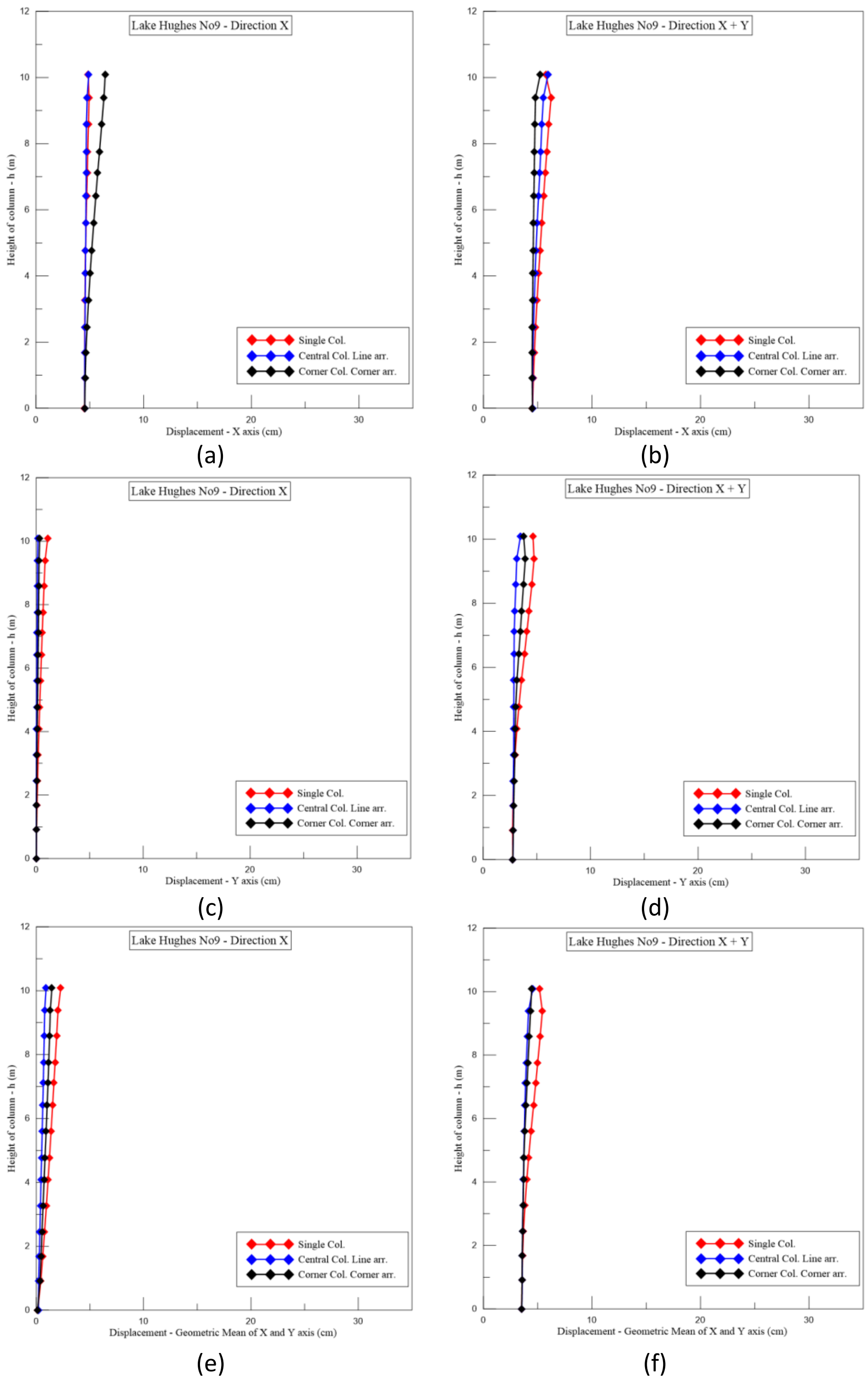



*Figure 160: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the intact model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Lake Hughes No9 record.*

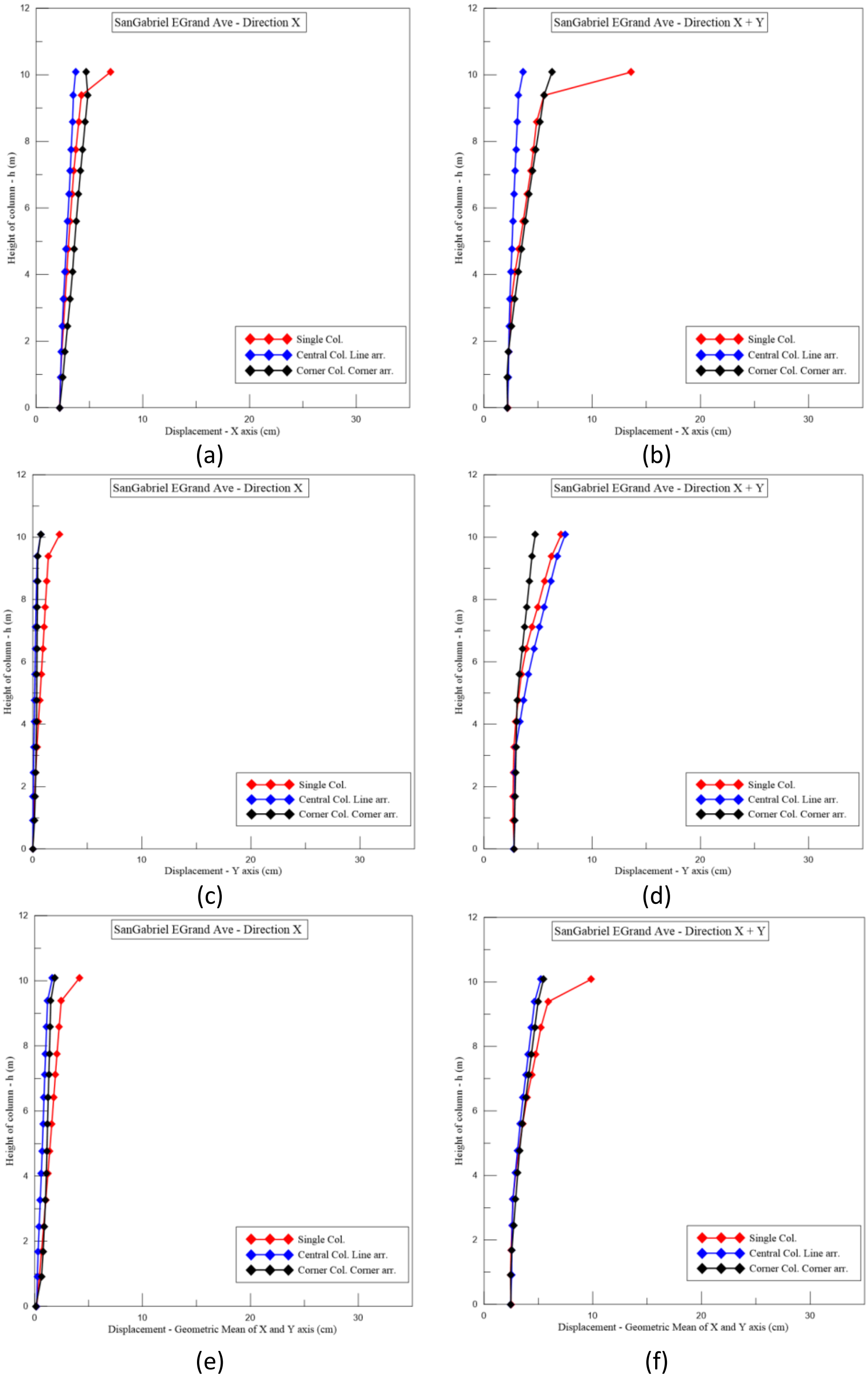



*Figure 161: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the intact model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of San Gabriel (E. Grand Ave.) record.*

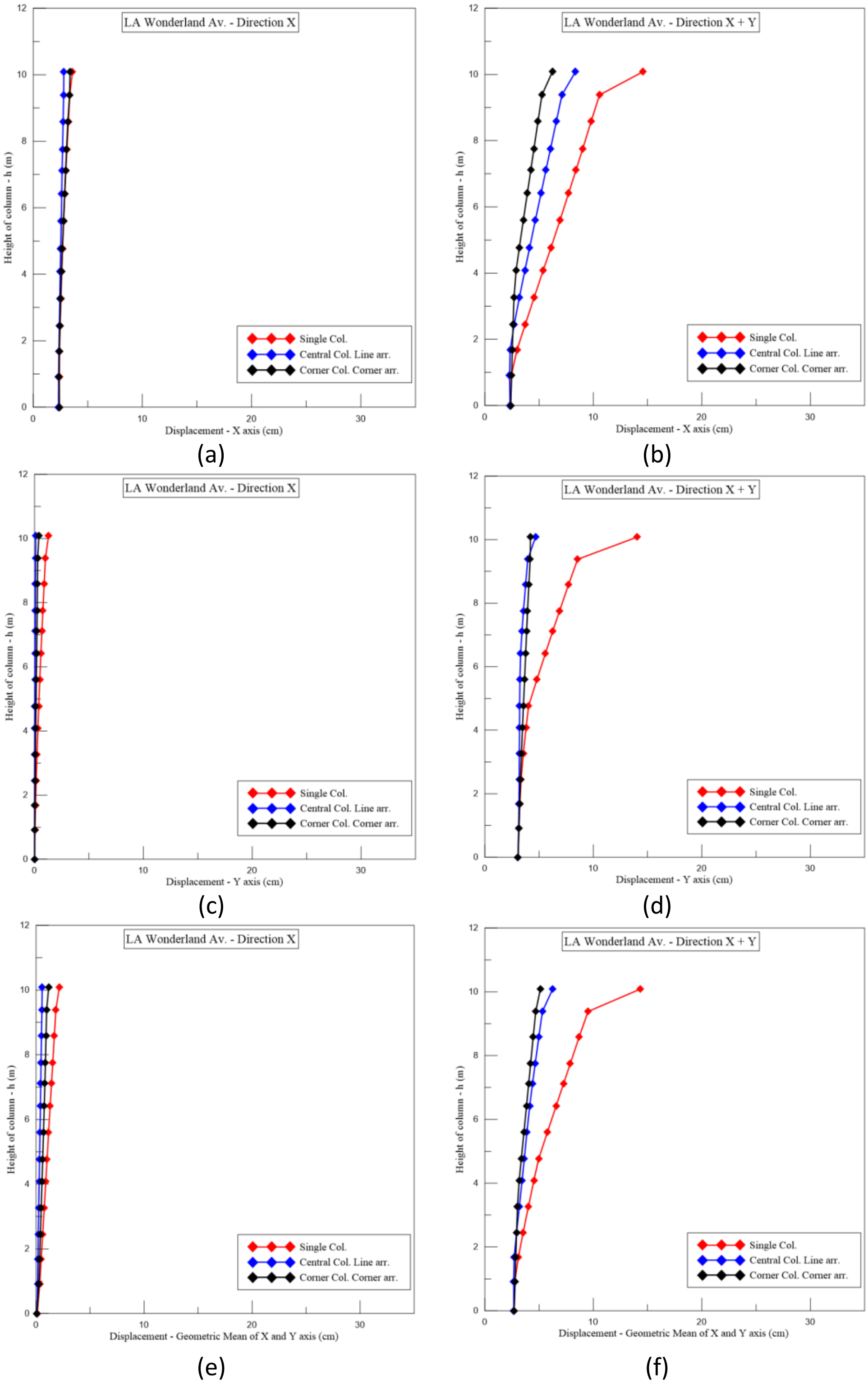



*Figure 162: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the intact model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of L.A. Wonderland Av.  record.*

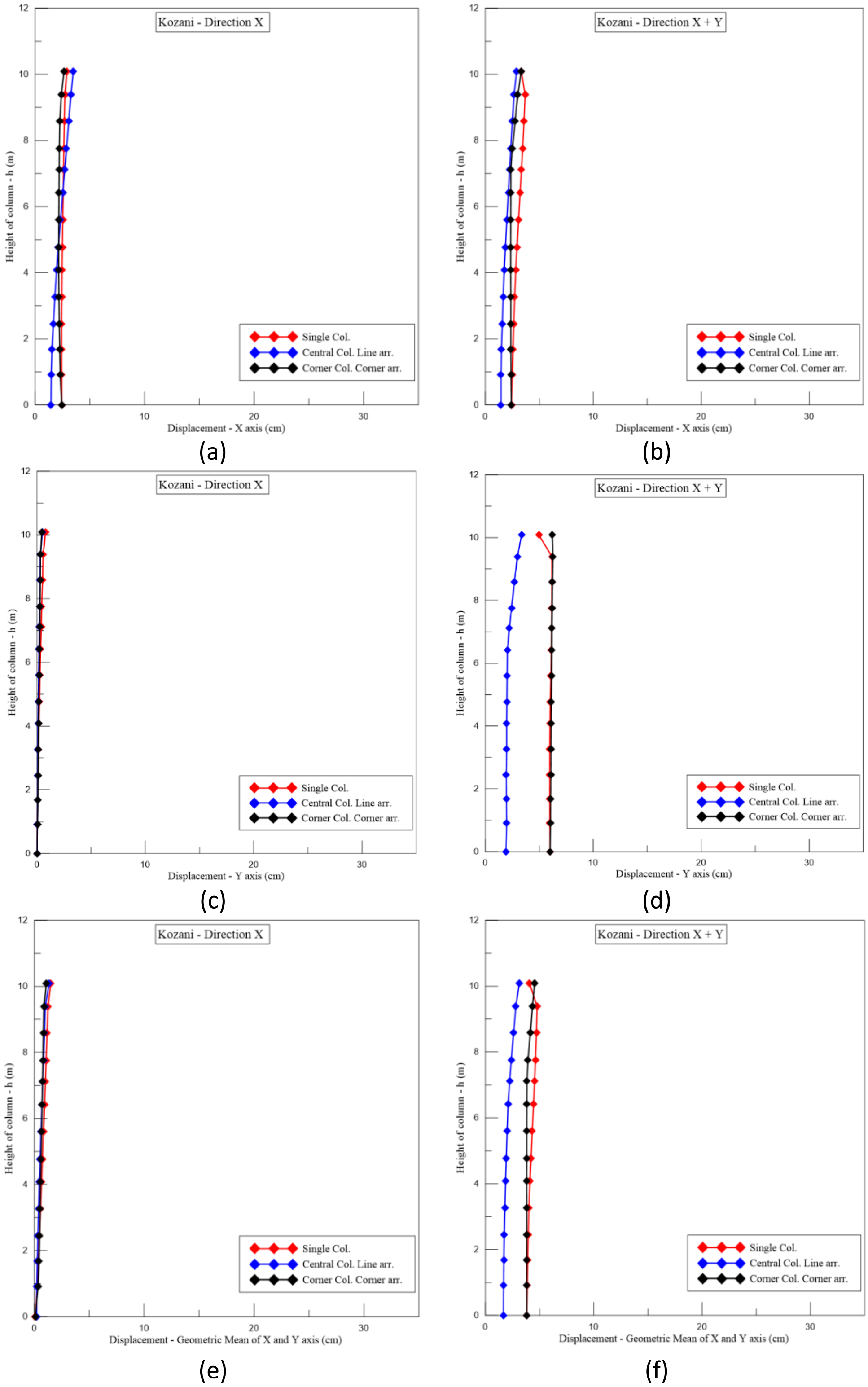



*Figure 163: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the intact model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Kozani record.*

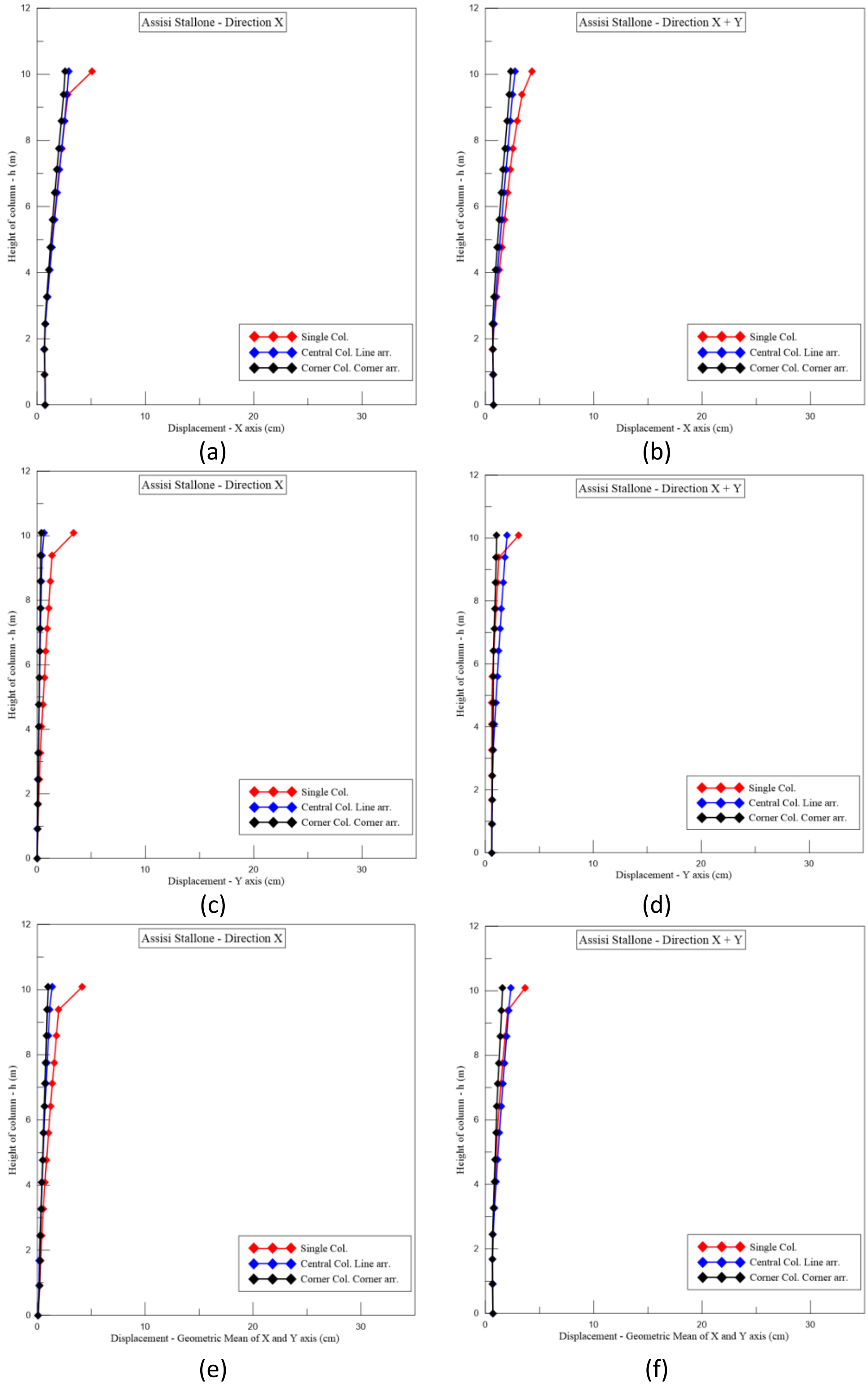



*Figure 164: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the intact model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Assisi Stallone record.*

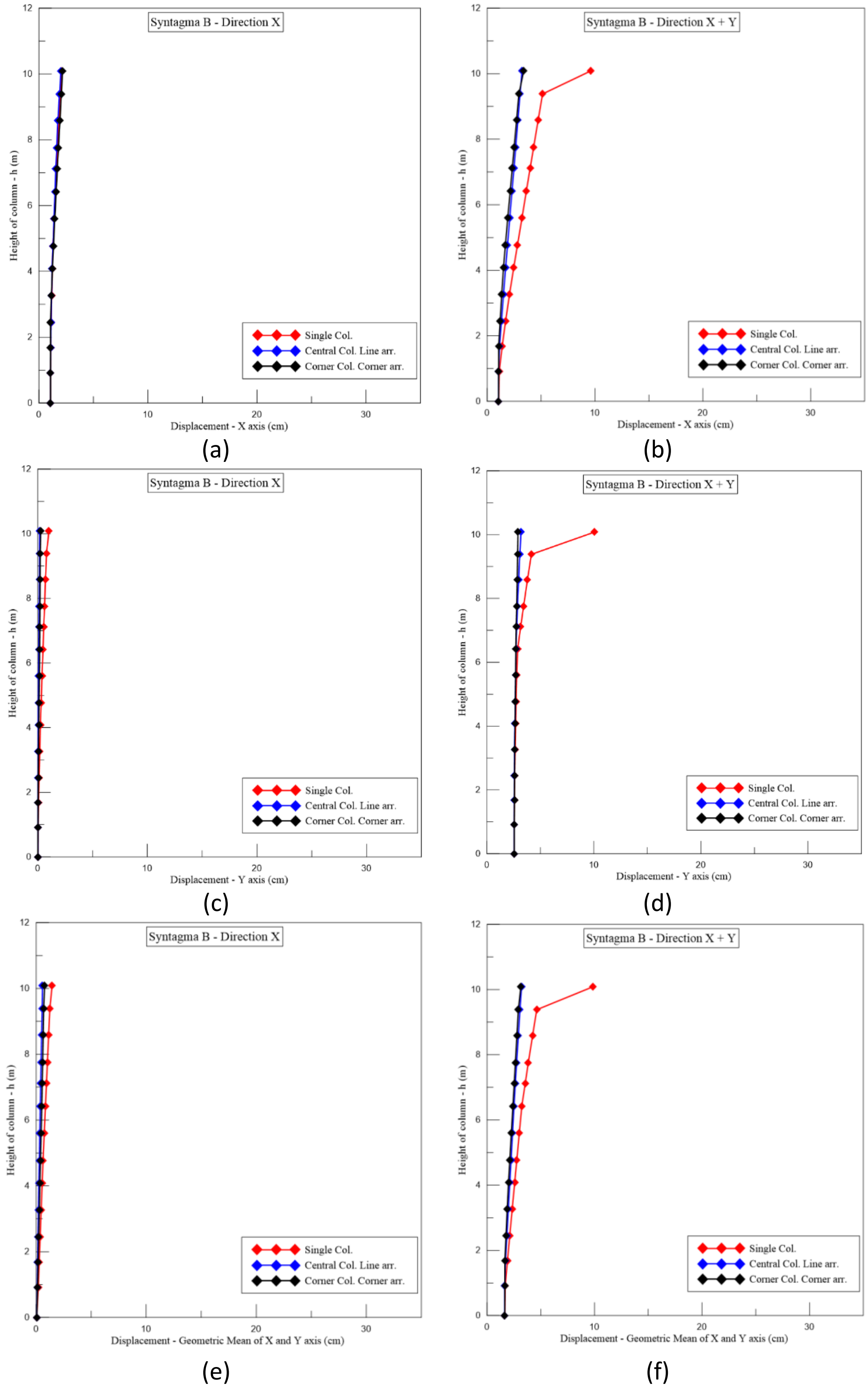



*Figure 165: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the intact model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Syntagma B record.*

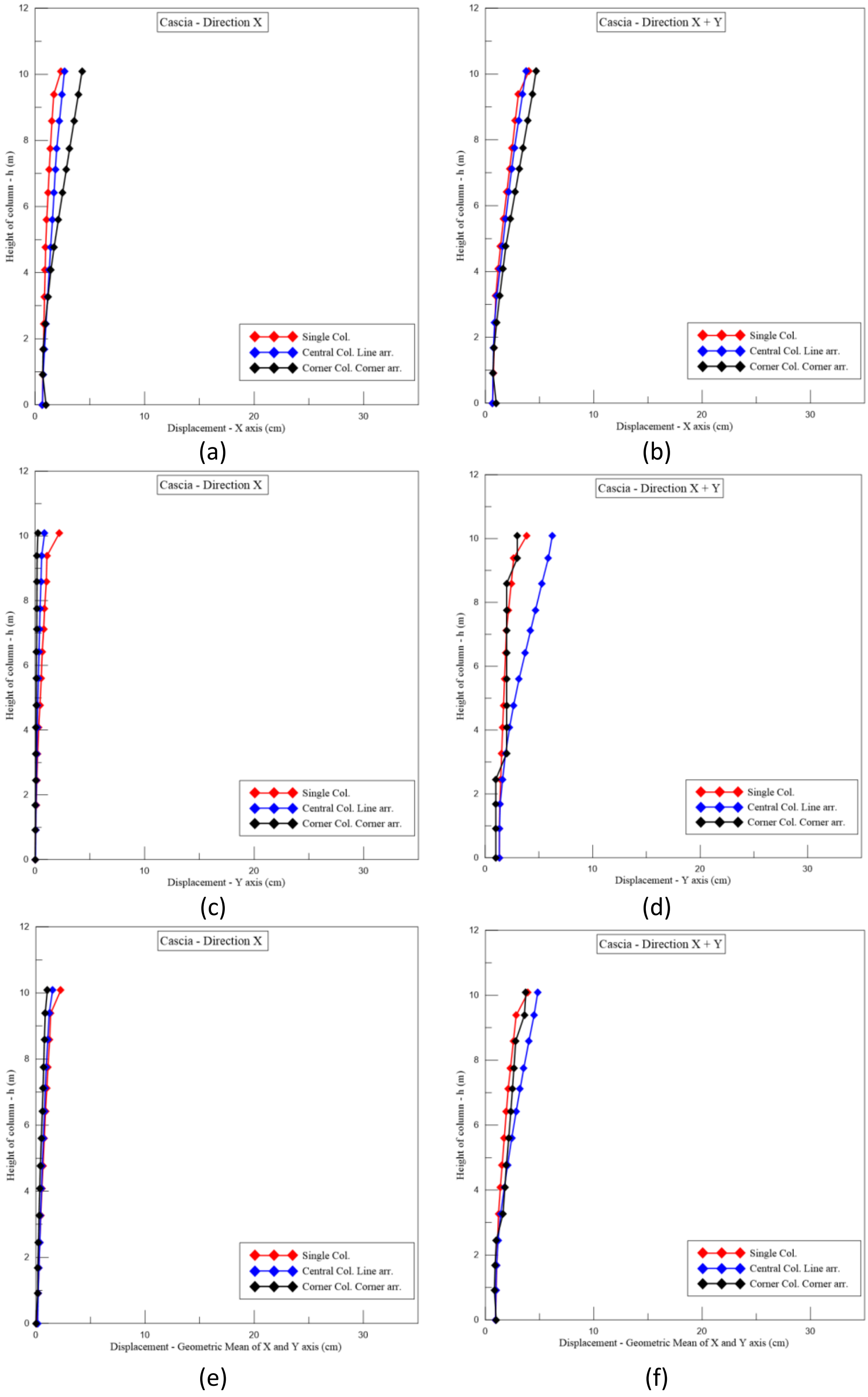



*Figure 166: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Cascia record.*

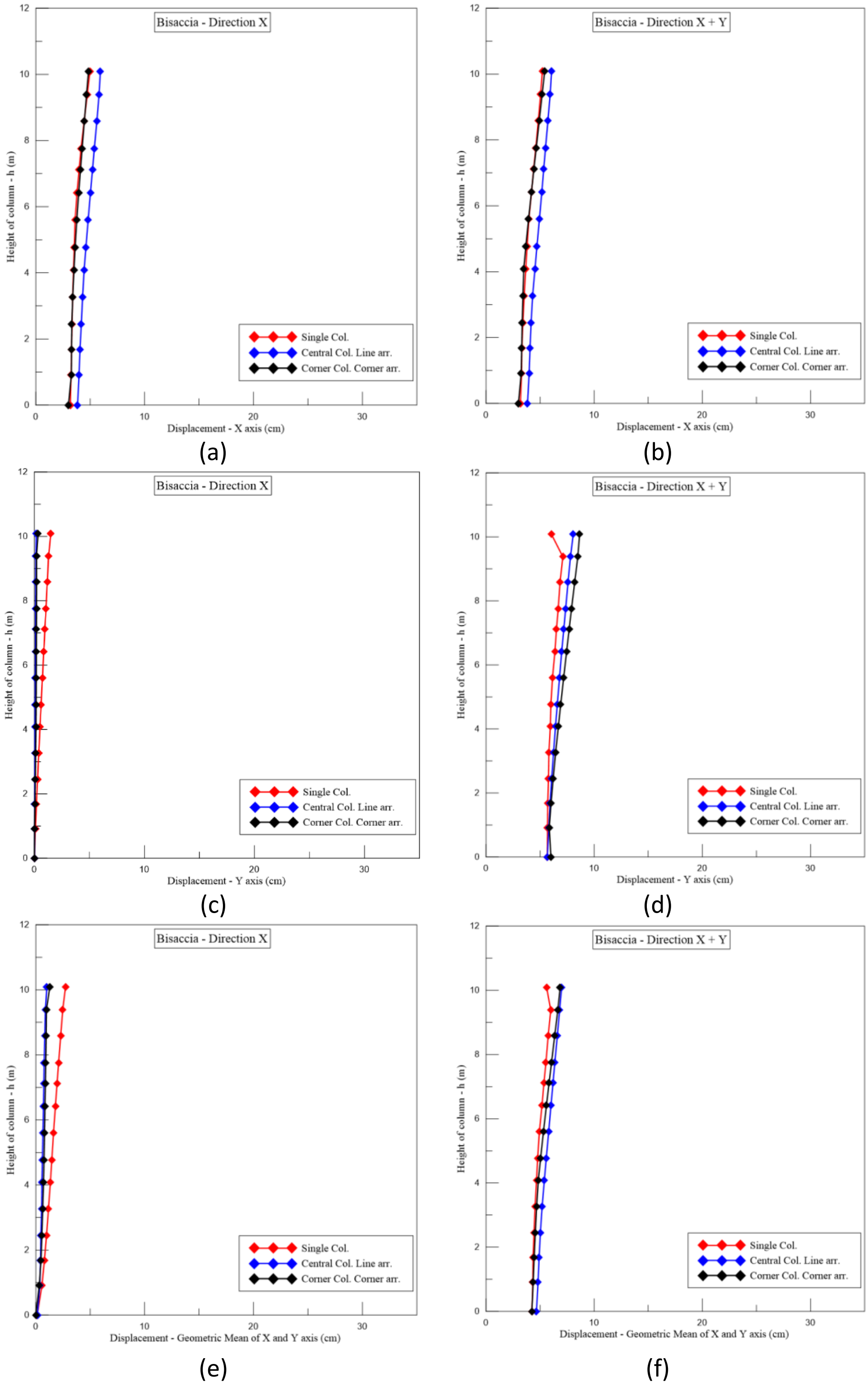



*Figure 167: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Bisaccia record.*

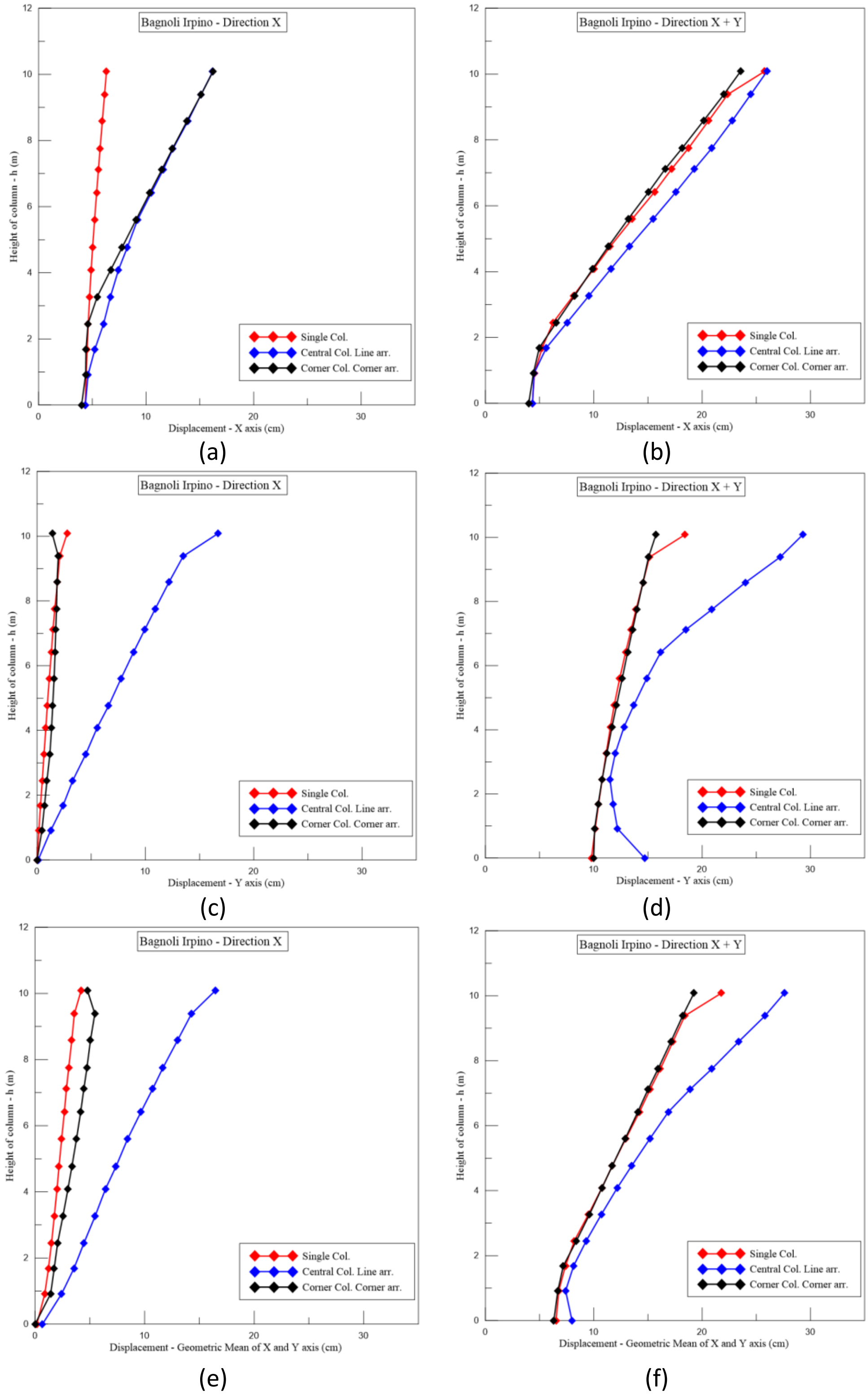



*Figure 168: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Bagnoli Irpino record.*

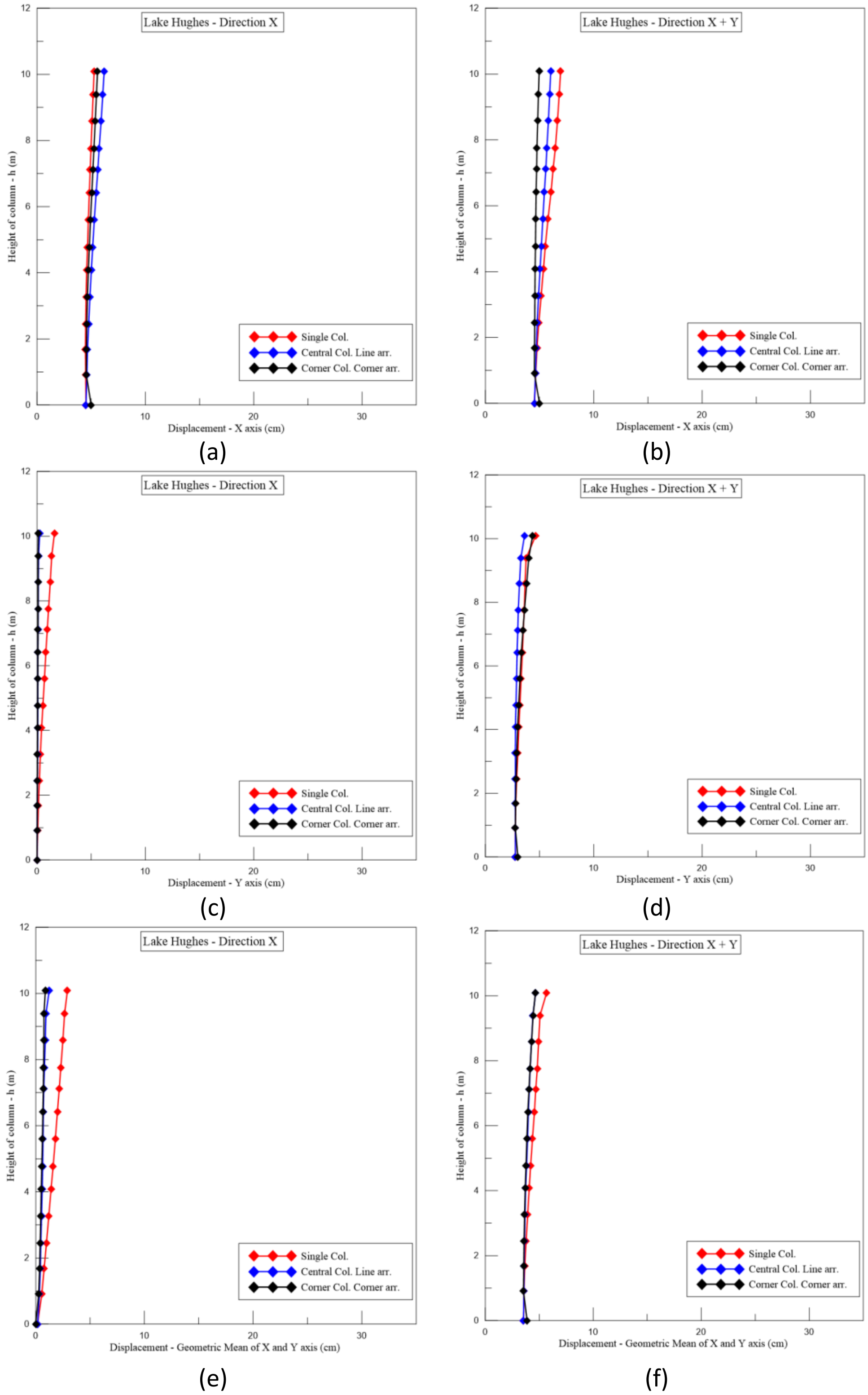



*Figure 169: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Lake Hughes No9 record.*

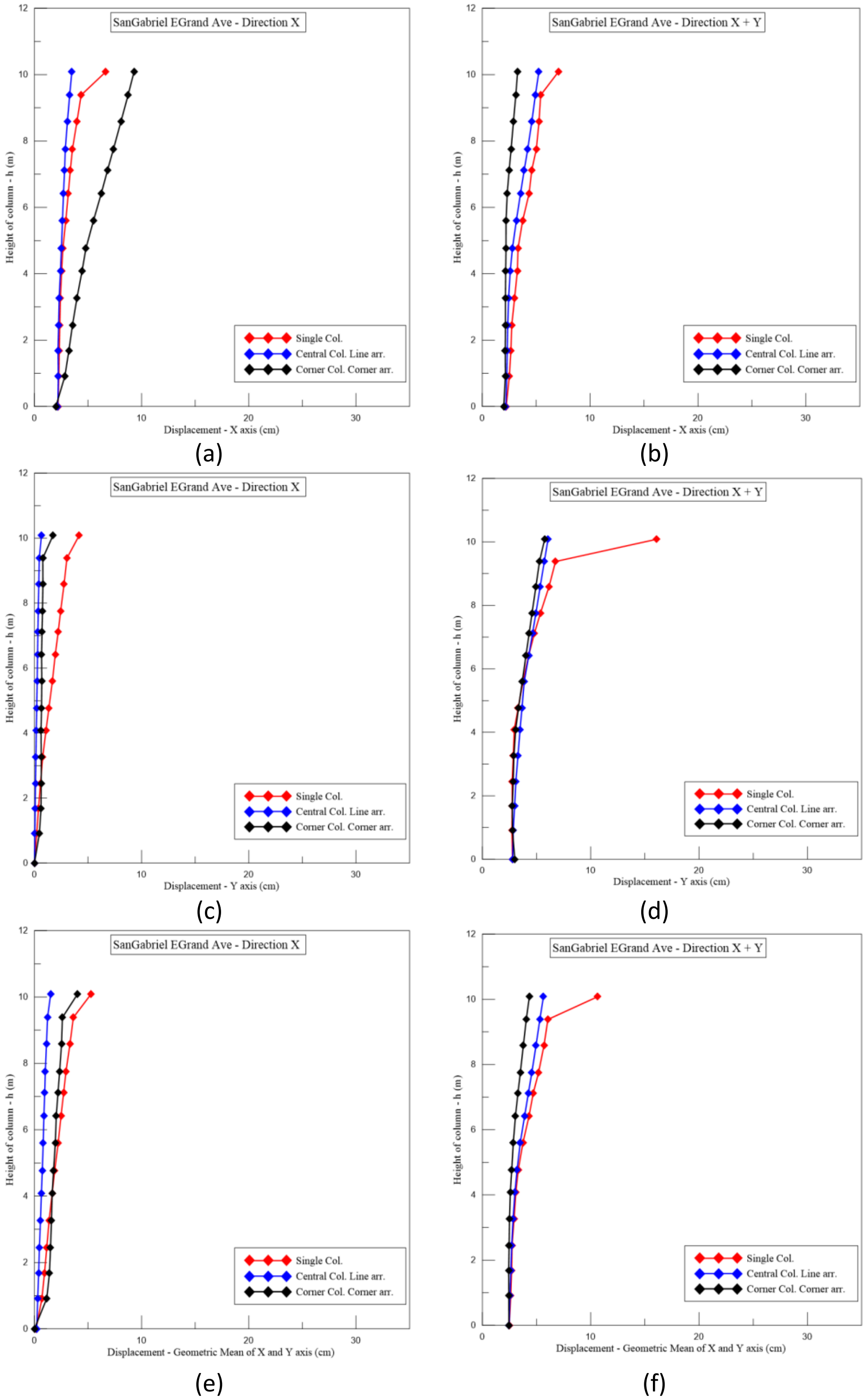



*Figure 170: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of San Gabriel (E. Grand Ave.) record.*

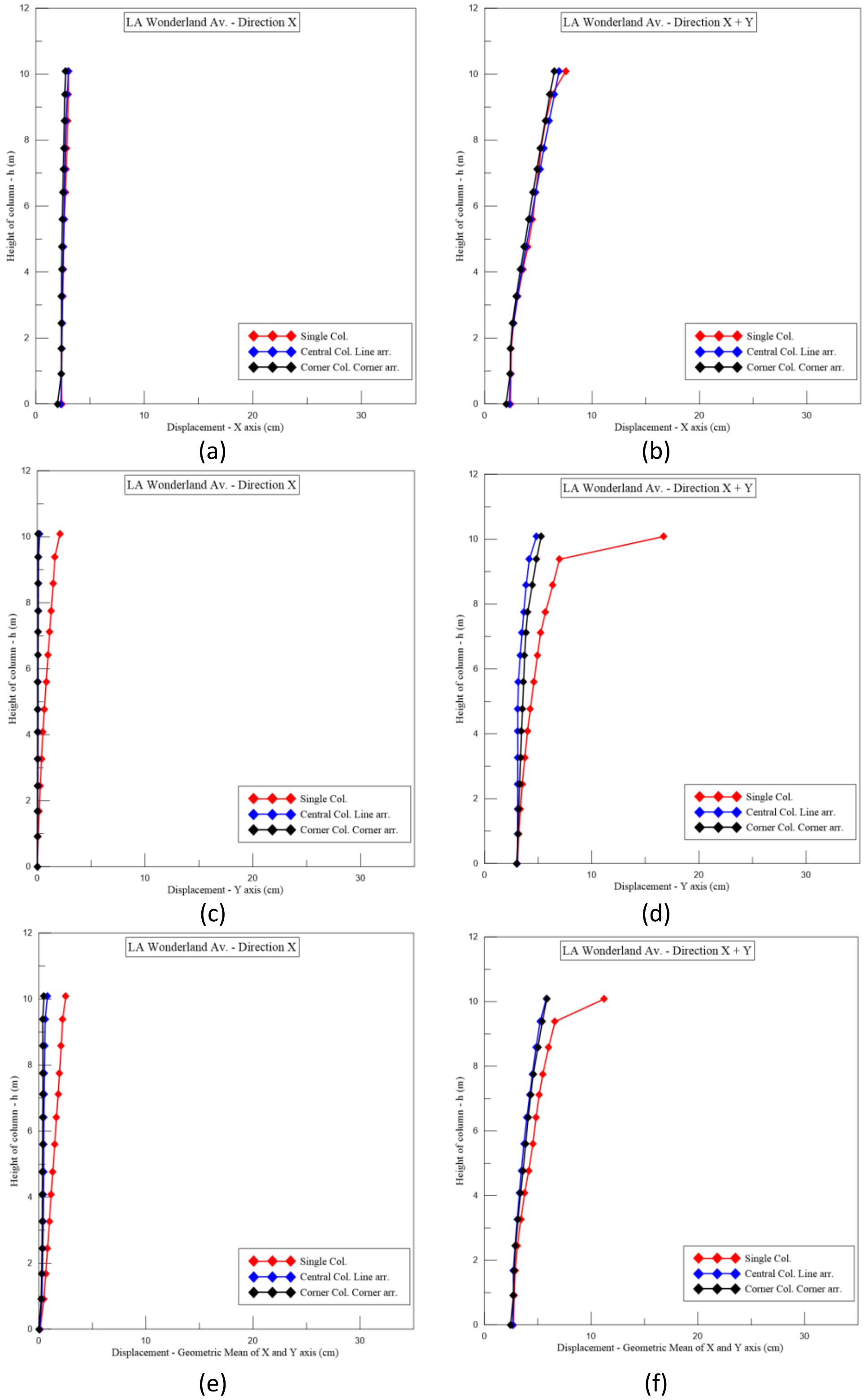



*Figure 171: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of L.A. Wonderland Av. record.*

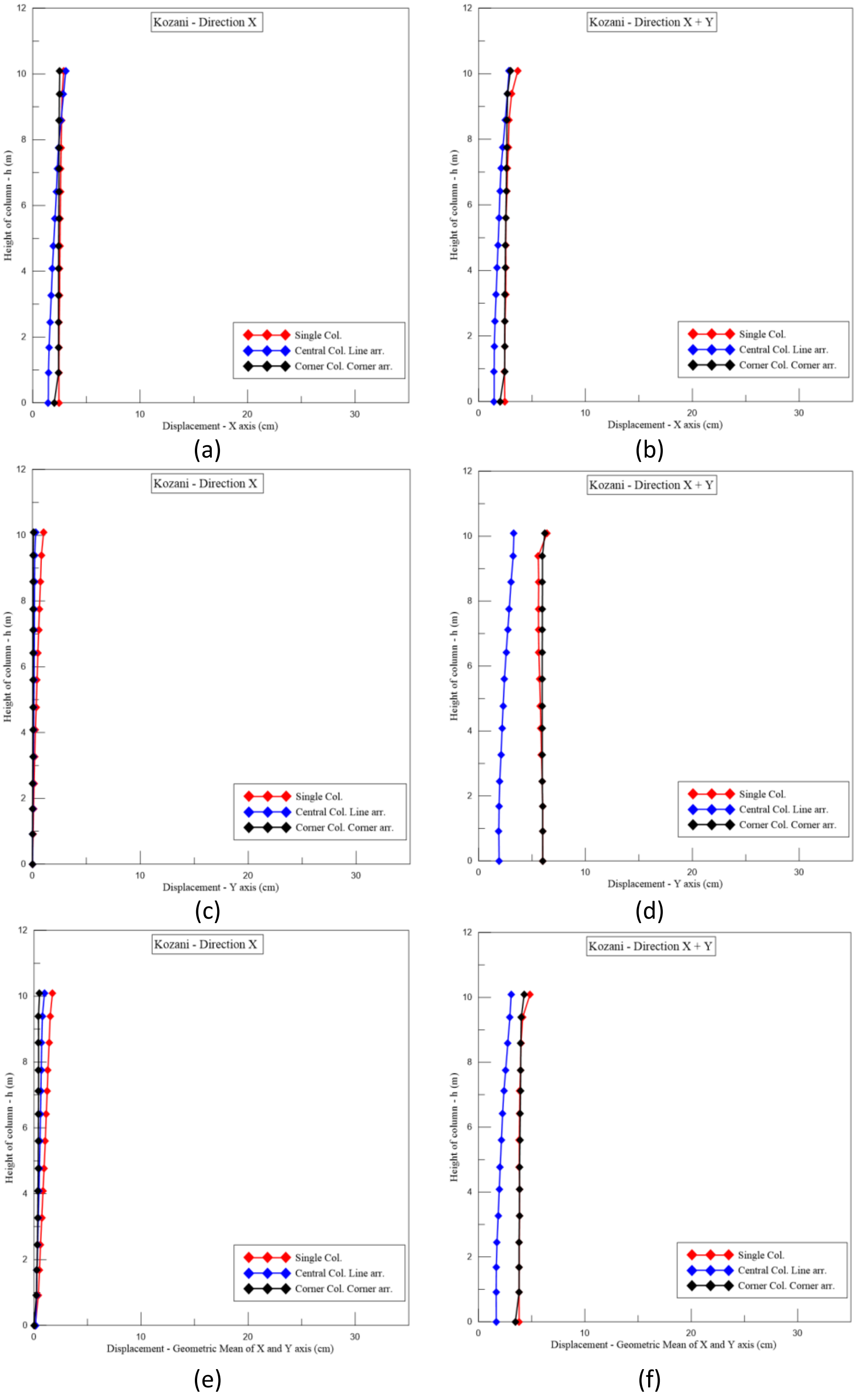



*Figure 172: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Kozani record.*

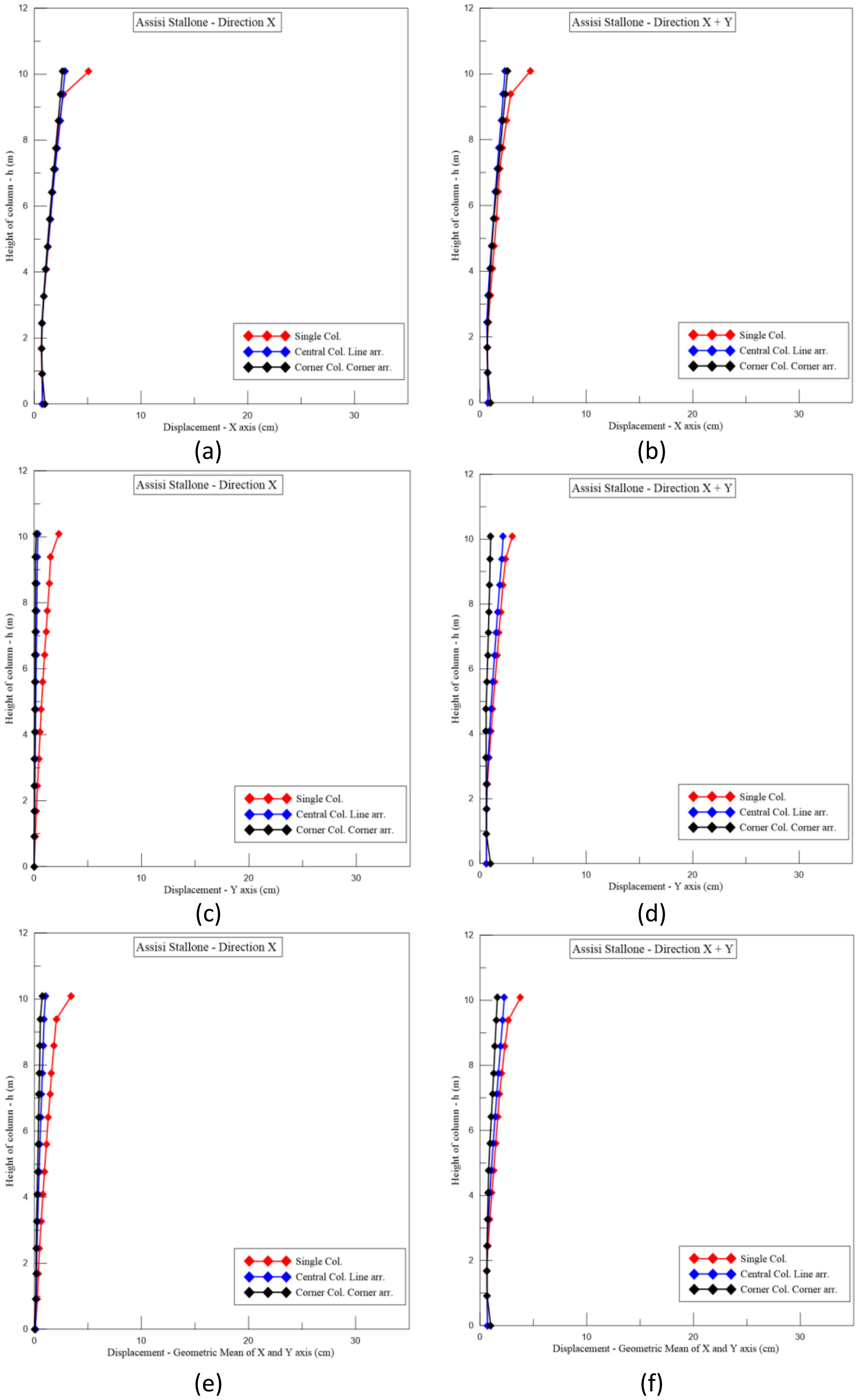



*Figure 173: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Assisi Stallone record.*

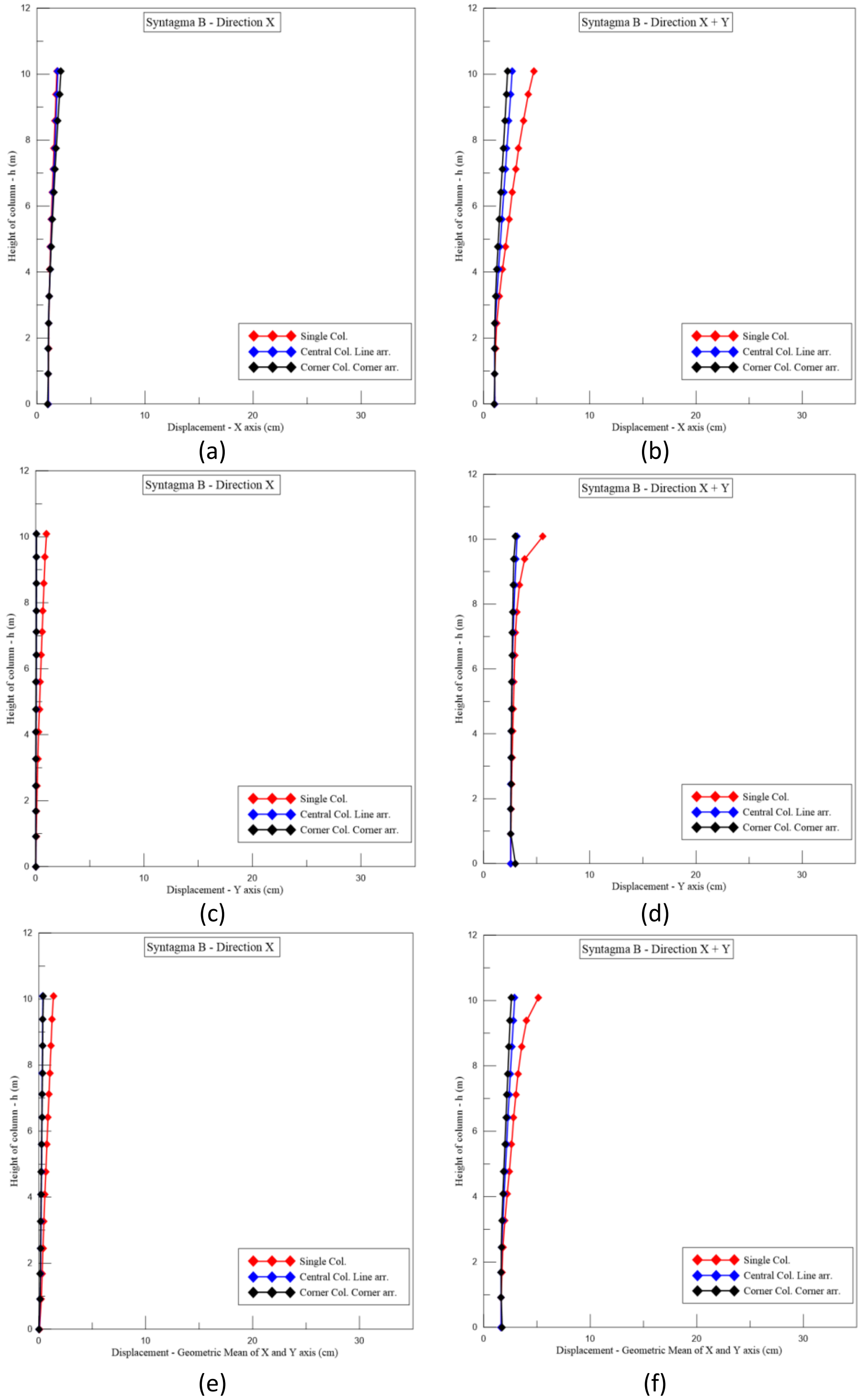



*Figure 174: Diagrams of absolute maximum displacement of x (a, b), y (c, d) and the corresponding geometric mean (e, f) axis for the damaged model of the single column, the central column of the colonnade in a line arrangement and the corner column of the colonnade in a corner arrangement in height of the column for x (a, c, e) and x + y (b, d, f) components of Syntagma B record.*

At this point, diagrams of maximum relative displacements in x-axis are presented with their mean value separately marked and also normalized to half the mean diameter of each column drum and then to the maximum value in height of each arrangement for the intact and the damaged model.

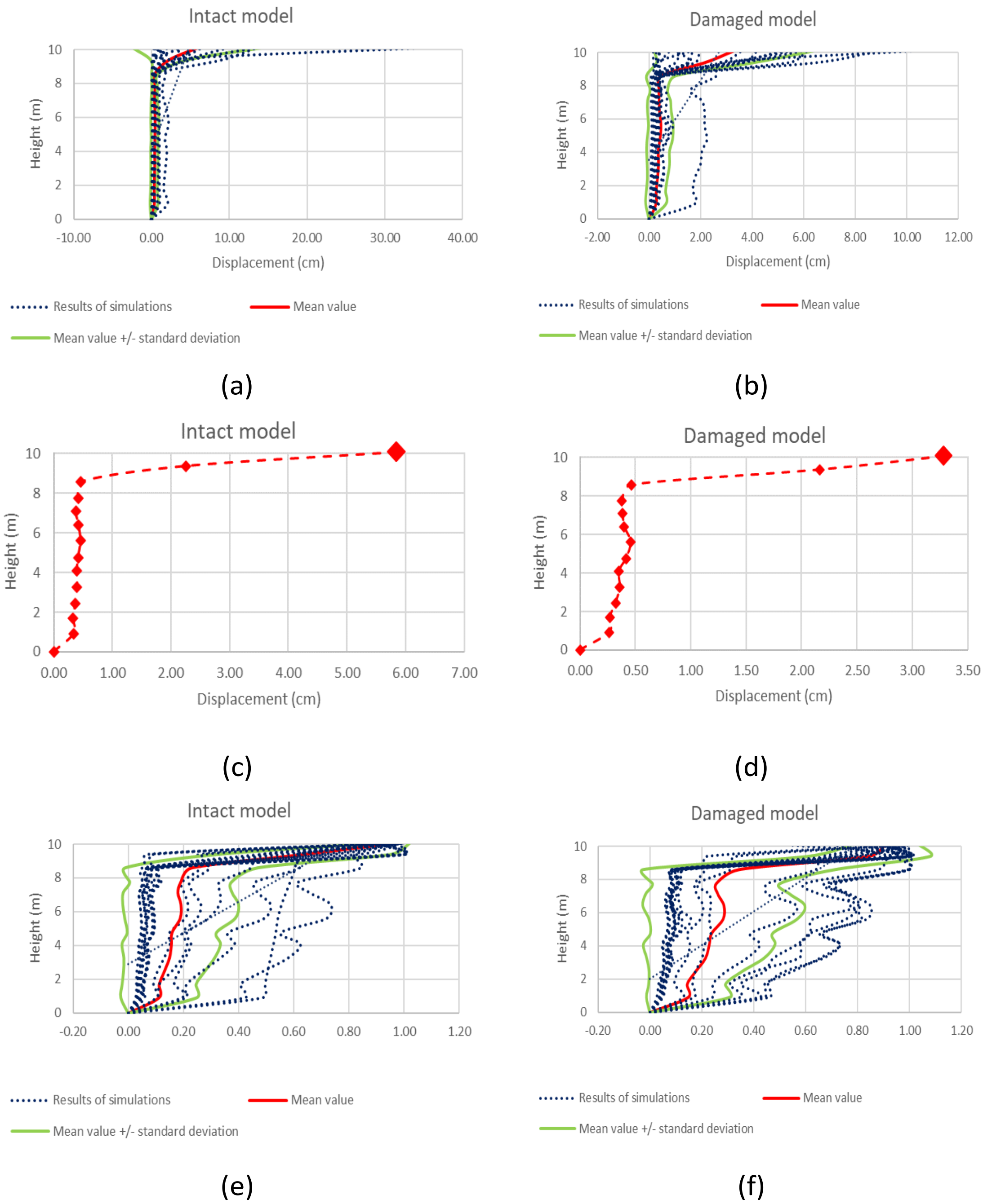



*Figure 175: Plots of maximum relative displacements in x-axis of all records, mean value, and standard deviation (a, b), of the mean value only (c, d) and further the a, b normalized to half the mean diameter of each column drum and then to the maximum value in height (e, f), of the* ***single column*** *for the intact (a, c, e) and the damaged (b, d, f) model.*

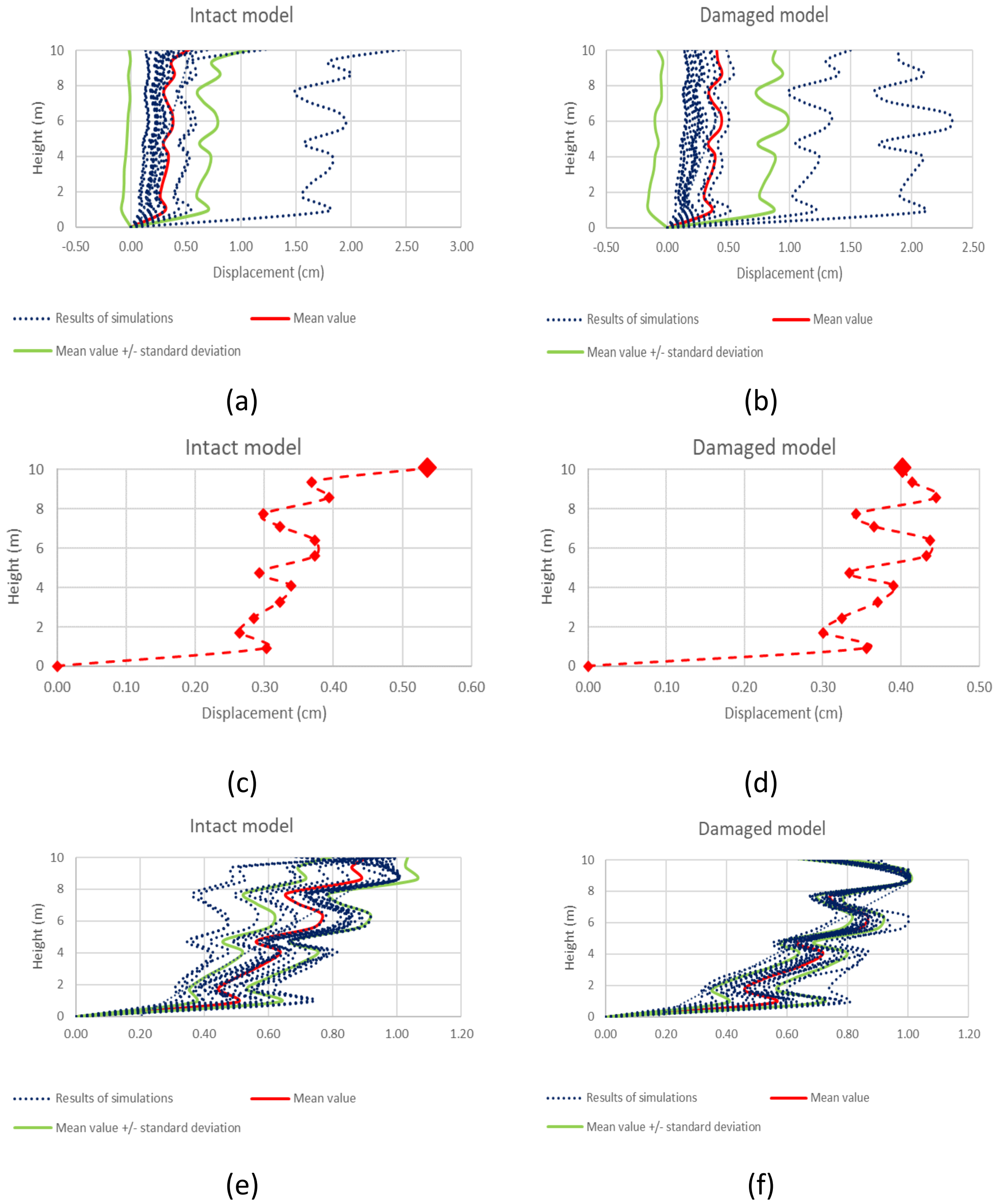



*Figure 176: Plots of maximum relative displacements in x-axis of all records, mean value, and standard deviation (a, b), of the mean value only (c, d) and further the a, b normalized to half the mean diameter of each column drum and then to the maximum value in height (e, f), of the central column of the* ***colonnade in a line arrangement*** *for the intact (a, c, e) and the damaged (b, d, f) model.*

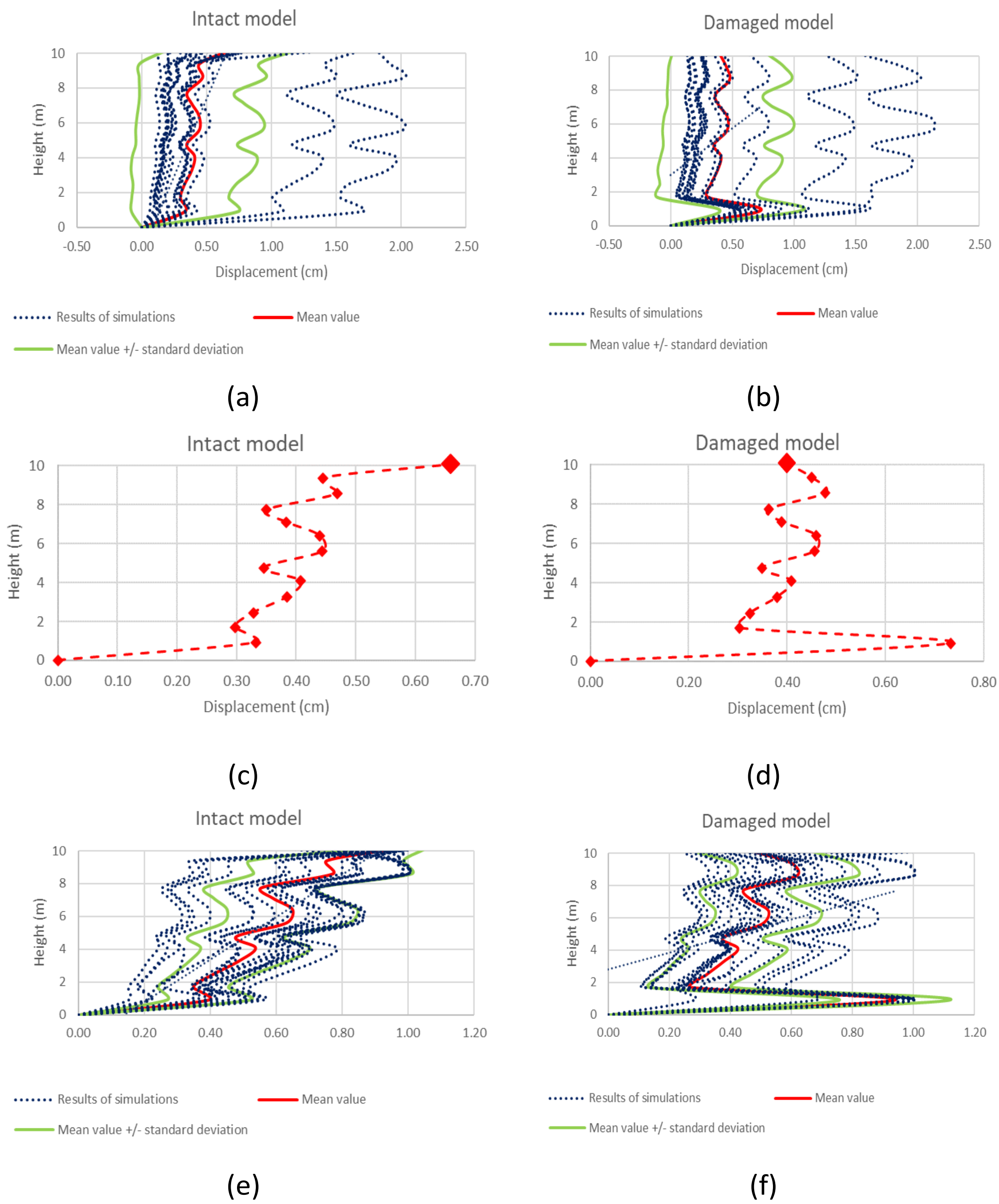



*Figure 177: Plots of maximum relative displacements in x-axis of all records, mean value, and standard deviation (a, b), of the mean value only (c, d) and further the a, b normalized to half the mean diameter of each column drum and then to the maximum value in height (e, f), of the corner column of the* ***colonnade in a corner arrangement*** *for the intact (a, c, e) and the damaged (b, d, f) model.*

## 4.3 Comparative observations on the behaviour and rigidity of the arrangements

Based on all the above results obtained from the analyses, the following are evident:

Obviously, no collapses are observed.

The X + Y records have worse results, usually for both x and y displacements.

In all models the highest response is observed by applying the 3rd record (Bagnoli-Irpino) in X + Y direction, with a significant difference compared to the other records - both in terms of absolute and relative displacements.

By simply observing the plots in Figures 130-177 of the absolute maximum total x and y displacements and relative maximum x displacements versus height, it becomes noticeable that the single column shows the maximum (relative) displacement in x (but also in y) in the column capital. The corresponding column in the colonnade models often shows maximum (relative) x-displacements in the 1st column drum as well as at intermediate (7th, 8th) ones, in the damaged models, while in the original (intact) models it shows high relative x-displacements and higher, e.g., in the capitals, as well.

From the plots of absolute maximum displacements, we are interested in the qualitative picture we get - in this case, we are not looking at the soil-structure displacement. From the results for the maximum relative displacements, the maximum relative displacement values and the maximum of the mean (in x) are obtained:

34.3 cm and 5.9 cm, respectively, (SC-intact), 10.2 cm and 3.3 cm (SC-damaged)
2.5 cm and 0.54 cm, respectively, (3CL-intact), 2.3 cm and 0.45 cm (3CL-damaged)
2 cm and 0.66 cm (3CC-intact), 2.1 cm and 0.7 cm, respectively (3CC-damaged),
where SC stands for “single column” 3CL stands for “3-column colonnade in a line arrangement” and 3CC stands for “3-column colonnade in a corner arrangement”.

The damaged models do not, in this respect, show systematically worse behaviour compared to intact ones; on the contrary, they often exhibit smaller displacements.

Larger displacements are observed in the single column, while the other two arrangements show similar behaviour – with the line arrangement being more vulnerable (e.g., in the example of the 3rd record).

Another interesting point that arises, and has not been presented so far, is that in more strong phenomena, such as e.g., the record of 3 in the X+Y direction, there are differences in the behaviour of the 3 columns of each arrangement, especially in the y direction. In the example of the colonnade in a line arrangement, the central column showed a y-displacement greater than the adjacent columns by up to ~ 10 cm even in the case of the intact model where the geometry between them was exactly the same. Appendix 2 provides indicative diagrams of absolute (maximum) displacements in x, y, z (in m and without maintaining a common scale) of all 3 columns of each colonnade arrangement for the case of the 3rd and 9th record.

# 5 CONCLUSIONS

Therefore, by completing the analyses and comparing and also contrasting the results, it is concluded that:

It is confirmed that these are generally structures characterized by stability.

Ground motions with strong directivity effects combined with large earthquake magnitude and duration and long dominants periods (such as the example of the 3rd record in X+Ψ) can have a significant impact and cause extremely increased displacements.

For the displacements observed here, blockages created by existing damages in the corresponding models often work beneficially for the columns, depending on the direction of the displacements.

The architraves (epistyles) act, in general, as stabilizers. It has been observed that as the size of such structures increases, stability increases (Psycharis, 2015).

When unfavourable characteristics are combined in a seismic record (such as the example of the 3rd record in X+Ψ), variations in kinematic behaviour are observed depending on the position of a column in an ancient colonnade.

The results of the dynamic analyses can then be compared with results obtained using the method of interferometry, which enables the deformations of structural systems due to seismic events to be monitored with high accuracy, remotely and non-invasively.

In any case, special attention should be paid to the geometry and parameters of the analysis due to the significant sensitivity and complexity of the problem.

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APPENDIXES

# APPENDIX 1

## THE 3DEC CODE FOR THE NUMERICAL SIMULATION OF COLONNADES

### *THE GEOMETRY OF THE INTACT MODELS OF THE COLONNADES*

### *Single column*

```
;6th_b

poly prism a -0.862,-0.938,-0.420 0.862,-0.938,-0.420 0.862,0.938,-0.420 -0.862,0.938,-0.420 &
        b -0.862,-0.938,0.0 0.862,-0.938,0.0 0.862,0.938,0.0 -0.862,0.938,0.0
range name 6th_b x -0.862 0.862 y -0.938 0.938 z -0.420 0.0

;6th_1

poly drum 0.0 0.0 0.0 0.0 0.0 0.918 0.825 0.816 20 90
range name 6th_1 x -0.825 0.825 y -0.825 0.825 z 0.0 0.918

;6th_2

poly drum 0.0 0.0 0.918 0.0 0.0 1.687 0.816 0.799 20 90
range name 6th_2 x -0.816 0.816 y -0.816 0.816 z 0.918 1.687

;6th_3

poly drum 0.0 0.0 1.687 0.0 0.0 2.456 0.799 0.785 20 90
range name 6th_3 x -0.799 0.799 y -0.799 0.799 z 1.687 2.456

;6th_4

poly drum 0.0 0.0 2.456 0.0 0.0 3.273 0.785 0.768 20 90
range name 6th_4 x -0.785 0.785 y -0.785 0.785 z 2.456 3.273

;6th_5

poly drum 0.0 0.0 3.273 0.0 0.0 4.090 0.768 0.7535 20 90
range name 6th_5 x -0.768 0.768 y -0.768 0.768 z 3.273 4.090

;6th_6

poly drum 0.0 0.0 4.090 0.0 0.0 4.763 0.7535 0.744 20 90
range name 6th_6 x -0.7535 0.7535 y -0.7535 0.7535 z 4.090 4.763

;6th_7

poly drum 0.0 0.0 4.763 0.0 0.0 5.604 0.744 0.732 20 90
range name 6th_7 x -0.744 0.744 y -0.744 0.744 z 4.763 5.604
```

```
;6th_8

poly drum 0.0 0.0 5.604 0.0 0.0 6.421 0.732 0.708 20 90
range name 6th_8 x -0.732 0.732 y -0.732 0.732 z 5.604 6.421

;6th_9

poly drum 0.0 0.0 6.421 0.0 0.0 7.118 0.708 0.6935 20 90
range name 6th_9 x -0.708 0.708 y -0.708 0.708 z 6.421 7.118

;6th_10

poly drum 0.0 0.0 7.118 0.0 0.0 7.748 0.6935 0.672 20 90
range name 6th_10 x -0.6935 0.6935 y -0.6935 0.6935 z 7.118 7.748

;6th_11

poly drum 0.0 0.0 7.748 0.0 0.0 8.589 0.672 0.648 20 90
range name 6th_11 x -0.672 0.672 y -0.672 0.672 z 7.538 8.589

;6th_12

poly drum 0.0 0.0 8.589 0.0 0.0 9.382 0.648 0.6385 20 90
range name 6th_12 x -0.648 0.648 y -0.648 0.648 z 8.589 9.382

;6th_y

poly drum 0.0 0.0 9.382 0.0 0.0 9.527 0.6385 0.648 20 90
range name 6th_y x -0.648 0.648 y -0.648 0.648 z 9.382 9.527
join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;6th_k1

poly drum 0.0 0.0 9.527 0.0 0.0 9.576 0.648 0.672 20 90
range name 6th_k1 x -0.672 0.672 y -0.672 0.672 z 9.527 9.576
join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;6th_k2

poly drum 0.0 0.0 9.576 0.0 0.0 9.793 0.672 0.840 20 90
range name 6th_k2 x -0.672 0.672 y -0.672 0.672 z 9.576 9.793
join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;6th_k3

poly prism a -0.852,-0.852,9.793 0.852,-0.852,9.793 0.852,0.852,9.793 -0.852,0.852,9.793 &
          b -0.852,-0.852,10.081 0.852,-0.852,10.081 0.852,0.852,10.081 -0.852,0.852,10.081
range name 6th_k3 x -0.852 0.852 y -0.852 0.852 z 9.793 10.081
join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081
```

*Colonnade in a line arrangement*

;central_(6th)

;6th_b

poly prism a -0.862,-0.938,-0.420 0.862,-0.938,-0.420 0.862,0.938,-0.420 -0.862,0.938,-0.420 &
b -0.862,-0.938,0.0 0.862,-0.938,0.0 0.862,0.938,0.0 -0.862,0.938,0.0
range name 6th_b x -0.862 0.862 y -0.938 0.938 z -0.420 0.0

;6th_1

poly prism a 0.825,0.0,0.0 0.762,0.316,0.0 0.583,0.583,0.0 0.316,0.762,0.0 0.0,0.825,0.0 -0.316,0.762,0.0 -0.583,0.583,0.0 -0.762,0.316,0.0 -0.825,0.0,0.0 -0.762,-0.316,0.0 -0.583,-0.583,0.0 -0.316,-0.762,0.0 0.0,-0.825,0.0 0.316,-0.762,0.0 0.583,-0.583,0.0 0.762,-0.316,0.0 &
b 0.816,0.0,0.918 0.754,0.312,0.918 0.577,0.577,0.918 0.312,0.754,0.918 0.0,0.816,0.918 -0.312,0.754,0.918 -0.577,0.577,0.918 -0.754,0.312,0.918 -0.816,0.0,0.918 -0.754,-0.312,0.918 -0.577,-0.577,0.918 -0.312,-0.754,0.918 0.0,-0.816,0.918 0.312,-0.754,0.918 0.577,-0.577,0.918 0.754,-0.312,0.918
range name 6th_1 x -0.825 0.825 y -0.825 0.825 z 0.0 0.918

;6th_2

poly prism a 0.816,0.0,0.918 0.754,0.312,0.918 0.577,0.577,0.918 0.312,0.754,0.918 0.0,0.816,0.918 -0.312,0.754,0.918 -0.577,0.577,0.918 -0.754,0.312,0.918 -0.816,0.0,0.918 -0.754,-0.312,0.918 -0.577,-0.577,0.918 -0.312,-0.754,0.918 0.0,-0.816,0.918 0.312,-0.754,0.918 0.577,-0.577,0.918 0.754,-0.312,0.918 &
b 0.799,0.0,1.687 0.738,0.306,1.687 0.565,0.565,1.687 0.306,0.738,1.687 0.0,0.799,1.687 -0.306,0.738,1.687 -0.565,0.565,1.687 -0.738,0.306,1.687 -0.799,0.0,1.687 -0.738,-0.306,1.687 -0.565,-0.565,1.687 -0.306,-0.738,1.687 0.0,-0.799,1.687 0.306,-0.738,1.687 0.565,-0.565,1.687 0.738,-0.306,1.687
range name 6th_2 x -0.816 0.816 y -0.816 0.816 z 0.918 1.687

;6th_3

poly prism a 0.799,0.0,1.687 0.738,0.306,1.687 0.565,0.565,1.687 0.306,0.738,1.687 0.0,0.799,1.687 -0.306,0.738,1.687 -0.565,0.565,1.687 -0.738,0.306,1.687 -0.799,0.0,1.687 -0.738,-0.306,1.687 -0.565,-0.565,1.687 -0.306,-0.738,1.687 0.0,-0.799,1.687 0.306,-0.738,1.687 0.565,-0.565,1.687 0.738,-0.306,1.687 &
b 0.785,0.0,2.456 0.725,0.300,2.456 0.555,0.555,2.456 0.300,0.725,2.456 0.0,0.785,2.456 -0.300,0.725,2.456 -0.555,0.555,2.456 -0.725,0.300,2.456 -0.785,0.0,2.456 -0.725,-0.300,2.456 -0.555,-0.555,2.456 -0.300,-0.725,2.456 0.0,-0.785,2.456 0.300,-0.725,2.456 0.555,-0.555,2.456 0.725,-0.300,2.456
range name 6th_3 x -0.799 0.799 y -0.799 0.799 z 1.687 2.456

;6th_4

poly prism a 0.785,0.0,2.456 0.725,0.300,2.456 0.555,0.555,2.456 0.300,0.725,2.456 0.0,0.785,2.456 -0.300,0.725,2.456 -0.555,0.555,2.456 -0.725,0.300,2.456 -0.785,0.0,2.456 -0.725,-0.300,2.456 -0.555,-0.555,2.456 -0.300,-0.725,2.456 0.0,-0.785,2.456 0.300,-0.725,2.456 0.555,-0.555,2.456 0.725,-0.300,2.456 &
b 0.768,0.0,3.273 0.710,0.294,3.273 0.543,0.543,3.273 0.294,0.710,3.273 0.0,0.768,3.273 -0.294,0.710,3.273 -0.543,0.543,3.273 -0.710,0.294,3.273 -0.768,0.0,3.273 -0.710,-0.294,3.273 -0.543,-

0.543,3.273 -0.294,-0.710,3.273 0.0,-0.768,3.273 0.294,-0.710,3.273 0.543,-0.543,3.273 0.710,-0.294,3.273
range name 6th_4 x -0.785 0.785 y -0.785 0.785 z 2.456 3.273

;6th_5

poly prism a 0.768,0.0,3.273 0.710,0.294,3.273 0.543,0.543,3.273 0.294,0.710,3.273 0.0,0.768,3.273 -0.294,0.710,3.273 -0.543,0.543,3.273 -0.710,0.294,3.273 -0.768,0.0,3.273 -0.710,-0.294,3.273 -0.543,-0.543,3.273 -0.294,-0.710,3.273 0.0,-0.768,3.273 0.294,-0.710,3.273 0.543,-0.543,3.273 0.710,-0.294,3.273 &
b 0.7535,0.0,4.090 0.696,0.288,4.090 0.533,0.533,4.090 0.288,0.696,4.090 0.0,0.7535,4.090 -0.288,0.696,4.090 -0.533,0.533,4.090 -0.696,0.288,4.090 -0.7535,0.0,4.090 -0.696,-0.288,4.090 -0.533,-0.533,4.090 -0.288,-0.696,4.090 0.0,-0.7535,4.090 0.288,-0.696,4.090 0.533,-0.533,4.090 0.696,-0.288,4.090
range name 6th_5 x -0.768 0.768 y -0.768 0.768 z 3.273 4.090

;6th_6

poly prism a 0.7535,0.0,4.090 0.696,0.288,4.090 0.533,0.533,4.090 0.288,0.696,4.090 0.0,0.7535,4.090 -0.288,0.696,4.090 -0.533,0.533,4.090 -0.696,0.288,4.090 -0.7535,0.0,4.090 -0.696,-0.288,4.090 -0.533,-0.533,4.090 -0.288,-0.696,4.090 0.0,-0.7535,4.090 0.288,-0.696,4.090 0.533,-0.533,4.090 0.696,-0.288,4.090 &
b 0.744,0.0,4.763 0.687,0.285,4.763 0.526,0.526,4.763 0.285,0.687,4.763 0.0,0.744,4.763 -0.285,0.687,4.763 -0.526,0.526,4.763 -0.687,0.285,4.763 -0.744,0.0,4.763 -0.687,-0.285,4.763 -0.526,-0.526,4.763 -0.285,-0.687,4.763 0.0,-0.744,4.763 0.285,-0.687,4.763 0.526,-0.526,4.763 0.687,-0.285,4.763
range name 6th_6 x -0.7535 0.7535 y -0.7535 0.7535 z 4.090 4.763

;6th_7

poly prism a 0.744,0.0,4.763 0.687,0.285,4.763 0.526,0.526,4.763 0.285,0.687,4.763 0.0,0.744,4.763 -0.285,0.687,4.763 -0.526,0.526,4.763 -0.687,0.285,4.763 -0.744,0.0,4.763 -0.687,-0.285,4.763 -0.526,-0.526,4.763 -0.285,-0.687,4.763 0.0,-0.744,4.763 0.285,-0.687,4.763 0.526,-0.526,4.763 0.687,-0.285,4.763 &
b 0.732,0.0,5.604 0.676,0.280,5.604 0.518,0.518,5.604 0.280,0.676,5.604 0.0,0.732,5.604 -0.280,0.676,5.604 -0.518,0.518,5.604 -0.676,0.280,5.604 -0.732,0.0,5.604 -0.676,-0.280,5.604 -0.518,-0.518,5.604 -0.280,-0.676,5.604 0.0,-0.732,5.604 0.280,-0.676,5.604 0.518,-0.518,5.604 0.676,-0.280,5.604
range name 6th_7 x -0.744 0.744 y -0.744 0.744 z 4.763 5.604

;6th_8

poly prism a 0.732,0.0,5.604 0.676,0.280,5.604 0.518,0.518,5.604 0.280,0.676,5.604 0.0,0.732,5.604 -0.280,0.676,5.604 -0.518,0.518,5.604 -0.676,0.280,5.604 -0.732,0.0,5.604 -0.676,-0.280,5.604 -0.518,-0.518,5.604 -0.280,-0.676,5.604 0.0,-0.732,5.604 0.280,-0.676,5.604 0.518,-0.518,5.604 0.676,-0.280,5.604 &
b 0.708,0.0,6.421 0.654,0.271,6.421 0.501,0.501,6.421 0.271,0.654,6.421 0.0,0.708,6.421 -0.271,0.654,6.421 -0.501,0.501,6.421 -0.654,0.271,6.421 -0.708,0.0,6.421 -0.654,-0.271,6.421 -0.501,-0.501,6.421 -0.271,-0.654,6.421 0.0,-0.708,6.421 0.271,-0.654,6.421 0.501,-0.501,6.421 0.654,-0.271,6.421
range name 6th_8 x -0.732 0.732 y -0.732 0.732 z 5.604 6.421

;6th_9

poly prism a 0.708,0.0,6.421 0.654,0.271,6.421 0.501,0.501,6.421 0.271,0.654,6.421 0.0,0.708,6.421 -0.271,0.654,6.421 -0.501,0.501,6.421 -0.654,0.271,6.421 -0.708,0.0,6.421 -0.654,-0.271,6.421 -0.501,-

0.501,6.421 -0.271,-0.654,6.421 0.0,-0.708,6.421 0.271,-0.654,6.421 0.501,-0.501,6.421 0.654,-0.271,6.421 &

b 0.6935,0.0,7.118 0.641,0.265,7.118 0.490,0.490,7.118 0.265,0.641,7.118 0.0,0.6935,7.118 -0.265,0.641,7.118 -0.490,0.490,7.118 -0.641,0.265,7.118 -0.6935,0.0,7.118 -0.641,-0.265,7.118 -0.490,-0.490,7.118 -0.265,-0.641,7.118 0.0,-0.6935,7.118 0.265,-0.641,7.118 0.490,-0.490,7.118 0.641,-0.265,7.118

range name 6th_9 x -0.708 0.708 y -0.708 0.708 z 6.421 7.118

;6th_10

poly prism a 0.6935,0.0,7.118 0.641,0.265,7.118 0.490,0.490,7.118 0.265,0.641,7.118 0.0,0.6935,7.118 -0.265,0.641,7.118 -0.490,0.490,7.118 -0.641,0.265,7.118 -0.6935,0.0,7.118 -0.641,-0.265,7.118 -0.490,-0.490,7.118 -0.265,-0.641,7.118 0.0,-0.6935,7.118 0.265,-0.641,7.118 0.490,-0.490,7.118 0.641,-0.265,7.118 &

b 0.672,0.0,7.748 0.621,0.257,7.748 0.475,0.475,7.748 0.257,0.621,7.748 0.0,0.672,7.748 -0.257,0.621,7.748 -0.475,0.475,7.748 -0.621,0.257,7.748 -0.672,0.0,7.748 -0.621,-0.257,7.748 -0.475,-0.475,7.748 -0.257,-0.621,7.748 0.0,-0.672,7.748 0.257,-0.621,7.748 0.475,-0.475,7.748 0.621,-0.257,7.748

range name 6th_10 x -0.6935 0.6935 y -0.6935 0.6935 z 7.118 7.748

;6th_11

poly prism a 0.672,0.0,7.748 0.621,0.257,7.748 0.475,0.475,7.748 0.257,0.621,7.748 0.0,0.672,7.748 -0.257,0.621,7.748 -0.475,0.475,7.748 -0.621,0.257,7.748 -0.672,0.0,7.748 -0.621,-0.257,7.748 -0.475,-0.475,7.748 -0.257,-0.621,7.748 0.0,-0.672,7.748 0.257,-0.621,7.748 0.475,-0.475,7.748 0.621,-0.257,7.748 &

b 0.648,0.0,8.589 0.599,0.248,8.589 0.458,0.458,8.589 0.248,0.599,8.589 0.0,0.648,8.589 -0.248,0.599,8.589 -0.458,0.458,8.589 -0.599,0.248,8.589 -0.648,0.0,8.589 -0.599,-0.248,8.589 -0.458,-0.458,8.589 -0.248,-0.599,8.589 0.0,-0.648,8.589 0.248,-0.599,8.589 0.458,-0.458,8.589 0.599,-0.248,8.589

range name 6th_11 x -0.672 0.672 y -0.672 0.672 z 7.538 8.589

;6th_12

poly prism a 0.648,0.0,8.589 0.599,0.248,8.589 0.458,0.458,8.589 0.248,0.599,8.589 0.0,0.648,8.589 -0.248,0.599,8.589 -0.458,0.458,8.589 -0.599,0.248,8.589 -0.648,0.0,8.589 -0.599,-0.248,8.589 -0.458,-0.458,8.589 -0.248,-0.599,8.589 0.0,-0.648,8.589 0.248,-0.599,8.589 0.458,-0.458,8.589 0.599,-0.248,8.589 &

b 0.6385,0.0,9.382 0.590,0.244,9.382 0.451,0.451,9.382 0.244,0.590,9.382 0.0,0.6385,9.382 -0.244,0.590,9.382 -0.451,0.451,9.382 -0.590,0.244,9.382 -0.6385,0.0,9.382 -0.590,-0.244,9.382 -0.451,-0.451,9.382 -0.244,-0.590,9.382 0.0,-0.6385,9.382 0.244,-0.590,9.382 0.451,-0.451,9.382 0.590,-0.244,9.382

range name 6th_12 x -0.648 0.648 y -0.648 0.648 z 8.589 9.382

;6th_y

poly prism a 0.6385,0.0,9.382 0.590,0.244,9.382 0.451,0.451,9.382 0.244,0.590,9.382 0.0,0.6385,9.382 -0.244,0.590,9.382 -0.451,0.451,9.382 -0.590,0.244,9.382 -0.6385,0.0,9.382 -0.590,-0.244,9.382 -0.451,-0.451,9.382 -0.244,-0.590,9.382 0.0,-0.6385,9.382 0.244,-0.590,9.382 0.451,-0.451,9.382 0.590,-0.244,9.382 &

b 0.648,0.0,9.527 0.599,0.248,9.527 0.458,0.458,9.527 0.248,0.599,9.527 0.0,0.648,9.527 -0.248,0.599,9.527 -0.458,0.458,9.527 -0.599,0.248,9.527 -0.648,0.0,9.527 -0.599,-0.248,9.527 -0.458,-0.458,9.527 -0.248,-0.599,9.527 0.0,-0.648,9.527 0.248,-0.599,9.527 0.458,-0.458,9.527 0.599,-0.248,9.527

range name 6th_y x -0.648 0.648 y -0.648 0.648 z 9.382 9.527

join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;6th_k1

poly prism a 0.648,0.0,9.527 0.599,0.248,9.527 0.458,0.458,9.527 0.248,0.599,9.527 0.0,0.648,9.527 -0.248,0.599,9.527 -0.458,0.458,9.527 -0.599,0.248,9.527 -0.648,0.0,9.527 -0.599,-0.248,9.527 -0.458,-0.458,9.527 -0.248,-0.599,9.527 0.0,-0.648,9.527 0.248,-0.599,9.527 0.458,-0.458,9.527 0.599,-0.248,9.527 &
b 0.672,0.0,9.576 0.621,0.257,9.576 0.475,0.475,9.576 0.257,0.621,9.576 0.0,0.672,9.576 -0.257,0.621,9.576 -0.475,0.475,9.576 -0.621,0.257,9.576 -0.672,0.0,9.576 -0.621,-0.257,9.576 -0.475,-0.475,9.576 -0.257,-0.621,9.576 0.0,-0.672,9.576 0.257,-0.621,9.576 0.475,-0.475,9.576 0.621,-0.257,9.576
range name 6th_k1 x -0.672 0.672 y -0.672 0.672 z 9.527 9.576
join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;6th_k2

poly prism a 0.672,0.0,9.576 0.621,0.257,9.576 0.475,0.475,9.576 0.257,0.621,9.576 0.0,0.672,9.576 -0.257,0.621,9.576 -0.475,0.475,9.576 -0.621,0.257,9.576 -0.672,0.0,9.576 -0.621,-0.257,9.576 -0.475,-0.475,9.576 -0.257,-0.621,9.576 0.0,-0.672,9.576 0.257,-0.621,9.576 0.475,-0.475,9.576 0.621,-0.257,9.576 &
b 0.840,0.0,9.793 0.776,0.321,9.793 0.594,0.594,9.793 0.321,0.776,9.793 0.0,0.840,9.793 -0.321,0.776,9.793 -0.594,0.594,9.793 -0.776,0.321,9.793 -0.840,0.0,9.793 -0.776,-0.321,9.793 -0.594,-0.594,9.793 -0.321,-0.776,9.793 0.0,-0.840,9.793 0.321,-0.776,9.793 0.594,-0.594,9.793 0.776,-0.321,9.793
range name 6th_k2 x -0.672 0.672 y -0.672 0.672 z 9.576 9.793
join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;6th_k3

poly prism a -0.852,-0.852,9.793 0.852,-0.852,9.793 0.852,0.852,9.793 -0.852,0.852,9.793 &
b -0.852,-0.852,10.081 0.852,-0.852,10.081 0.852,0.852,10.081 -0.852,0.852,10.081
range name 6th_k3 x -0.852 0.852 y -0.852 0.852 z 9.793 10.081
join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;left_

;left_b

poly prism a -4.862,-0.938,-0.420 -3.138,-0.938,-0.420 -3.138,0.938,-0.420 -4.862,0.938,-0.420 &
b -4.862,-0.938,0.0 -3.138,-0.938,0.0 -3.138,0.938,0.0 -4.862,0.938,0.0
range name l_b x -4.862 -3.138 y -0.938 0.938 z -0.420 0.0

;left_1

poly prism a -3.175,0.0,0.0 -3.238,0.316,0.0 -3.417,0.583,0.0 -3.684,0.762,0.0 -4.000,0.825,0.0 -4.316,0.762,0.0 -4.583,0.583,0.0 -4.762,0.316,0.0 -4.825,0.0,0.0 -4.762,-0.316,0.0 -4.583,-0.583,0.0 -4.316,-0.762,0.0 -4.000,-0.825,0.0 -3.684,-0.762,0.0 -3.417,-0.583,0.0 -3.238,-0.316,0.0 &
b -3.184,0.0,0.918 -3.246,0.312,0.918 -3.423,0.577,0.918 -3.688,0.754,0.918 -4.000,0.816,0.918 -4.312,0.754,0.918 -4.577,0.577,0.918 -4.754,0.312,0.918 -4.816,0.0,0.918 -4.754,-0.312,0.918 -4.577,-0.577,0.918 -4.312,-0.754,0.918 -4.000,-0.816,0.918 -3.688,-0.754,0.918 -3.423,-0.577,0.918 -3.246,-0.312,0.918

range name l_1 x -4.825 -3.175 y -0.825 0.825 z 0.0 0.918

;left_2

poly prism a -3.184,0.0,0.918 -3.246,0.312,0.918 -3.423,0.577,0.918 -3.688,0.754,0.918 -4.000,0.816,0.918 -4.312,0.754,0.918 -4.577,0.577,0.918 -4.754,0.312,0.918 -4.816,0.0,0.918 -4.754,-0.312,0.918 -4.577,-0.577,0.918 -4.312,-0.754,0.918 -4.000,-0.816,0.918 -3.688,-0.754,0.918 -3.423,-0.577,0.918 -3.246,-0.312,0.918 &
b -3.201,0.0,1.687 -3.262,0.306,1.687 -3.435,0.565,1.687 -3.694,0.738,1.687 -4.000,0.799,1.687 -4.306,0.738,1.687 -4.565,0.565,1.687 -4.738,0.306,1.687 -4.799,0.0,1.687 -4.738,-0.306,1.687 -4.565,-0.565,1.687 -4.306,-0.738,1.687 -4.000,-0.799,1.687 -3.694,-0.738,1.687 -3.435,-0.565,1.687 -3.262,-0.306,1.687
range name l_2 x -4.816 -3.184 y -0.816 0.816 z 0.918 1.687

;left_3

poly prism a -3.201,0.0,1.687 -3.262,0.306,1.687 -3.435,0.565,1.687 -3.694,0.738,1.687 -4.000,0.799,1.687 -4.306,0.738,1.687 -4.565,0.565,1.687 -4.738,0.306,1.687 -4.799,0.0,1.687 -4.738,-0.306,1.687 -4.565,-0.565,1.687 -4.306,-0.738,1.687 -4.000,-0.799,1.687 -3.694,-0.738,1.687 -3.435,-0.565,1.687 -3.262,-0.306,1.687 &
b -3.215,0.0,2.456 -3.275,0.300,2.456 -3.445,0.555,2.456 -3.700,0.725,2.456 -4.000,0.785,2.456 -4.300,0.725,2.456 -4.555,0.555,2.456 -4.725,0.300,2.456 -4.785,0.0,2.456 -4.725,-0.300,2.456 -4.555,-0.555,2.456 -4.300,-0.725,2.456 -4.000,-0.785,2.456 -3.700,-0.725,2.456 -3.445,-0.555,2.456 -3.275,-0.300,2.456
range name l_3 x -4.799 -3.201 y -0.799 0.799 z 1.687 2.456

;left_4

poly prism a -3.215,0.0,2.456 -3.275,0.300,2.456 -3.445,0.555,2.456 -3.700,0.725,2.456 -4.000,0.785,2.456 -4.300,0.725,2.456 -4.555,0.555,2.456 -4.725,0.300,2.456 -4.785,0.0,2.456 -4.725,-0.300,2.456 -4.555,-0.555,2.456 -4.300,-0.725,2.456 -4.000,-0.785,2.456 -3.700,-0.725,2.456 -3.445,-0.555,2.456 -3.275,-0.300,2.456 &
b -3.232,0.0,3.273 -3.290,0.294,3.273 -3.457,0.543,3.273 -3.706,0.710,3.273 -4.000,0.768,3.273 -4.294,0.710,3.273 -4.543,0.543,3.273 -4.710,0.294,3.273 -4.768,0.0,3.273 -4.710,-0.294,3.273 -4.543,-0.543,3.273 -4.294,-0.710,3.273 -4.000,-0.768,3.273 -3.706,-0.710,3.273 -3.457,-0.543,3.273 -3.290,-0.294,3.273
range name l_4 x -4.785 -3.215 y -0.785 0.785 z 2.456 3.273

;left_5

poly prism a -3.232,0.0,3.273 -3.290,0.294,3.273 -3.457,0.543,3.273 -3.706,0.710,3.273 -4.000,0.768,3.273 -4.294,0.710,3.273 -4.543,0.543,3.273 -4.710,0.294,3.273 -4.768,0.0,3.273 -4.710,-0.294,3.273 -4.543,-0.543,3.273 -4.294,-0.710,3.273 -4.000,-0.768,3.273 -3.706,-0.710,3.273 -3.457,-0.543,3.273 -3.290,-0.294,3.273 &
b -3.247,0.0,4.090 -3.304,0.288,4.090 -3.467,0.533,4.090 -3.712,0.696,4.090 -4.000,0.754,4.090 -4.288,0.696,4.090 -4.533,0.533,4.090 -4.696,0.288,4.090 -4.754,0.0,4.090 -4.696,-0.288,4.090 -4.533,-0.533,4.090 -4.288,-0.696,4.090 -4.000,-0.754,4.090 -3.712,-0.696,4.090 -3.467,-0.533,4.090 -3.304,-0.288,4.090
range name l_5 x -4.768 -3.232 y -0.768 0.768 z 3.273 4.090

;left_6

poly prism a -3.247,0.0,4.090 -3.304,0.288,4.090 -3.467,0.533,4.090 -3.712,0.696,4.090 -4.000,0.754,4.090 -4.288,0.696,4.090 -4.533,0.533,4.090 -4.696,0.288,4.090 -4.754,0.0,4.090 -4.696,-0.288,4.090 -4.533,-0.533,4.090 -4.288,-0.696,4.090 -4.000,-0.754,4.090 -3.712,-0.696,4.090 -3.467,-0.533,4.090 -3.304,-0.288,4.090 &

b -3.256,0.0,4.763 -3.313,0.285,4.763 -3.474,0.526,4.763 -3.715,0.687,4.763 -4.000,0.744,4.763 -4.285,0.687,4.763 -4.526,0.526,4.763 -4.687,0.285,4.763 -4.744,0.0,4.763 -4.687,-0.285,4.763 -4.526,-0.526,4.763 -4.285,-0.687,4.763 -4.000,-0.744,4.763 -3.715,-0.687,4.763 -3.474,-0.526,4.763 -3.313,-0.285,4.763
range name l_6 x -4.754 -3.247 y -0.7535 0.7535 z 4.090 4.763

;left_7

poly prism a -3.256,0.0,4.763 -3.313,0.285,4.763 -3.474,0.526,4.763 -3.715,0.687,4.763 -4.000,0.744,4.763 -4.285,0.687,4.763 -4.526,0.526,4.763 -4.687,0.285,4.763 -4.744,0.0,4.763 -4.687,-0.285,4.763 -4.526,-0.526,4.763 -4.285,-0.687,4.763 -4.000,-0.744,4.763 -3.715,-0.687,4.763 -3.474,-0.526,4.763 -3.313,-0.285,4.763 &
b -3.268,0.0,5.604 -3.324,0.280,5.604 -3.482,0.518,5.604 -3.720,0.676,5.604 -4.000,0.732,5.604 -4.280,0.676,5.604 -4.518,0.518,5.604 -4.676,0.280,5.604 -4.732,0.0,5.604 -4.676,-0.280,5.604 -4.518,-0.518,5.604 -4.280,-0.676,5.604 -4.000,-0.732,5.604 -3.720,-0.676,5.604 -3.482,-0.518,5.604 -3.324,-0.280,5.604
range name l_7 x -4.744 -3.256 y -0.744 0.744 z 4.763 5.604

;left_8

poly prism a -3.268,0.0,5.604 -3.324,0.280,5.604 -3.482,0.518,5.604 -3.720,0.676,5.604 -4.000,0.732,5.604 -4.280,0.676,5.604 -4.518,0.518,5.604 -4.676,0.280,5.604 -4.732,0.0,5.604 -4.676,-0.280,5.604 -4.518,-0.518,5.604 -4.280,-0.676,5.604 -4.000,-0.732,5.604 -3.720,-0.676,5.604 -3.482,-0.518,5.604 -3.324,-0.280,5.604 &
b -3.292,0.0,6.421 -3.346,0.271,6.421 -3.499,0.501,6.421 -3.729,0.654,6.421 -4.000,0.708,6.421 -4.271,0.654,6.421 -4.501,0.501,6.421 -4.654,0.271,6.421 -4.708,0.0,6.421 -4.654,-0.271,6.421 -4.501,-0.501,6.421 -4.271,-0.654,6.421 -4.000,-0.708,6.421 -3.729,-0.654,6.421 -3.499,-0.501,6.421 -3.346,-0.271,6.421
range name l_8 x -4.732 -3.268 y -0.732 0.732 z 5.604 6.421

;left_9

poly prism a -3.292,0.0,6.421 -3.346,0.271,6.421 -3.499,0.501,6.421 -3.729,0.654,6.421 -4.000,0.708,6.421 -4.271,0.654,6.421 -4.501,0.501,6.421 -4.654,0.271,6.421 -4.708,0.0,6.421 -4.654,-0.271,6.421 -4.501,-0.501,6.421 -4.271,-0.654,6.421 -4.000,-0.708,6.421 -3.729,-0.654,6.421 -3.499,-0.501,6.421 -3.346,-0.271,6.421 &
b -3.307,0.0,7.118 -3.359,0.265,7.118 -3.510,0.490,7.118 -3.735,0.641,7.118 -4.000,0.694,7.118 -4.265,0.641,7.118 -4.490,0.490,7.118 -4.641,0.265,7.118 -4.694,0.0,7.118 -4.641,-0.265,7.118 -4.490,-0.490,7.118 -4.265,-0.641,7.118 -4.000,-0.694,7.118 -3.735,-0.641,7.118 -3.510,-0.490,7.118 -3.359,-0.265,7.118
range name l_9 x -4.708 -3.292 y -0.708 0.708 z 6.421 7.118

;left_10

poly prism a -3.307,0.0,7.118 -3.359,0.265,7.118 -3.510,0.490,7.118 -3.735,0.641,7.118 -4.000,0.694,7.118 -4.265,0.641,7.118 -4.490,0.490,7.118 -4.641,0.265,7.118 -4.694,0.0,7.118 -4.641,-0.265,7.118 -4.490,-0.490,7.118 -4.265,-0.641,7.118 -4.000,-0.694,7.118 -3.735,-0.641,7.118 -3.510,-0.490,7.118 -3.359,-0.265,7.118 &
b -3.328,0.0,7.748 -3.379,0.257,7.748 -3.525,0.475,7.748 -3.743,0.621,7.748 -4.000,0.672,7.748 -4.257,0.621,7.748 -4.475,0.475,7.748 -4.621,0.257,7.748 -4.672,0.0,7.748 -4.621,-0.257,7.748 -4.475,-0.475,7.748 -4.257,-0.621,7.748 -4.000,-0.672,7.748 -3.743,-0.621,7.748 -3.525,-0.475,7.748 -3.379,-0.257,7.748
range name l_10 x -4.694 -3.307 y -0.6935 0.6935 z 7.118 7.748

;left_11

poly prism a -3.328,0.0,7.748 -3.379,0.257,7.748 -3.525,0.475,7.748 -3.743,0.621,7.748 -4.000,0.672,7.748 -4.257,0.621,7.748 -4.475,0.475,7.748 -4.621,0.257,7.748 -4.672,0.0,7.748 -4.621,-0.257,7.748 -4.475,-0.475,7.748 -4.257,-0.621,7.748 -4.000,-0.672,7.748 -3.743,-0.621,7.748 -3.525,-0.475,7.748 -3.379,-0.257,7.748 &
b -3.352,0.0,8.589 -3.401,0.248,8.589 -3.542,0.458,8.589 -3.752,0.599,8.589 -4.000,0.648,8.589 -4.248,0.599,8.589 -4.458,0.458,8.589 -4.599,0.248,8.589 -4.648,0.0,8.589 -4.599,-0.248,8.589 -4.458,-0.458,8.589 -4.248,-0.599,8.589 -4.000,-0.648,8.589 -3.752,-0.599,8.589 -3.542,-0.458,8.589 -3.401,-0.248,8.589
range name l_11 x -4.672 -3.328 y -0.672 0.672 z 7.538 8.589

;left_12

poly prism a -3.352,0.0,8.589 -3.401,0.248,8.589 -3.542,0.458,8.589 -3.752,0.599,8.589 -4.000,0.648,8.589 -4.248,0.599,8.589 -4.458,0.458,8.589 -4.599,0.248,8.589 -4.648,0.0,8.589 -4.599,-0.248,8.589 -4.458,-0.458,8.589 -4.248,-0.599,8.589 -4.000,-0.648,8.589 -3.752,-0.599,8.589 -3.542,-0.458,8.589 -3.401,-0.248,8.589 &
b -3.362,0.0,9.382 -3.410,0.244,9.382 -3.549,0.451,9.382 -3.756,0.590,9.382 -4.000,0.639,9.382 -4.244,0.590,9.382 -4.451,0.451,9.382 -4.590,0.244,9.382 -4.639,0.0,9.382 -4.590,-0.244,9.382 -4.451,-0.451,9.382 -4.244,-0.590,9.382 -4.000,-0.639,9.382 -3.756,-0.590,9.382 -3.549,-0.451,9.382 -3.410,-0.244,9.382
range name l_12 x -4.648 -3.352 y -0.648 0.648 z 8.589 9.382

;left_y

poly prism a -3.362,0.0,9.382 -3.410,0.244,9.382 -3.549,0.451,9.382 -3.756,0.590,9.382 -4.000,0.639,9.382 -4.244,0.590,9.382 -4.451,0.451,9.382 -4.590,0.244,9.382 -4.639,0.0,9.382 -4.590,-0.244,9.382 -4.451,-0.451,9.382 -4.244,-0.590,9.382 -4.000,-0.639,9.382 -3.756,-0.590,9.382 -3.549,-0.451,9.382 -3.410,-0.244,9.382 &
b -3.352,0.0,9.527 -3.401,0.248,9.527 -3.542,0.458,9.527 -3.752,0.599,9.527 -4.000,0.648,9.527 -4.248,0.599,9.527 -4.458,0.458,9.527 -4.599,0.248,9.527 -4.648,0.0,9.527 -4.599,-0.248,9.527 -4.458,-0.458,9.527 -4.248,-0.599,9.527 -4.000,-0.648,9.527 -3.752,-0.599,9.527 -3.542,-0.458,9.527 -3.401,-0.248,9.527
range name l_y x -4.648 -3.352 y -0.648 0.648 z 9.382 9.527
join_contact on range x -4.852 -3.148 y -0.852 0.852 z 9.383 10.081

;left_k1

poly prism a -3.352,0.0,9.527 -3.401,0.248,9.527 -3.542,0.458,9.527 -3.752,0.599,9.527 -4.000,0.648,9.527 -4.248,0.599,9.527 -4.458,0.458,9.527 -4.599,0.248,9.527 -4.648,0.0,9.527 -4.599,-0.248,9.527 -4.458,-0.458,9.527 -4.248,-0.599,9.527 -4.000,-0.648,9.527 -3.752,-0.599,9.527 -3.542,-0.458,9.527 -3.401,-0.248,9.527 &
b -3.328,0.0,9.576 -3.379,0.257,9.576 -3.525,0.475,9.576 -3.743,0.621,9.576 -4.000,0.672,9.576 -4.257,0.621,9.576 -4.475,0.475,9.576 -4.621,0.257,9.576 -4.672,0.0,9.576 -4.621,-0.257,9.576 -4.475,-0.475,9.576 -4.257,-0.621,9.576 -4.000,-0.672,9.576 -3.743,-0.621,9.576 -3.525,-0.475,9.576 -3.379,-0.257,9.576
range name l_k1 x -4.672 -3.328 y -0.672 0.672 z 9.527 9.576
join_contact on range x -4.852 -3.148 y -0.852 0.852 z 9.383 10.081

;left_k2

poly prism a -3.328,0.0,9.576 -3.379,0.257,9.576 -3.525,0.475,9.576 -3.743,0.621,9.576 -4.000,0.672,9.576 -4.257,0.621,9.576 -4.475,0.475,9.576 -4.621,0.257,9.576 -4.672,0.0,9.576 -4.621,-0.257,9.576 -4.475,-0.475,9.576 -4.257,-0.621,9.576 -4.000,-0.672,9.576 -3.743,-0.621,9.576 -3.525,-0.475,9.576 -3.379,-0.257,9.576 &

b -3.160,0.0,9.793 -3.224,0.321,9.793 -3.406,0.594,9.793 -3.679,0.776,9.793 -4.000,0.840,9.793 -4.321,0.776,9.793 -4.594,0.594,9.793 -4.776,0.321,9.793 -4.840,0.0,9.793 -4.776,-0.321,9.793 -4.594,-0.594,9.793 -4.321,-0.776,9.793 -4.000,-0.840,9.793 -3.679,-0.776,9.793 -3.406,-0.594,9.793 -3.224,-0.321,9.793
range name l_k2 x -4.840 -3.160 y -0.840 0.840 z 9.576 9.793
join_contact on range x -4.852 -3.148 y -0.852 0.852 z 9.383 10.081

;left_k3

poly prism a -4.852,-0.852,9.793 -3.148,-0.852,9.793 -3.148,0.852,9.793 -4.852,0.852,9.793 &
b -4.852,-0.852,10.081 -3.148,-0.852,10.081 -3.148,0.852,10.081 -4.852,0.852,10.081
range name l_k3 x -4.852 -3.148 y -0.852 0.852 z 9.793 10.081
join_contact on range x -4.852 -3.148 y -0.852 0.852 z 9.383 10.081

;right_

;right_b

poly prism a 4.862,-0.938,-0.420 3.138,-0.938,-0.420 3.138,0.938,-0.420 4.862,0.938,-0.420 &
b 4.862,-0.938,0.0 3.138,-0.938,0.0 3.138,0.938,0.0 4.862,0.938,0.0
range name r_b x 3.138 4.862 y -0.938 0.938 z -0.420 0.0

;right_1

poly prism a 3.175,0.0,0.0 3.238,0.316,0.0 3.417,0.583,0.0 3.684,0.762,0.0 4.000,0.825,0.0 4.316,0.762,0.0 4.583,0.583,0.0 4.762,0.316,0.0 4.825,0.0,0.0 4.762,-0.316,0.0 4.583,-0.583,0.0 4.316,-0.762,0.0 4.000,-0.825,0.0 3.684,-0.762,0.0 3.417,-0.583,0.0 3.238,-0.316,0.0 &
b 3.184,0.0,0.918 3.246,0.312,0.918 3.423,0.577,0.918 3.688,0.754,0.918 4.000,0.816,0.918 4.312,0.754,0.918 4.577,0.577,0.918 4.754,0.312,0.918 4.816,0.0,0.918 4.754,-0.312,0.918 4.577,-0.577,0.918 4.312,-0.754,0.918 4.000,-0.816,0.918 3.688,-0.754,0.918 3.423,-0.577,0.918 3.246,-0.312,0.918
range name r_1 x 3.175 4.825 y -0.825 0.825 z 0.0 0.918

;right_2

poly prism a 3.184,0.0,0.918 3.246,0.312,0.918 3.423,0.577,0.918 3.688,0.754,0.918 4.000,0.816,0.918 4.312,0.754,0.918 4.577,0.577,0.918 4.754,0.312,0.918 4.816,0.0,0.918 4.754,-0.312,0.918 4.577,-0.577,0.918 4.312,-0.754,0.918 4.000,-0.816,0.918 3.688,-0.754,0.918 3.423,-0.577,0.918 3.246,-0.312,0.918 &
b 3.201,0.0,1.687 3.262,0.306,1.687 3.435,0.565,1.687 3.694,0.738,1.687 4.000,0.799,1.687 4.306,0.738,1.687 4.565,0.565,1.687 4.738,0.306,1.687 4.799,0.0,1.687 4.738,-0.306,1.687 4.565,-0.565,1.687 4.306,-0.738,1.687 4.000,-0.799,1.687 3.694,-0.738,1.687 3.435,-0.565,1.687 3.262,-0.306,1.687
range name r_2 x 3.184 4.816 y -0.816 0.816 z 0.918 1.687

;right_3

poly prism a 3.201,0.0,1.687 3.262,0.306,1.687 3.435,0.565,1.687 3.694,0.738,1.687 4.000,0.799,1.687 4.306,0.738,1.687 4.565,0.565,1.687 4.738,0.306,1.687 4.799,0.0,1.687 4.738,-0.306,1.687 4.565,-0.565,1.687 4.306,-0.738,1.687 4.000,-0.799,1.687 3.694,-0.738,1.687 3.435,-0.565,1.687 3.262,-0.306,1.687 &
b 3.215,0.0,2.456 3.275,0.300,2.456 3.445,0.555,2.456 3.700,0.725,2.456 4.000,0.785,2.456 4.300,0.725,2.456 4.555,0.555,2.456 4.725,0.300,2.456 4.785,0.0,2.456 4.725,-0.300,2.456 4.555,-0.555,2.456 4.300,-0.725,2.456 4.000,-0.785,2.456 3.700,-0.725,2.456 3.445,-0.555,2.456 3.275,-0.300,2.456

range name r_3 x 3.201 4.799 y -0.799 0.799 z 1.687 2.456

;right_4

poly prism a 3.215,0.0,2.456 3.275,0.300,2.456 3.445,0.555,2.456 3.700,0.725,2.456 4.000,0.785,2.456 4.300,0.725,2.456 4.555,0.555,2.456 4.725,0.300,2.456 4.785,0.0,2.456 4.725,-0.300,2.456 4.555,-0.555,2.456 4.300,-0.725,2.456 4.000,-0.785,2.456 3.700,-0.725,2.456 3.445,-0.555,2.456 3.275,-0.300,2.456 &
b 3.232,0.0,3.273 3.290,0.294,3.273 3.457,0.543,3.273 3.706,0.710,3.273 4.000,0.768,3.273 4.294,0.710,3.273 4.543,0.543,3.273 4.710,0.294,3.273 4.768,0.0,3.273 4.710,-0.294,3.273 4.543,-0.543,3.273 4.294,-0.710,3.273 4.000,-0.768,3.273 3.706,-0.710,3.273 3.457,-0.543,3.273 3.290,-0.294,3.273
range name r_4 x 3.215 4.785 y -0.785 0.785 z 2.456 3.273

;right_5

poly prism a 3.232,0.0,3.273 3.290,0.294,3.273 3.457,0.543,3.273 3.706,0.710,3.273 4.000,0.768,3.273 4.294,0.710,3.273 4.543,0.543,3.273 4.710,0.294,3.273 4.768,0.0,3.273 4.710,-0.294,3.273 4.543,-0.543,3.273 4.294,-0.710,3.273 4.000,-0.768,3.273 3.706,-0.710,3.273 3.457,-0.543,3.273 3.290,-0.294,3.273 &
b 3.247,0.0,4.090 3.304,0.288,4.090 3.467,0.533,4.090 3.712,0.696,4.090 4.000,0.754,4.090 4.288,0.696,4.090 4.533,0.533,4.090 4.696,0.288,4.090 4.754,0.0,4.090 4.696,-0.288,4.090 4.533,-0.533,4.090 4.288,-0.696,4.090 4.000,-0.754,4.090 3.712,-0.696,4.090 3.467,-0.533,4.090 3.304,-0.288,4.090
range name r_5 x 3.232 4.768 y -0.768 0.768 z 3.273 4.090

;right_6

poly prism a 3.247,0.0,4.090 3.304,0.288,4.090 3.467,0.533,4.090 3.712,0.696,4.090 4.000,0.754,4.090 4.288,0.696,4.090 4.533,0.533,4.090 4.696,0.288,4.090 4.754,0.0,4.090 4.696,-0.288,4.090 4.533,-0.533,4.090 4.288,-0.696,4.090 4.000,-0.754,4.090 3.712,-0.696,4.090 3.467,-0.533,4.090 3.304,-0.288,4.090 &
b 3.256,0.0,4.763 3.313,0.285,4.763 3.474,0.526,4.763 3.715,0.687,4.763 4.000,0.744,4.763 4.285,0.687,4.763 4.526,0.526,4.763 4.687,0.285,4.763 4.744,0.0,4.763 4.687,-0.285,4.763 4.526,-0.526,4.763 4.285,-0.687,4.763 4.000,-0.744,4.763 3.715,-0.687,4.763 3.474,-0.526,4.763 3.313,-0.285,4.763
range name r_6 x 3.247 4.754 y -0.7535 0.7535 z 4.090 4.763

;right_7

poly prism a 3.256,0.0,4.763 3.313,0.285,4.763 3.474,0.526,4.763 3.715,0.687,4.763 4.000,0.744,4.763 4.285,0.687,4.763 4.526,0.526,4.763 4.687,0.285,4.763 4.744,0.0,4.763 4.687,-0.285,4.763 4.526,-0.526,4.763 4.285,-0.687,4.763 4.000,-0.744,4.763 3.715,-0.687,4.763 3.474,-0.526,4.763 3.313,-0.285,4.763 &
b 3.268,0.0,5.604 3.324,0.280,5.604 3.482,0.518,5.604 3.720,0.676,5.604 4.000,0.732,5.604 4.280,0.676,5.604 4.518,0.518,5.604 4.676,0.280,5.604 4.732,0.0,5.604 4.676,-0.280,5.604 4.518,-0.518,5.604 4.280,-0.676,5.604 4.000,-0.732,5.604 3.720,-0.676,5.604 3.482,-0.518,5.604 3.324,-0.280,5.604
range name r_7 x 3.256 4.744 y -0.744 0.744 z 4.763 5.604

;right_8

poly prism a 3.268,0.0,5.604 3.324,0.280,5.604 3.482,0.518,5.604 3.720,0.676,5.604 4.000,0.732,5.604 4.280,0.676,5.604 4.518,0.518,5.604 4.676,0.280,5.604 4.732,0.0,5.604 4.676,-0.280,5.604 4.518,-0.518,5.604 4.280,-0.676,5.604 4.000,-0.732,5.604 3.720,-0.676,5.604 3.482,-0.518,5.604 3.324,-0.280,5.604 &

b 3.292,0.0,6.421 3.346,0.271,6.421 3.499,0.501,6.421 3.729,0.654,6.421 4.000,0.708,6.421 4.271,0.654,6.421 4.501,0.501,6.421 4.654,0.271,6.421 4.708,0.0,6.421 4.654,-0.271,6.421 4.501,-0.501,6.421 4.271,-0.654,6.421 4.000,-0.708,6.421 3.729,-0.654,6.421 3.499,-0.501,6.421 3.346,-0.271,6.421
range name r_8 x 3.268 4.732 y -0.732 0.732 z 5.604 6.421

;right_9

poly prism a 3.292,0.0,6.421 3.346,0.271,6.421 3.499,0.501,6.421 3.729,0.654,6.421 4.000,0.708,6.421 4.271,0.654,6.421 4.501,0.501,6.421 4.654,0.271,6.421 4.708,0.0,6.421 4.654,-0.271,6.421 4.501,-0.501,6.421 4.271,-0.654,6.421 4.000,-0.708,6.421 3.729,-0.654,6.421 3.499,-0.501,6.421 3.346,-0.271,6.421 &
b 3.307,0.0,7.118 3.359,0.265,7.118 3.510,0.490,7.118 3.735,0.641,7.118 4.000,0.694,7.118 4.265,0.641,7.118 4.490,0.490,7.118 4.641,0.265,7.118 4.694,0.0,7.118 4.641,-0.265,7.118 4.490,-0.490,7.118 4.265,-0.641,7.118 4.000,-0.694,7.118 3.735,-0.641,7.118 3.510,-0.490,7.118 3.359,-0.265,7.118
range name r_9 x 3.292 4.708 y -0.708 0.708 z 6.421 7.118

;right_10

poly prism a 3.307,0.0,7.118 3.359,0.265,7.118 3.510,0.490,7.118 3.735,0.641,7.118 4.000,0.694,7.118 4.265,0.641,7.118 4.490,0.490,7.118 4.641,0.265,7.118 4.694,0.0,7.118 4.641,-0.265,7.118 4.490,-0.490,7.118 4.265,-0.641,7.118 4.000,-0.694,7.118 3.735,-0.641,7.118 3.510,-0.490,7.118 3.359,-0.265,7.118 &
b 3.328,0.0,7.748 3.379,0.257,7.748 3.525,0.475,7.748 3.743,0.621,7.748 4.000,0.672,7.748 4.257,0.621,7.748 4.475,0.475,7.748 4.621,0.257,7.748 4.672,0.0,7.748 4.621,-0.257,7.748 4.475,-0.475,7.748 4.257,-0.621,7.748 4.000,-0.672,7.748 3.743,-0.621,7.748 3.525,-0.475,7.748 3.379,-0.257,7.748
range name r_10 x 3.307 4.694 y -0.6935 0.6935 z 7.118 7.748

;right_11

poly prism a 3.328,0.0,7.748 3.379,0.257,7.748 3.525,0.475,7.748 3.743,0.621,7.748 4.000,0.672,7.748 4.257,0.621,7.748 4.475,0.475,7.748 4.621,0.257,7.748 4.672,0.0,7.748 4.621,-0.257,7.748 4.475,-0.475,7.748 4.257,-0.621,7.748 4.000,-0.672,7.748 3.743,-0.621,7.748 3.525,-0.475,7.748 3.379,-0.257,7.748 &
b 3.352,0.0,8.589 3.401,0.248,8.589 3.542,0.458,8.589 3.752,0.599,8.589 4.000,0.648,8.589 4.248,0.599,8.589 4.458,0.458,8.589 4.599,0.248,8.589 4.648,0.0,8.589 4.599,-0.248,8.589 4.458,-0.458,8.589 4.248,-0.599,8.589 4.000,-0.648,8.589 3.752,-0.599,8.589 3.542,-0.458,8.589 3.401,-0.248,8.589
range name r_11 x 3.328 4.672 y -0.672 0.672 z 7.538 8.589

;right_12

poly prism a 3.352,0.0,8.589 3.401,0.248,8.589 3.542,0.458,8.589 3.752,0.599,8.589 4.000,0.648,8.589 4.248,0.599,8.589 4.458,0.458,8.589 4.599,0.248,8.589 4.648,0.0,8.589 4.599,-0.248,8.589 4.458,-0.458,8.589 4.248,-0.599,8.589 4.000,-0.648,8.589 3.752,-0.599,8.589 3.542,-0.458,8.589 3.401,-0.248,8.589 &
b 3.362,0.0,9.382 3.410,0.244,9.382 3.549,0.451,9.382 3.756,0.590,9.382 4.000,0.639,9.382 4.244,0.590,9.382 4.451,0.451,9.382 4.590,0.244,9.382 4.639,0.0,9.382 4.590,-0.244,9.382 4.451,-0.451,9.382 4.244,-0.590,9.382 4.000,-0.639,9.382 3.756,-0.590,9.382 3.549,-0.451,9.382 3.410,-0.244,9.382
range name r_12 x 3.352 4.648 y -0.648 0.648 z 8.589 9.382

;right_y

poly prism a 3.362,0.0,9.382 3.410,0.244,9.382 3.549,0.451,9.382 3.756,0.590,9.382 4.000,0.639,9.382 4.244,0.590,9.382 4.451,0.451,9.382 4.590,0.244,9.382 4.639,0.0,9.382 4.590,-0.244,9.382 4.451,-0.451,9.382 4.244,-0.590,9.382 4.000,-0.639,9.382 3.756,-0.590,9.382 3.549,-0.451,9.382 3.410,-0.244,9.382 &
b 3.352,0.0,9.527 3.401,0.248,9.527 3.542,0.458,9.527 3.752,0.599,9.527 4.000,0.648,9.527 4.248,0.599,9.527 4.458,0.458,9.527 4.599,0.248,9.527 4.648,0.0,9.527 4.599,-0.248,9.527 4.458,-0.458,9.527 4.248,-0.599,9.527 4.000,-0.648,9.527 3.752,-0.599,9.527 3.542,-0.458,9.527 3.401,-0.248,9.527
range name r_y x 3.352 4.648 y -0.648 0.648 z 9.382 9.527
join_contact on range x 3.148 4.852 y -0.852 0.852 z 9.383 10.081

;right_k1

poly prism a 3.352,0.0,9.527 3.401,0.248,9.527 3.542,0.458,9.527 3.752,0.599,9.527 4.000,0.648,9.527 4.248,0.599,9.527 4.458,0.458,9.527 4.599,0.248,9.527 4.648,0.0,9.527 4.599,-0.248,9.527 4.458,-0.458,9.527 4.248,-0.599,9.527 4.000,-0.648,9.527 3.752,-0.599,9.527 3.542,-0.458,9.527 3.401,-0.248,9.527 &
b 3.328,0.0,9.576 3.379,0.257,9.576 3.525,0.475,9.576 3.743,0.621,9.576 4.000,0.672,9.576 4.257,0.621,9.576 4.475,0.475,9.576 4.621,0.257,9.576 4.672,0.0,9.576 4.621,-0.257,9.576 4.475,-0.475,9.576 4.257,-0.621,9.576 4.000,-0.672,9.576 3.743,-0.621,9.576 3.525,-0.475,9.576 3.379,-0.257,9.576
range name r_k1 x 3.328 4.672 y -0.672 0.672 z 9.527 9.576
join_contact on range x 3.148 4.852 y -0.852 0.852 z 9.383 10.081

;right_k2

poly prism a 3.328,0.0,9.576 3.379,0.257,9.576 3.525,0.475,9.576 3.743,0.621,9.576 4.000,0.672,9.576 4.257,0.621,9.576 4.475,0.475,9.576 4.621,0.257,9.576 4.672,0.0,9.576 4.621,-0.257,9.576 4.475,-0.475,9.576 4.257,-0.621,9.576 4.000,-0.672,9.576 3.743,-0.621,9.576 3.525,-0.475,9.576 3.379,-0.257,9.576 &
b 3.160,0.0,9.793 3.224,0.321,9.793 3.406,0.594,9.793 3.679,0.776,9.793 4.000,0.840,9.793 4.321,0.776,9.793 4.594,0.594,9.793 4.776,0.321,9.793 4.840,0.0,9.793 4.776,-0.321,9.793 4.594,-0.594,9.793 4.321,-0.776,9.793 4.000,-0.840,9.793 3.679,-0.776,9.793 3.406,-0.594,9.793 3.224,-0.321,9.793
range name r_k2 x 3.160 4.840 y -0.840 0.840 z 9.576 9.793
join_contact on range x 3.148 4.852 y -0.852 0.852 z 9.383 10.081

;right_k3

poly prism a 4.852,-0.852,9.793 3.148,-0.852,9.793 3.148,0.852,9.793 4.852,0.852,9.793 &
b 4.852,-0.852,10.081 3.148,-0.852,10.081 3.148,0.852,10.081 4.852,0.852,10.081
range name r_k3 x 3.148 4.852 y -0.852 0.852 z 9.793 10.081
join_contact on range x 3.148 4.852 y -0.852 0.852 z 9.383 10.081

## *Colonnade in a corner arrangement*

;corner_(6th)

;6th_b

poly prism a -0.862,-0.938,-0.420 0.862,-0.938,-0.420 0.862,0.938,-0.420 -0.862,0.938,-0.420 &
b -0.862,-0.938,0.0 0.862,-0.938,0.0 0.862,0.938,0.0 -0.862,0.938,0.0
range name 6th_b x -0.862 0.862 y -0.938 0.938 z -0.420 0.0

;6th_1

poly prism a 0.825,0.0,0.0 0.762,0.316,0.0 0.583,0.583,0.0 0.316,0.762,0.0 0.0,0.825,0.0 -0.316,0.762,0.0 -0.583,0.583,0.0 -0.762,0.316,0.0 -0.825,0.0,0.0 -0.762,-0.316,0.0 -0.583,-0.583,0.0 -0.316,-0.762,0.0 0.0,-0.825,0.0 0.316,-0.762,0.0 0.583,-0.583,0.0 0.762,-0.316,0.0 &
b 0.816,0.0,0.918 0.754,0.312,0.918 0.577,0.577,0.918 0.312,0.754,0.918 0.0,0.816,0.918 -0.312,0.754,0.918 -0.577,0.577,0.918 -0.754,0.312,0.918 -0.816,0.0,0.918 -0.754,-0.312,0.918 -0.577,-0.577,0.918 -0.312,-0.754,0.918 0.0,-0.816,0.918 0.312,-0.754,0.918 0.577,-0.577,0.918 0.754,-0.312,0.918
range name 6th_1 x -0.825 0.825 y -0.825 0.825 z 0.0 0.918

;6th_2

poly prism a 0.816,0.0,0.918 0.754,0.312,0.918 0.577,0.577,0.918 0.312,0.754,0.918 0.0,0.816,0.918 -0.312,0.754,0.918 -0.577,0.577,0.918 -0.754,0.312,0.918 -0.816,0.0,0.918 -0.754,-0.312,0.918 -0.577,-0.577,0.918 -0.312,-0.754,0.918 0.0,-0.816,0.918 0.312,-0.754,0.918 0.577,-0.577,0.918 0.754,-0.312,0.918 &
b 0.799,0.0,1.687 0.738,0.306,1.687 0.565,0.565,1.687 0.306,0.738,1.687 0.0,0.799,1.687 -0.306,0.738,1.687 -0.565,0.565,1.687 -0.738,0.306,1.687 -0.799,0.0,1.687 -0.738,-0.306,1.687 -0.565,-0.565,1.687 -0.306,-0.738,1.687 0.0,-0.799,1.687 0.306,-0.738,1.687 0.565,-0.565,1.687 0.738,-0.306,1.687
range name 6th_2 x -0.816 0.816 y -0.816 0.816 z 0.918 1.687

;6th_3

poly prism a 0.799,0.0,1.687 0.738,0.306,1.687 0.565,0.565,1.687 0.306,0.738,1.687 0.0,0.799,1.687 -0.306,0.738,1.687 -0.565,0.565,1.687 -0.738,0.306,1.687 -0.799,0.0,1.687 -0.738,-0.306,1.687 -0.565,-0.565,1.687 -0.306,-0.738,1.687 0.0,-0.799,1.687 0.306,-0.738,1.687 0.565,-0.565,1.687 0.738,-0.306,1.687 &
b 0.785,0.0,2.456 0.725,0.300,2.456 0.555,0.555,2.456 0.300,0.725,2.456 0.0,0.785,2.456 -0.300,0.725,2.456 -0.555,0.555,2.456 -0.725,0.300,2.456 -0.785,0.0,2.456 -0.725,-0.300,2.456 -0.555,-0.555,2.456 -0.300,-0.725,2.456 0.0,-0.785,2.456 0.300,-0.725,2.456 0.555,-0.555,2.456 0.725,-0.300,2.456
range name 6th_3 x -0.799 0.799 y -0.799 0.799 z 1.687 2.456

;6th_4

poly prism a 0.785,0.0,2.456 0.725,0.300,2.456 0.555,0.555,2.456 0.300,0.725,2.456 0.0,0.785,2.456 -0.300,0.725,2.456 -0.555,0.555,2.456 -0.725,0.300,2.456 -0.785,0.0,2.456 -0.725,-0.300,2.456 -0.555,-0.555,2.456 -0.300,-0.725,2.456 0.0,-0.785,2.456 0.300,-0.725,2.456 0.555,-0.555,2.456 0.725,-0.300,2.456 &
b 0.768,0.0,3.273 0.710,0.294,3.273 0.543,0.543,3.273 0.294,0.710,3.273 0.0,0.768,3.273 -0.294,0.710,3.273 -0.543,0.543,3.273 -0.710,0.294,3.273 -0.768,0.0,3.273 -0.710,-0.294,3.273 -0.543,-0.543,3.273 -0.294,-0.710,3.273 0.0,-0.768,3.273 0.294,-0.710,3.273 0.543,-0.543,3.273 0.710,-0.294,3.273
range name 6th_4 x -0.785 0.785 y -0.785 0.785 z 2.456 3.273

;6th_5

poly prism a 0.768,0.0,3.273 0.710,0.294,3.273 0.543,0.543,3.273 0.294,0.710,3.273 0.0,0.768,3.273 -0.294,0.710,3.273 -0.543,0.543,3.273 -0.710,0.294,3.273 -0.768,0.0,3.273 -0.710,-0.294,3.273 -0.543,-0.543,3.273 -0.294,-0.710,3.273 0.0,-0.768,3.273 0.294,-0.710,3.273 0.543,-0.543,3.273 0.710,-0.294,3.273 &
b 0.7535,0.0,4.090 0.696,0.288,4.090 0.533,0.533,4.090 0.288,0.696,4.090 0.0,0.7535,4.090 -0.288,0.696,4.090 -0.533,0.533,4.090 -0.696,0.288,4.090 -0.7535,0.0,4.090 -0.696,-0.288,4.090 -0.533,-0.533,4.090 -0.288,-0.696,4.090 0.0,-0.7535,4.090 0.288,-0.696,4.090 0.533,-0.533,4.090 0.696,-0.288,4.090
range name 6th_5 x -0.768 0.768 y -0.768 0.768 z 3.273 4.090

;6th_6

poly prism a 0.7535,0.0,4.090 0.696,0.288,4.090 0.533,0.533,4.090 0.288,0.696,4.090 0.0,0.7535,4.090 -0.288,0.696,4.090 -0.533,0.533,4.090 -0.696,0.288,4.090 -0.7535,0.0,4.090 -0.696,-0.288,4.090 -0.533,-0.533,4.090 -0.288,-0.696,4.090 0.0,-0.7535,4.090 0.288,-0.696,4.090 0.533,-0.533,4.090 0.696,-0.288,4.090 &
b 0.744,0.0,4.763 0.687,0.285,4.763 0.526,0.526,4.763 0.285,0.687,4.763 0.0,0.744,4.763 -0.285,0.687,4.763 -0.526,0.526,4.763 -0.687,0.285,4.763 -0.744,0.0,4.763 -0.687,-0.285,4.763 -0.526,-0.526,4.763 -0.285,-0.687,4.763 0.0,-0.744,4.763 0.285,-0.687,4.763 0.526,-0.526,4.763 0.687,-0.285,4.763
range name 6th_6 x -0.7535 0.7535 y -0.7535 0.7535 z 4.090 4.763

;6th_7

poly prism a 0.744,0.0,4.763 0.687,0.285,4.763 0.526,0.526,4.763 0.285,0.687,4.763 0.0,0.744,4.763 -0.285,0.687,4.763 -0.526,0.526,4.763 -0.687,0.285,4.763 -0.744,0.0,4.763 -0.687,-0.285,4.763 -0.526,-0.526,4.763 -0.285,-0.687,4.763 0.0,-0.744,4.763 0.285,-0.687,4.763 0.526,-0.526,4.763 0.687,-0.285,4.763 &
b 0.732,0.0,5.604 0.676,0.280,5.604 0.518,0.518,5.604 0.280,0.676,5.604 0.0,0.732,5.604 -0.280,0.676,5.604 -0.518,0.518,5.604 -0.676,0.280,5.604 -0.732,0.0,5.604 -0.676,-0.280,5.604 -0.518,-0.518,5.604 -0.280,-0.676,5.604 0.0,-0.732,5.604 0.280,-0.676,5.604 0.518,-0.518,5.604 0.676,-0.280,5.604
range name 6th_7 x -0.744 0.744 y -0.744 0.744 z 4.763 5.604

;6th_8

poly prism a 0.732,0.0,5.604 0.676,0.280,5.604 0.518,0.518,5.604 0.280,0.676,5.604 0.0,0.732,5.604 -0.280,0.676,5.604 -0.518,0.518,5.604 -0.676,0.280,5.604 -0.732,0.0,5.604 -0.676,-0.280,5.604 -0.518,-0.518,5.604 -0.280,-0.676,5.604 0.0,-0.732,5.604 0.280,-0.676,5.604 0.518,-0.518,5.604 0.676,-0.280,5.604 &
b 0.708,0.0,6.421 0.654,0.271,6.421 0.501,0.501,6.421 0.271,0.654,6.421 0.0,0.708,6.421 -0.271,0.654,6.421 -0.501,0.501,6.421 -0.654,0.271,6.421 -0.708,0.0,6.421 -0.654,-0.271,6.421 -0.501,-0.501,6.421 -0.271,-0.654,6.421 0.0,-0.708,6.421 0.271,-0.654,6.421 0.501,-0.501,6.421 0.654,-0.271,6.421
range name 6th_8 x -0.732 0.732 y -0.732 0.732 z 5.604 6.421

;6th_9

poly prism a 0.708,0.0,6.421 0.654,0.271,6.421 0.501,0.501,6.421 0.271,0.654,6.421 0.0,0.708,6.421 -0.271,0.654,6.421 -0.501,0.501,6.421 -0.654,0.271,6.421 -0.708,0.0,6.421 -0.654,-0.271,6.421 -0.501,-0.501,6.421 -0.271,-0.654,6.421 0.0,-0.708,6.421 0.271,-0.654,6.421 0.501,-0.501,6.421 0.654,-0.271,6.421 &
b 0.6935,0.0,7.118 0.641,0.265,7.118 0.490,0.490,7.118 0.265,0.641,7.118 0.0,0.6935,7.118 -0.265,0.641,7.118 -0.490,0.490,7.118 -0.641,0.265,7.118 -0.6935,0.0,7.118 -0.641,-0.265,7.118 -0.490,-0.490,7.118 -0.265,-0.641,7.118 0.0,-0.6935,7.118 0.265,-0.641,7.118 0.490,-0.490,7.118 0.641,-0.265,7.118

range name 6th_9 x -0.708 0.708 y -0.708 0.708 z 6.421 7.118

;6th_10

poly prism a 0.6935,0.0,7.118 0.641,0.265,7.118 0.490,0.490,7.118 0.265,0.641,7.118 0.0,0.6935,7.118 -0.265,0.641,7.118 -0.490,0.490,7.118 -0.641,0.265,7.118 -0.6935,0.0,7.118 -0.641,-0.265,7.118 -0.490,-0.490,7.118 -0.265,-0.641,7.118 0.0,-0.6935,7.118 0.265,-0.641,7.118 0.490,-0.490,7.118 0.641,-0.265,7.118 &
b 0.672,0.0,7.748 0.621,0.257,7.748 0.475,0.475,7.748 0.257,0.621,7.748 0.0,0.672,7.748 -0.257,0.621,7.748 -0.475,0.475,7.748 -0.621,0.257,7.748 -0.672,0.0,7.748 -0.621,-0.257,7.748 -0.475,-0.475,7.748 -0.257,-0.621,7.748 0.0,-0.672,7.748 0.257,-0.621,7.748 0.475,-0.475,7.748 0.621,-0.257,7.748
range name 6th_10 x -0.6935 0.6935 y -0.6935 0.6935 z 7.118 7.748

;6th_11

poly prism a 0.672,0.0,7.748 0.621,0.257,7.748 0.475,0.475,7.748 0.257,0.621,7.748 0.0,0.672,7.748 -0.257,0.621,7.748 -0.475,0.475,7.748 -0.621,0.257,7.748 -0.672,0.0,7.748 -0.621,-0.257,7.748 -0.475,-0.475,7.748 -0.257,-0.621,7.748 0.0,-0.672,7.748 0.257,-0.621,7.748 0.475,-0.475,7.748 0.621,-0.257,7.748 &
b 0.648,0.0,8.589 0.599,0.248,8.589 0.458,0.458,8.589 0.248,0.599,8.589 0.0,0.648,8.589 -0.248,0.599,8.589 -0.458,0.458,8.589 -0.599,0.248,8.589 -0.648,0.0,8.589 -0.599,-0.248,8.589 -0.458,-0.458,8.589 -0.248,-0.599,8.589 0.0,-0.648,8.589 0.248,-0.599,8.589 0.458,-0.458,8.589 0.599,-0.248,8.589
range name 6th_11 x -0.672 0.672 y -0.672 0.672 z 7.538 8.589

;6th_12

poly prism a 0.648,0.0,8.589 0.599,0.248,8.589 0.458,0.458,8.589 0.248,0.599,8.589 0.0,0.648,8.589 -0.248,0.599,8.589 -0.458,0.458,8.589 -0.599,0.248,8.589 -0.648,0.0,8.589 -0.599,-0.248,8.589 -0.458,-0.458,8.589 -0.248,-0.599,8.589 0.0,-0.648,8.589 0.248,-0.599,8.589 0.458,-0.458,8.589 0.599,-0.248,8.589 &
b 0.6385,0.0,9.382 0.590,0.244,9.382 0.451,0.451,9.382 0.244,0.590,9.382 0.0,0.6385,9.382 -0.244,0.590,9.382 -0.451,0.451,9.382 -0.590,0.244,9.382 -0.6385,0.0,9.382 -0.590,-0.244,9.382 -0.451,-0.451,9.382 -0.244,-0.590,9.382 0.0,-0.6385,9.382 0.244,-0.590,9.382 0.451,-0.451,9.382 0.590,-0.244,9.382
range name 6th_12 x -0.648 0.648 y -0.648 0.648 z 8.589 9.382

;6th_y

poly prism a 0.6385,0.0,9.382 0.590,0.244,9.382 0.451,0.451,9.382 0.244,0.590,9.382 0.0,0.6385,9.382 -0.244,0.590,9.382 -0.451,0.451,9.382 -0.590,0.244,9.382 -0.6385,0.0,9.382 -0.590,-0.244,9.382 -0.451,-0.451,9.382 -0.244,-0.590,9.382 0.0,-0.6385,9.382 0.244,-0.590,9.382 0.451,-0.451,9.382 0.590,-0.244,9.382 &
b 0.648,0.0,9.527 0.599,0.248,9.527 0.458,0.458,9.527 0.248,0.599,9.527 0.0,0.648,9.527 -0.248,0.599,9.527 -0.458,0.458,9.527 -0.599,0.248,9.527 -0.648,0.0,9.527 -0.599,-0.248,9.527 -0.458,-0.458,9.527 -0.248,-0.599,9.527 0.0,-0.648,9.527 0.248,-0.599,9.527 0.458,-0.458,9.527 0.599,-0.248,9.527
range name 6th_y x -0.648 0.648 y -0.648 0.648 z 9.382 9.527
join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;6th_k1

poly prism a 0.648,0.0,9.527 0.599,0.248,9.527 0.458,0.458,9.527 0.248,0.599,9.527 0.0,0.648,9.527 -0.248,0.599,9.527 -0.458,0.458,9.527 -0.599,0.248,9.527 -0.648,0.0,9.527 -0.599,-0.248,9.527 -0.458,-0.458,9.527 -0.248,-0.599,9.527 0.0,-0.648,9.527 0.248,-0.599,9.527 0.458,-0.458,9.527 0.599,-0.248,9.527 &

b 0.672,0.0,9.576 0.621,0.257,9.576 0.475,0.475,9.576 0.257,0.621,9.576 0.0,0.672,9.576 -0.257,0.621,9.576 -0.475,0.475,9.576 -0.621,0.257,9.576 -0.672,0.0,9.576 -0.621,-0.257,9.576 -0.475,-0.475,9.576 -0.257,-0.621,9.576 0.0,-0.672,9.576 0.257,-0.621,9.576 0.475,-0.475,9.576 0.621,-0.257,9.576

range name 6th_k1 x -0.672 0.672 y -0.672 0.672 z 9.527 9.576

join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;6th_k2

poly prism a 0.672,0.0,9.576 0.621,0.257,9.576 0.475,0.475,9.576 0.257,0.621,9.576 0.0,0.672,9.576 -0.257,0.621,9.576 -0.475,0.475,9.576 -0.621,0.257,9.576 -0.672,0.0,9.576 -0.621,-0.257,9.576 -0.475,-0.475,9.576 -0.257,-0.621,9.576 0.0,-0.672,9.576 0.257,-0.621,9.576 0.475,-0.475,9.576 0.621,-0.257,9.576 &

b 0.840,0.0,9.793 0.776,0.321,9.793 0.594,0.594,9.793 0.321,0.776,9.793 0.0,0.840,9.793 -0.321,0.776,9.793 -0.594,0.594,9.793 -0.776,0.321,9.793 -0.840,0.0,9.793 -0.776,-0.321,9.793 -0.594,-0.594,9.793 -0.321,-0.776,9.793 0.0,-0.840,9.793 0.321,-0.776,9.793 0.594,-0.594,9.793 0.776,-0.321,9.793

range name 6th_k2 x -0.672 0.672 y -0.672 0.672 z 9.576 9.793

join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;6th_k3

poly prism a -0.852,-0.852,9.793 0.852,-0.852,9.793 0.852,0.852,9.793 -0.852,0.852,9.793 &

b -0.852,-0.852,10.081 0.852,-0.852,10.081 0.852,0.852,10.081 -0.852,0.852,10.081

range name 6th_k3 x -0.852 0.852 y -0.852 0.852 z 9.793 10.081

join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;right_

;right_b

poly prism a 4.862,-0.938,-0.420 3.138,-0.938,-0.420 3.138,0.938,-0.420 4.862,0.938,-0.420 &

b 4.862,-0.938,0.0 3.138,-0.938,0.0 3.138,0.938,0.0 4.862,0.938,0.0

range name r_b x 3.138 4.862 y -0.938 0.938 z -0.420 0.0

;right_1

poly prism a 3.175,0.0,0.0 3.238,0.316,0.0 3.417,0.583,0.0 3.684,0.762,0.0 4.000,0.825,0.0 4.316,0.762,0.0 4.583,0.583,0.0 4.762,0.316,0.0 4.825,0.0,0.0 4.762,-0.316,0.0 4.583,-0.583,0.0 4.316,-0.762,0.0 4.000,-0.825,0.0 3.684,-0.762,0.0 3.417,-0.583,0.0 3.238,-0.316,0.0 &

b 3.184,0.0,0.918 3.246,0.312,0.918 3.423,0.577,0.918 3.688,0.754,0.918 4.000,0.816,0.918 4.312,0.754,0.918 4.577,0.577,0.918 4.754,0.312,0.918 4.816,0.0,0.918 4.754,-0.312,0.918 4.577,-0.577,0.918 4.312,-0.754,0.918 4.000,-0.816,0.918 3.688,-0.754,0.918 3.423,-0.577,0.918 3.246,-0.312,0.918

range name r_1 x 3.175 4.825 y -0.825 0.825 z 0.0 0.918

;right_2

poly prism a 3.184,0.0,0.918 3.246,0.312,0.918 3.423,0.577,0.918 3.688,0.754,0.918 4.000,0.816,0.918 4.312,0.754,0.918 4.577,0.577,0.918 4.754,0.312,0.918 4.816,0.0,0.918 4.754,-0.312,0.918 4.577,-0.577,0.918 4.312,-0.754,0.918 4.000,-0.816,0.918 3.688,-0.754,0.918 3.423,-0.577,0.918 3.246,-0.312,0.918 &

b 3.201,0.0,1.687 3.262,0.306,1.687 3.435,0.565,1.687 3.694,0.738,1.687 4.000,0.799,1.687 4.306,0.738,1.687 4.565,0.565,1.687 4.738,0.306,1.687 4.799,0.0,1.687 4.738,-0.306,1.687 4.565,-0.565,1.687 4.306,-0.738,1.687 4.000,-0.799,1.687 3.694,-0.738,1.687 3.435,-0.565,1.687 3.262,-0.306,1.687

range name r_2 x 3.184 4.816 y -0.816 0.816 z 0.918 1.687

;right_3

poly prism a 3.201,0.0,1.687 3.262,0.306,1.687 3.435,0.565,1.687 3.694,0.738,1.687 4.000,0.799,1.687 4.306,0.738,1.687 4.565,0.565,1.687 4.738,0.306,1.687 4.799,0.0,1.687 4.738,-0.306,1.687 4.565,-0.565,1.687 4.306,-0.738,1.687 4.000,-0.799,1.687 3.694,-0.738,1.687 3.435,-0.565,1.687 3.262,-0.306,1.687 &

b 3.215,0.0,2.456 3.275,0.300,2.456 3.445,0.555,2.456 3.700,0.725,2.456 4.000,0.785,2.456 4.300,0.725,2.456 4.555,0.555,2.456 4.725,0.300,2.456 4.785,0.0,2.456 4.725,-0.300,2.456 4.555,-0.555,2.456 4.300,-0.725,2.456 4.000,-0.785,2.456 3.700,-0.725,2.456 3.445,-0.555,2.456 3.275,-0.300,2.456

range name r_3 x 3.201 4.799 y -0.799 0.799 z 1.687 2.456

;right_4

poly prism a 3.215,0.0,2.456 3.275,0.300,2.456 3.445,0.555,2.456 3.700,0.725,2.456 4.000,0.785,2.456 4.300,0.725,2.456 4.555,0.555,2.456 4.725,0.300,2.456 4.785,0.0,2.456 4.725,-0.300,2.456 4.555,-0.555,2.456 4.300,-0.725,2.456 4.000,-0.785,2.456 3.700,-0.725,2.456 3.445,-0.555,2.456 3.275,-0.300,2.456 &

b 3.232,0.0,3.273 3.290,0.294,3.273 3.457,0.543,3.273 3.706,0.710,3.273 4.000,0.768,3.273 4.294,0.710,3.273 4.543,0.543,3.273 4.710,0.294,3.273 4.768,0.0,3.273 4.710,-0.294,3.273 4.543,-0.543,3.273 4.294,-0.710,3.273 4.000,-0.768,3.273 3.706,-0.710,3.273 3.457,-0.543,3.273 3.290,-0.294,3.273

range name r_4 x 3.215 4.785 y -0.785 0.785 z 2.456 3.273

;right_5

poly prism a 3.232,0.0,3.273 3.290,0.294,3.273 3.457,0.543,3.273 3.706,0.710,3.273 4.000,0.768,3.273 4.294,0.710,3.273 4.543,0.543,3.273 4.710,0.294,3.273 4.768,0.0,3.273 4.710,-0.294,3.273 4.543,-0.543,3.273 4.294,-0.710,3.273 4.000,-0.768,3.273 3.706,-0.710,3.273 3.457,-0.543,3.273 3.290,-0.294,3.273 &

b 3.247,0.0,4.090 3.304,0.288,4.090 3.467,0.533,4.090 3.712,0.696,4.090 4.000,0.754,4.090 4.288,0.696,4.090 4.533,0.533,4.090 4.696,0.288,4.090 4.754,0.0,4.090 4.696,-0.288,4.090 4.533,-0.533,4.090 4.288,-0.696,4.090 4.000,-0.754,4.090 3.712,-0.696,4.090 3.467,-0.533,4.090 3.304,-0.288,4.090

range name r_5 x 3.232 4.768 y -0.768 0.768 z 3.273 4.090

;right_6

poly prism a 3.247,0.0,4.090 3.304,0.288,4.090 3.467,0.533,4.090 3.712,0.696,4.090 4.000,0.754,4.090 4.288,0.696,4.090 4.533,0.533,4.090 4.696,0.288,4.090 4.754,0.0,4.090 4.696,-0.288,4.090 4.533,-0.533,4.090 4.288,-0.696,4.090 4.000,-0.754,4.090 3.712,-0.696,4.090 3.467,-0.533,4.090 3.304,-0.288,4.090 &

b 3.256,0.0,4.763 3.313,0.285,4.763 3.474,0.526,4.763 3.715,0.687,4.763 4.000,0.744,4.763 4.285,0.687,4.763 4.526,0.526,4.763 4.687,0.285,4.763 4.744,0.0,4.763 4.687,-0.285,4.763 4.526,-

0.526,4.763 4.285,-0.687,4.763 4.000,-0.744,4.763 3.715,-0.687,4.763 3.474,-0.526,4.763 3.313,-0.285,4.763
range name r_6 x 3.247 4.754 y -0.7535 0.7535 z 4.090 4.763

;right_7

poly prism a 3.256,0.0,4.763 3.313,0.285,4.763 3.474,0.526,4.763 3.715,0.687,4.763 4.000,0.744,4.763 4.285,0.687,4.763 4.526,0.526,4.763 4.687,0.285,4.763 4.744,0.0,4.763 4.687,-0.285,4.763 4.526,-0.526,4.763 4.285,-0.687,4.763 4.000,-0.744,4.763 3.715,-0.687,4.763 3.474,-0.526,4.763 3.313,-0.285,4.763 &
b 3.268,0.0,5.604 3.324,0.280,5.604 3.482,0.518,5.604 3.720,0.676,5.604 4.000,0.732,5.604 4.280,0.676,5.604 4.518,0.518,5.604 4.676,0.280,5.604 4.732,0.0,5.604 4.676,-0.280,5.604 4.518,-0.518,5.604 4.280,-0.676,5.604 4.000,-0.732,5.604 3.720,-0.676,5.604 3.482,-0.518,5.604 3.324,-0.280,5.604
range name r_7 x 3.256 4.744 y -0.744 0.744 z 4.763 5.604

;right_8

poly prism a 3.268,0.0,5.604 3.324,0.280,5.604 3.482,0.518,5.604 3.720,0.676,5.604 4.000,0.732,5.604 4.280,0.676,5.604 4.518,0.518,5.604 4.676,0.280,5.604 4.732,0.0,5.604 4.676,-0.280,5.604 4.518,-0.518,5.604 4.280,-0.676,5.604 4.000,-0.732,5.604 3.720,-0.676,5.604 3.482,-0.518,5.604 3.324,-0.280,5.604 &
b 3.292,0.0,6.421 3.346,0.271,6.421 3.499,0.501,6.421 3.729,0.654,6.421 4.000,0.708,6.421 4.271,0.654,6.421 4.501,0.501,6.421 4.654,0.271,6.421 4.708,0.0,6.421 4.654,-0.271,6.421 4.501,-0.501,6.421 4.271,-0.654,6.421 4.000,-0.708,6.421 3.729,-0.654,6.421 3.499,-0.501,6.421 3.346,-0.271,6.421
range name r_8 x 3.268 4.732 y -0.732 0.732 z 5.604 6.421

;right_9

poly prism a 3.292,0.0,6.421 3.346,0.271,6.421 3.499,0.501,6.421 3.729,0.654,6.421 4.000,0.708,6.421 4.271,0.654,6.421 4.501,0.501,6.421 4.654,0.271,6.421 4.708,0.0,6.421 4.654,-0.271,6.421 4.501,-0.501,6.421 4.271,-0.654,6.421 4.000,-0.708,6.421 3.729,-0.654,6.421 3.499,-0.501,6.421 3.346,-0.271,6.421 &
b 3.307,0.0,7.118 3.359,0.265,7.118 3.510,0.490,7.118 3.735,0.641,7.118 4.000,0.694,7.118 4.265,0.641,7.118 4.490,0.490,7.118 4.641,0.265,7.118 4.694,0.0,7.118 4.641,-0.265,7.118 4.490,-0.490,7.118 4.265,-0.641,7.118 4.000,-0.694,7.118 3.735,-0.641,7.118 3.510,-0.490,7.118 3.359,-0.265,7.118
range name r_9 x 3.292 4.708 y -0.708 0.708 z 6.421 7.118

;right_10

poly prism a 3.307,0.0,7.118 3.359,0.265,7.118 3.510,0.490,7.118 3.735,0.641,7.118 4.000,0.694,7.118 4.265,0.641,7.118 4.490,0.490,7.118 4.641,0.265,7.118 4.694,0.0,7.118 4.641,-0.265,7.118 4.490,-0.490,7.118 4.265,-0.641,7.118 4.000,-0.694,7.118 3.735,-0.641,7.118 3.510,-0.490,7.118 3.359,-0.265,7.118 &
b 3.328,0.0,7.748 3.379,0.257,7.748 3.525,0.475,7.748 3.743,0.621,7.748 4.000,0.672,7.748 4.257,0.621,7.748 4.475,0.475,7.748 4.621,0.257,7.748 4.672,0.0,7.748 4.621,-0.257,7.748 4.475,-0.475,7.748 4.257,-0.621,7.748 4.000,-0.672,7.748 3.743,-0.621,7.748 3.525,-0.475,7.748 3.379,-0.257,7.748
range name r_10 x 3.307 4.694 y -0.6935 0.6935 z 7.118 7.748

;right_11

poly prism a 3.328,0.0,7.748 3.379,0.257,7.748 3.525,0.475,7.748 3.743,0.621,7.748 4.000,0.672,7.748 4.257,0.621,7.748 4.475,0.475,7.748 4.621,0.257,7.748 4.672,0.0,7.748 4.621,-0.257,7.748 4.475,-

0.475,7.748 4.257,-0.621,7.748 4.000,-0.672,7.748 3.743,-0.621,7.748 3.525,-0.475,7.748 3.379,-0.257,7.748 &
b 3.352,0.0,8.589 3.401,0.248,8.589 3.542,0.458,8.589 3.752,0.599,8.589 4.000,0.648,8.589 4.248,0.599,8.589 4.458,0.458,8.589 4.599,0.248,8.589 4.648,0.0,8.589 4.599,-0.248,8.589 4.458,-0.458,8.589 4.248,-0.599,8.589 4.000,-0.648,8.589 3.752,-0.599,8.589 3.542,-0.458,8.589 3.401,-0.248,8.589
range name r_11 x 3.328 4.672 y -0.672 0.672 z 7.538 8.589

;right_12

poly prism a 3.352,0.0,8.589 3.401,0.248,8.589 3.542,0.458,8.589 3.752,0.599,8.589 4.000,0.648,8.589 4.248,0.599,8.589 4.458,0.458,8.589 4.599,0.248,8.589 4.648,0.0,8.589 4.599,-0.248,8.589 4.458,-0.458,8.589 4.248,-0.599,8.589 4.000,-0.648,8.589 3.752,-0.599,8.589 3.542,-0.458,8.589 3.401,-0.248,8.589 &
b 3.362,0.0,9.382 3.410,0.244,9.382 3.549,0.451,9.382 3.756,0.590,9.382 4.000,0.639,9.382 4.244,0.590,9.382 4.451,0.451,9.382 4.590,0.244,9.382 4.639,0.0,9.382 4.590,-0.244,9.382 4.451,-0.451,9.382 4.244,-0.590,9.382 4.000,-0.639,9.382 3.756,-0.590,9.382 3.549,-0.451,9.382 3.410,-0.244,9.382
range name r_12 x 3.352 4.648 y -0.648 0.648 z 8.589 9.382

;right_y

poly prism a 3.362,0.0,9.382 3.410,0.244,9.382 3.549,0.451,9.382 3.756,0.590,9.382 4.000,0.639,9.382 4.244,0.590,9.382 4.451,0.451,9.382 4.590,0.244,9.382 4.639,0.0,9.382 4.590,-0.244,9.382 4.451,-0.451,9.382 4.244,-0.590,9.382 4.000,-0.639,9.382 3.756,-0.590,9.382 3.549,-0.451,9.382 3.410,-0.244,9.382 &
b 3.352,0.0,9.527 3.401,0.248,9.527 3.542,0.458,9.527 3.752,0.599,9.527 4.000,0.648,9.527 4.248,0.599,9.527 4.458,0.458,9.527 4.599,0.248,9.527 4.648,0.0,9.527 4.599,-0.248,9.527 4.458,-0.458,9.527 4.248,-0.599,9.527 4.000,-0.648,9.527 3.752,-0.599,9.527 3.542,-0.458,9.527 3.401,-0.248,9.527
range name r_y x 3.352 4.648 y -0.648 0.648 z 9.382 9.527
join_contact on range x 3.148 4.852 y -0.852 0.852 z 9.383 10.081

;right_k1

poly prism a 3.352,0.0,9.527 3.401,0.248,9.527 3.542,0.458,9.527 3.752,0.599,9.527 4.000,0.648,9.527 4.248,0.599,9.527 4.458,0.458,9.527 4.599,0.248,9.527 4.648,0.0,9.527 4.599,-0.248,9.527 4.458,-0.458,9.527 4.248,-0.599,9.527 4.000,-0.648,9.527 3.752,-0.599,9.527 3.542,-0.458,9.527 3.401,-0.248,9.527 &
b 3.328,0.0,9.576 3.379,0.257,9.576 3.525,0.475,9.576 3.743,0.621,9.576 4.000,0.672,9.576 4.257,0.621,9.576 4.475,0.475,9.576 4.621,0.257,9.576 4.672,0.0,9.576 4.621,-0.257,9.576 4.475,-0.475,9.576 4.257,-0.621,9.576 4.000,-0.672,9.576 3.743,-0.621,9.576 3.525,-0.475,9.576 3.379,-0.257,9.576
range name r_k1 x 3.328 4.672 y -0.672 0.672 z 9.527 9.576
join_contact on range x 3.148 4.852 y -0.852 0.852 z 9.383 10.081

;right_k2

poly prism a 3.328,0.0,9.576 3.379,0.257,9.576 3.525,0.475,9.576 3.743,0.621,9.576 4.000,0.672,9.576 4.257,0.621,9.576 4.475,0.475,9.576 4.621,0.257,9.576 4.672,0.0,9.576 4.621,-0.257,9.576 4.475,-0.475,9.576 4.257,-0.621,9.576 4.000,-0.672,9.576 3.743,-0.621,9.576 3.525,-0.475,9.576 3.379,-0.257,9.576 &
b 3.160,0.0,9.793 3.224,0.321,9.793 3.406,0.594,9.793 3.679,0.776,9.793 4.000,0.840,9.793 4.321,0.776,9.793 4.594,0.594,9.793 4.776,0.321,9.793 4.840,0.0,9.793 4.776,-0.321,9.793 4.594,-

0.594,9.793 4.321,-0.776,9.793 4.000,-0.840,9.793 3.679,-0.776,9.793 3.406,-0.594,9.793 3.224,-0.321,9.793
range name r_k2 x 3.160 4.840 y -0.840 0.840 z 9.576 9.793
join_contact on range x 3.148 4.852 y -0.852 0.852 z 9.383 10.081

;right_k3

poly prism a 4.852,-0.852,9.793 3.148,-0.852,9.793 3.148,0.852,9.793 4.852,0.852,9.793 &
b 4.852,-0.852,10.081 3.148,-0.852,10.081 3.148,0.852,10.081 4.852,0.852,10.081
range name r_k3 x 3.148 4.852 y -0.852 0.852 z 9.793 10.081
join_contact on range x 3.148 4.852 y -0.852 0.852 z 9.383 10.081

;behind

;behind_b

poly prism a -0.862,3.062,-0.420 0.862,3.062,-0.420 0.862,4.938,-0.420 -0.862,4.938,-0.420 &
b -0.862,3.062,0.0 0.862,3.062,0.0 0.862,4.938,0.0 -0.862,4.938,0.0
range name b_b x -0.862 0.862 y 3.062 4.938 z -0.420 0.0

;behind_1

poly prism a 0.825,4.000,0.0 0.762,4.316,0.0 0.583,4.583,0.0 0.316,4.762,0.0 0.0,4.825,0.0 -0.316,4.762,0.0 -0.583,4.583,0.0 -0.762,4.316,0.0 -0.825,4.000,0.0 -0.762,3.684,0.0 -0.583,3.417,0.0 -0.316,3.238,0.0 0.0,3.175,0.0 0.316,3.238,0.0 0.583,3.417,0.0 0.762,3.684,0.0 &
b 0.816,4.000,0.918 0.754,4.312,0.918 0.577,4.577,0.918 0.312,4.754,0.918 0.0,4.816,0.918 -0.312,4.754,0.918 -0.577,4.577,0.918 -0.754,4.312,0.918 -0.816,4.000,0.918 -0.754,3.688,0.918 -0.577,3.423,0.918 -0.312,3.246,0.918 0.0,3.184,0.918 0.312,3.246,0.918 0.577,3.423,0.918 0.754,3.688,0.918
range name b_1 x -0.825 0.825 y 3.175 4.825 z 0.0 0.918

;behind_2

poly prism a 0.816,4.000,0.918 0.754,4.312,0.918 0.577,4.577,0.918 0.312,4.754,0.918 0.0,4.816,0.918 -0.312,4.754,0.918 -0.577,4.577,0.918 -0.754,4.312,0.918 -0.816,4.000,0.918 -0.754,3.688,0.918 -0.577,3.423,0.918 -0.312,3.246,0.918 0.0,3.184,0.918 0.312,3.246,0.918 0.577,3.423,0.918 0.754,3.688,0.918 &
b 0.799,4.000,1.687 0.738,4.306,1.687 0.565,4.565,1.687 0.306,4.738,1.687 0.0,4.799,1.687 -0.306,4.738,1.687 -0.565,4.565,1.687 -0.738,4.306,1.687 -0.799,4.000,1.687 -0.738,3.694,1.687 -0.565,3.435,1.687 -0.306,3.262,1.687 0.0,3.201,1.687 0.306,3.262,1.687 0.565,3.435,1.687 0.738,3.694,1.687
range name b_2 x -0.816 0.816 y 3.184 4.816 z 0.918 1.687

;behind_3

poly prism a 0.799,4.000,1.687 0.738,4.306,1.687 0.565,4.565,1.687 0.306,4.738,1.687 0.0,4.799,1.687 -0.306,4.738,1.687 -0.565,4.565,1.687 -0.738,4.306,1.687 -0.799,4.000,1.687 -0.738,3.694,1.687 -0.565,3.435,1.687 -0.306,3.262,1.687 0.0,3.201,1.687 0.306,3.262,1.687 0.565,3.435,1.687 0.738,3.694,1.687 &
b 0.785,4.000,2.456 0.725,4.300,2.456 0.555,4.555,2.456 0.300,4.725,2.456 0.0,4.785,2.456 -0.300,4.725,2.456 -0.555,4.555,2.456 -0.725,4.300,2.456 -0.785,4.000,2.456 -0.725,3.700,2.456 -0.555,3.445,2.456 -0.300,3.275,2.456 0.0,3.215,2.456 0.300,3.275,2.456 0.555,3.445,2.456 0.725,3.700,2.456

range name b_3 x -0.799 0.799 y 3.201 4.799 z 1.687 2.456

;behind_4

poly prism a 0.785,4.000,2.456 0.725,4.300,2.456 0.555,4.555,2.456 0.300,4.725,2.456 0.0,4.785,2.456 -0.300,4.725,2.456 -0.555,4.555,2.456 -0.725,4.300,2.456 -0.785,4.000,2.456 -0.725,3.700,2.456 -0.555,3.445,2.456 -0.300,3.275,2.456 0.0,3.215,2.456 0.300,3.275,2.456 0.555,3.445,2.456 0.725,3.700,2.456 &
b 0.768,4.000,3.273 0.710,4.294,3.273 0.543,4.543,3.273 0.294,4.710,3.273 0.0,4.768,3.273 -0.294,4.710,3.273 -0.543,4.543,3.273 -0.710,4.294,3.273 -0.768,4.000,3.273 -0.710,3.706,3.273 -0.543,3.457,3.273 -0.294,3.290,3.273 0.0,3.232,3.273 0.294,3.290,3.273 0.543,3.457,3.273 0.710,3.706,3.273
range name b_4 x -0.785 0.785 y 3.215 4.785 z 2.456 3.273

;behind_5

poly prism a 0.768,4.000,3.273 0.710,4.294,3.273 0.543,4.543,3.273 0.294,4.710,3.273 0.0,4.768,3.273 -0.294,4.710,3.273 -0.543,4.543,3.273 -0.710,4.294,3.273 -0.768,4.000,3.273 -0.710,3.706,3.273 -0.543,3.457,3.273 -0.294,3.290,3.273 0.0,3.232,3.273 0.294,3.290,3.273 0.543,3.457,3.273 0.710,3.706,3.273 &
b 0.754,4.000,4.090 0.696,4.288,4.090 0.533,4.533,4.090 0.288,4.696,4.090 0.0,4.754,4.090 -0.288,4.696,4.090 -0.533,4.533,4.090 -0.696,4.288,4.090 -0.754,4.000,4.090 -0.696,3.712,4.090 -0.533,3.467,4.090 -0.288,3.304,4.090 0.0,3.247,4.090 0.288,3.304,4.090 0.533,3.467,4.090 0.696,3.712,4.090
range name b_5 x -0.768 0.768 y 3.232 4.768 z 3.273 4.090

;behind_6

poly prism a 0.754,4.000,4.090 0.696,4.288,4.090 0.533,4.533,4.090 0.288,4.696,4.090 0.0,4.754,4.090 -0.288,4.696,4.090 -0.533,4.533,4.090 -0.696,4.288,4.090 -0.754,4.000,4.090 -0.696,3.712,4.090 -0.533,3.467,4.090 -0.288,3.304,4.090 0.0,3.247,4.090 0.288,3.304,4.090 0.533,3.467,4.090 0.696,3.712,4.090 &
b 0.744,4.000,4.763 0.687,4.285,4.763 0.526,4.526,4.763 0.285,4.687,4.763 0.0,4.744,4.763 -0.285,4.687,4.763 -0.526,4.526,4.763 -0.687,4.285,4.763 -0.744,4.000,4.763 -0.687,3.715,4.763 -0.526,3.474,4.763 -0.285,3.313,4.763 0.0,3.256,4.763 0.285,3.313,4.763 0.526,3.474,4.763 0.687,3.715,4.763
range name b_6 x -0.7535 0.7535 y 3.247 4.754 z 4.090 4.763

;behind_7

poly prism a 0.744,4.000,4.763 0.687,4.285,4.763 0.526,4.526,4.763 0.285,4.687,4.763 0.0,4.744,4.763 -0.285,4.687,4.763 -0.526,4.526,4.763 -0.687,4.285,4.763 -0.744,4.000,4.763 -0.687,3.715,4.763 -0.526,3.474,4.763 -0.285,3.313,4.763 0.0,3.256,4.763 0.285,3.313,4.763 0.526,3.474,4.763 0.687,3.715,4.763 &
b 0.732,4.000,5.604 0.676,4.280,5.604 0.518,4.518,5.604 0.280,4.676,5.604 0.0,4.732,5.604 -0.280,4.676,5.604 -0.518,4.518,5.604 -0.676,4.280,5.604 -0.732,4.000,5.604 -0.676,3.720,5.604 -0.518,3.482,5.604 -0.280,3.324,5.604 0.0,3.268,5.604 0.280,3.324,5.604 0.518,3.482,5.604 0.676,3.720,5.604
range name b_7 x -0.744 0.744 y 3.256 4.744 z 4.763 5.604

;behind_8

poly prism a 0.732,4.000,5.604 0.676,4.280,5.604 0.518,4.518,5.604 0.280,4.676,5.604 0.0,4.732,5.604 -0.280,4.676,5.604 -0.518,4.518,5.604 -0.676,4.280,5.604 -0.732,4.000,5.604 -0.676,3.720,5.604 -0.518,3.482,5.604 -0.280,3.324,5.604 0.0,3.268,5.604 0.280,3.324,5.604 0.518,3.482,5.604 0.676,3.720,5.604 &

b 0.708,4.000,6.421 0.654,4.271,6.421 0.501,4.501,6.421 0.271,4.654,6.421 0.0,4.708,6.421 -0.271,4.654,6.421 -0.501,4.501,6.421 -0.654,4.271,6.421 -0.708,4.000,6.421 -0.654,3.729,6.421 -0.501,3.499,6.421 -0.271,3.346,6.421 0.0,3.292,6.421 0.271,3.346,6.421 0.501,3.499,6.421 0.654,3.729,6.421
range name b_8 x -0.732 0.732 y 3.268 4.732 z 5.604 6.421

;behind_9

poly prism a 0.708,4.000,6.421 0.654,4.271,6.421 0.501,4.501,6.421 0.271,4.654,6.421 0.0,4.708,6.421 -0.271,4.654,6.421 -0.501,4.501,6.421 -0.654,4.271,6.421 -0.708,4.000,6.421 -0.654,3.729,6.421 -0.501,3.499,6.421 -0.271,3.346,6.421 0.0,3.292,6.421 0.271,3.346,6.421 0.501,3.499,6.421 0.654,3.729,6.421 &
b 0.694,4.000,7.118 0.641,4.265,7.118 0.490,4.490,7.118 0.265,4.641,7.118 0.0,4.694,7.118 -0.265,4.641,7.118 -0.490,4.490,7.118 -0.641,4.265,7.118 -0.694,4.000,7.118 -0.641,3.735,7.118 -0.490,3.510,7.118 -0.265,3.359,7.118 0.0,3.307,7.118 0.265,3.359,7.118 0.490,3.510,7.118 0.641,3.735,7.118
range name b_9 x -0.708 0.708 y 3.292 4.708 z 6.421 7.118

;behind_10

poly prism a 0.694,4.000,7.118 0.641,4.265,7.118 0.490,4.490,7.118 0.265,4.641,7.118 0.0,4.694,7.118 -0.265,4.641,7.118 -0.490,4.490,7.118 -0.641,4.265,7.118 -0.694,4.000,7.118 -0.641,3.735,7.118 -0.490,3.510,7.118 -0.265,3.359,7.118 0.0,3.307,7.118 0.265,3.359,7.118 0.490,3.510,7.118 0.641,3.735,7.118 &
b 0.672,4.000,7.748 0.621,4.257,7.748 0.475,4.475,7.748 0.257,4.621,7.748 0.0,4.672,7.748 -0.257,4.621,7.748 -0.475,4.475,7.748 -0.621,4.257,7.748 -0.672,4.000,7.748 -0.621,3.743,7.748 -0.475,3.525,7.748 -0.257,3.379,7.748 0.0,3.328,7.748 0.257,3.379,7.748 0.475,3.525,7.748 0.621,3.743,7.748
range name b_10 x -0.6935 0.6935 y 3.307 4.694 z 7.118 7.748

;behind_11

poly prism a 0.672,4.000,7.748 0.621,4.257,7.748 0.475,4.475,7.748 0.257,4.621,7.748 0.0,4.672,7.748 -0.257,4.621,7.748 -0.475,4.475,7.748 -0.621,4.257,7.748 -0.672,4.000,7.748 -0.621,3.743,7.748 -0.475,3.525,7.748 -0.257,3.379,7.748 0.0,3.328,7.748 0.257,3.379,7.748 0.475,3.525,7.748 0.621,3.743,7.748 &
b 0.648,4.000,8.589 0.599,4.248,8.589 0.458,4.458,8.589 0.248,4.599,8.589 0.0,4.648,8.589 -0.248,4.599,8.589 -0.458,4.458,8.589 -0.599,4.248,8.589 -0.648,4.000,8.589 -0.599,3.752,8.589 -0.458,3.542,8.589 -0.248,3.401,8.589 0.0,3.352,8.589 0.248,3.401,8.589 0.458,3.542,8.589 0.599,3.752,8.589
range name b_11 x -0.672 0.672 y 3.328 4.672 z 7.538 8.589

;behind_12

poly prism a 0.648,4.000,8.589 0.599,4.248,8.589 0.458,4.458,8.589 0.248,4.599,8.589 0.0,4.648,8.589 -0.248,4.599,8.589 -0.458,4.458,8.589 -0.599,4.248,8.589 -0.648,4.000,8.589 -0.599,3.752,8.589 -0.458,3.542,8.589 -0.248,3.401,8.589 0.0,3.352,8.589 0.248,3.401,8.589 0.458,3.542,8.589 0.599,3.752,8.589 &
b 0.639,4.000,9.382 0.590,4.244,9.382 0.451,4.451,9.382 0.244,4.590,9.382 0.0,4.639,9.382 -0.244,4.590,9.382 -0.451,4.451,9.382 -0.590,4.244,9.382 -0.639,4.000,9.382 -0.590,3.756,9.382 -0.451,3.549,9.382 -0.244,3.410,9.382 0.0,3.362,9.382 0.244,3.410,9.382 0.451,3.549,9.382 0.590,3.756,9.382
range name b_12 x -0.648 0.648 y 3.352 4.648 z 8.589 9.382

;behind_y

poly prism a 0.639,4.000,9.382 0.590,4.244,9.382 0.451,4.451,9.382 0.244,4.590,9.382 0.0,4.639,9.382 -0.244,4.590,9.382 -0.451,4.451,9.382 -0.590,4.244,9.382 -0.639,4.000,9.382 -0.590,3.756,9.382 -0.451,3.549,9.382 -0.244,3.410,9.382 0.0,3.362,9.382 0.244,3.410,9.382 0.451,3.549,9.382 0.590,3.756,9.382 &

b 0.648,4.000,9.527 0.599,4.248,9.527 0.458,4.458,9.527 0.248,4.599,9.527 0.0,4.648,9.527 -0.248,4.599,9.527 -0.458,4.458,9.527 -0.599,4.248,9.527 -0.648,4.000,9.527 -0.599,3.752,9.527 -0.458,3.542,9.527 -0.248,3.401,9.527 0.0,3.352,9.527 0.248,3.401,9.527 0.458,3.542,9.527 0.599,3.752,9.527

range name b_y x -0.648 0.648 y 3.352 4.648 z 9.382 9.527

join_contact on range x -0.852 0.852 y 3.148 4.852 z 9.793 10.081

;behind_k1

poly prism a 0.648,4.000,9.527 0.599,4.248,9.527 0.458,4.458,9.527 0.248,4.599,9.527 0.0,4.648,9.527 -0.248,4.599,9.527 -0.458,4.458,9.527 -0.599,4.248,9.527 -0.648,4.000,9.527 -0.599,3.752,9.527 -0.458,3.542,9.527 -0.248,3.401,9.527 0.0,3.352,9.527 0.248,3.401,9.527 0.458,3.542,9.527 0.599,3.752,9.527 &

b 0.672,4.000,9.576 0.621,4.257,9.576 0.475,4.475,9.576 0.257,4.621,9.576 0.0,4.672,9.576 -0.257,4.621,9.576 -0.475,4.475,9.576 -0.621,4.257,9.576 -0.672,4.000,9.576 -0.621,3.743,9.576 -0.475,3.525,9.576 -0.257,3.379,9.576 0.0,3.328,9.576 0.257,3.379,9.576 0.475,3.525,9.576 0.621,3.743,9.576

range name b_k1 x -0.672 0.672 y 3.328 4.672 z 9.527 9.576

join_contact on range x -0.852 0.852 y 3.148 4.852 z 9.793 10.081

;behind_k2

poly prism a 0.672,4.000,9.576 0.621,4.257,9.576 0.475,4.475,9.576 0.257,4.621,9.576 0.0,4.672,9.576 -0.257,4.621,9.576 -0.475,4.475,9.576 -0.621,4.257,9.576 -0.672,4.000,9.576 -0.621,3.743,9.576 -0.475,3.525,9.576 -0.257,3.379,9.576 0.0,3.328,9.576 0.257,3.379,9.576 0.475,3.525,9.576 0.621,3.743,9.576 &

b 0.840,4.000,9.793 0.776,4.321,9.793 0.594,4.594,9.793 0.321,4.776,9.793 0.0,4.840,9.793 -0.321,4.776,9.793 -0.594,4.594,9.793 -0.776,4.321,9.793 -0.840,4.000,9.793 -0.776,3.679,9.793 -0.594,3.406,9.793 -0.321,3.224,9.793 0.0,3.160,9.793 0.321,3.224,9.793 0.594,3.406,9.793 0.776,3.679,9.793

range name b_k2 x -0.840 0.840 y 3.160 4.840 z 9.576 9.793

join_contact on range x -0.852 0.852 y 3.148 4.852 z 9.793 10.081

;behind_k3

poly prism a -0.852,3.148,9.793 0.852,3.148,9.793 0.852,4.852,9.793 -0.852,4.852,9.793 &

b -0.852,3.148,10.081 0.852,3.148,10.081 0.852,4.852,10.081 -0.852,4.852,10.081

range name b_k3 x -0.852 0.852 y 3.148 4.852 z 9.793 10.081

join_contact on range x -0.852 0.852 y 3.148 4.852 z 9.793 10.081

*THE GEOMETRY OF THE DAMAGED MODELS OF THE COLONNADES*

*Colonnade in a line arrangement*

;central_(6th)

;6th_b

poly prism a -0.862,-0.938,-0.420 -0.670,-0.930,-0.420 0.718,-0.938,-0.420 0.862,-0.938,-0.420 0.862,0.938,-0.420 -0.862,0.938,-0.420 &
b -0.862,-0.938,0.0 -0.670,-0.938,0.0 0.718,-0.938,0.0 0.862,-0.782,0.0 0.862,0.938,0.0 -0.862,0.938,0.0
range name 6th_b x -0.862 0.862 y -0.938 0.938 z -0.420 0.0

;6th_1

poly prism a 0.825,0.0,0.0 0.762,0.316,0.0 0.583,0.583,0.0 0.316,0.762,0.0 0.0,0.825,0.0 -0.316,0.762,0.0 -0.583,0.583,0.0 -0.762,0.316,0.0 -0.825,0.0,0.0 -0.762,-0.316,0.0 -0.583,-0.583,0.0 -0.369,-0.730,0.0 -0.316,-0.762,0.0 0.0,-0.825,0.0 0.316,-0.762,0.0 0.583,-0.583,0.0 0.681,-0.300,0.0 &
b 0.768,0.0,0.918 0.754,0.312,0.918 0.577,0.577,0.918 0.312,0.754,0.918 0.0,0.816,0.918 -0.312,0.754,0.918 -0.577,0.577,0.918 -0.754,0.312,0.918 -0.816,0.0,0.918 -0.754,-0.312,0.918 -0.577,-0.577,0.918 -0.369,-0.728,0.918 -0.312,-0.754,0.918 0.0,-0.816,0.918 0.312,-0.754,0.918 0.577,-0.577,0.918 0.667,-0.312,0.918
range name 6th_1 x -0.825 0.825 y -0.825 0.825 z 0.0 0.918

;6th_2

poly prism a 0.768,0.0,0.918 0.754,0.312,0.918 0.577,0.577,0.918 0.312,0.754,0.918 0.0,0.816,0.918 -0.312,0.754,0.918 -0.577,0.577,0.918 -0.754,0.312,0.918 -0.816,0.0,0.918 -0.754,-0.312,0.918 -0.577,-0.577,0.918 -0.312,-0.754,0.918 0.0,-0.816,0.918 0.312,-0.754,0.918 0.367,-0.710,0.918 0.577,-0.577,0.918 0.667,-0.312,0.918 &
b 0.751,0.0,1.687 0.738,0.306,1.687 0.565,0.565,1.687 0.306,0.738,1.687 0.0,0.799,1.687 -0.306,0.738,1.687 -0.565,0.565,1.687 -0.738,0.306,1.687 -0.799,0.0,1.687 -0.738,-0.306,1.687 -0.565,-0.565,1.687 -0.306,-0.738,1.687 0.0,-0.799,1.687 0.306,-0.738,1.687 0.367,-0.700,1.687 0.565,-0.565,1.687 0.712,-0.306,1.687
range name 6th_2 x -0.816 0.816 y -0.816 0.816 z 0.918 1.687

;6th_3

poly prism a 0.727,0.0,1.687 0.727,0.306,1.687 0.565,0.565,1.687 0.306,0.738,1.687 0.0,0.799,1.687 -0.306,0.738,1.687 -0.565,0.565,1.687 -0.738,0.306,1.687 -0.799,0.0,1.687 -0.738,-0.306,1.687 -0.565,-0.565,1.687 -0.306,-0.738,1.687 0.0,-0.799,1.687 0.306,-0.738,1.687 0.565,-0.565,1.687 0.720,-0.306,1.687 &
b 0.708,0.0,2.456 0.708,0.300,2.456 0.555,0.555,2.456 0.300,0.725,2.456 0.0,0.785,2.456 -0.300,0.725,2.456 -0.555,0.555,2.456 -0.725,0.300,2.456 -0.761,0.0,2.456 -0.725,-0.300,2.456 -0.555,-0.555,2.456 -0.300,-0.725,2.456 0.0,-0.785,2.456 0.300,-0.725,2.456 0.555,-0.555,2.456 0.641,-0.290,2.456
range name 6th_3 x -0.799 0.799 y -0.799 0.799 z 1.687 2.456

;6th_4

poly prism a 0.720,0.0,2.456 0.720,0.300,2.456 0.555,0.555,2.456 0.300,0.725,2.456 0.0,0.785,2.456 -0.300,0.725,2.456 -0.555,0.555,2.456 -0.725,0.300,2.456 -0.785,0.0,2.456 -0.725,-0.300,2.456 -0.555,-0.555,2.456 -0.300,-0.725,2.456 0.0,-0.785,2.456 0.300,-0.725,2.456 0.545,-0.560,2.456 0.555,-0.555,2.456 0.720,-0.290,2.456 &

b 0.720,0.0,3.273 0.710,0.294,3.273 0.543,0.543,3.273 0.294,0.710,3.273 0.0,0.768,3.273 -0.294,0.710,3.273 -0.543,0.543,3.273 -0.710,0.294,3.273 -0.720,0.0,3.273 -0.710,-0.280,3.273 -0.543,-0.525,3.273 -0.294,-0.700,3.273 0.0,-0.755,3.273 0.294,-0.706,3.273 0.545,-0.541,3.273 0.543,-0.543,3.273 0.672,-0.289,3.273

range name 6th_4 x -0.785 0.785 y -0.785 0.785 z 2.456 3.273

;6th_5

poly prism a 0.725,0.0,3.273 0.710,0.294,3.273 0.543,0.543,3.273 0.294,0.710,3.273 0.0,0.768,3.273 -0.294,0.710,3.273 -0.543,0.543,3.273 -0.710,0.294,3.273 -0.768,0.0,3.273 -0.710,-0.294,3.273 -0.543,-0.543,3.273 -0.294,-0.695,3.273 0.0,-0.768,3.273 0.105,-0.761,3.273 0.294,-0.725,3.273 0.543,-0.543,3.273 0.710,-0.294,3.273 &

b 0.701,0.0,4.090 0.696,0.288,4.090 0.533,0.533,4.090 0.288,0.696,4.090 0.0,0.754,4.090 -0.288,0.696,4.090 -0.533,0.533,4.090 -0.696,0.288,4.090 -0.754,0.0,4.090 -0.696,-0.288,4.090 -0.533,-0.533,4.090 -0.288,-0.670,4.090 0.0,-0.754,4.090 0.105,-0.730,4.090 0.288,-0.696,4.090 0.533,-0.533,4.090 0.696,-0.288,4.090

range name 6th_5 x -0.768 0.768 y -0.768 0.768 z 3.273 4.090

;6th_6

poly prism a 0.739,0.0,4.090 0.696,0.288,4.090 0.533,0.533,4.090 0.288,0.696,4.090 0.0,0.754,4.090 -0.288,0.696,4.090 -0.533,0.533,4.090 -0.696,0.288,4.090 -0.754,0.0,4.090 -0.696,-0.288,4.090 -0.533,-0.510,4.090 -0.288,-0.625,4.090 0.0,-0.754,4.090 0.288,-0.640,4.090 0.504,-0.560,4.090 0.533,-0.533,4.090 0.696,-0.288,4.090 &

b 0.696,0.0,4.763 0.687,0.285,4.763 0.526,0.526,4.763 0.285,0.687,4.763 0.0,0.744,4.763 -0.285,0.687,4.763 -0.526,0.526,4.763 -0.687,0.285,4.763 -0.744,0.0,4.763 -0.687,-0.270,4.763 -0.526,-0.490,4.763 -0.285,-0.640,4.763 0.0,-0.690,4.763 0.285,-0.650,4.763 0.504,-0.580,4.763 0.526,-0.526,4.763 0.687,-0.285,4.763

range name 6th_6 x -0.7535 0.7535 y -0.7535 0.7535 z 4.090 4.763

;6th_7

poly prism a 0.648,0.0,4.763 0.648,0.285,4.763 0.526,0.526,4.763 0.285,0.687,4.763 0.0,0.744,4.763 -0.285,0.687,4.763 -0.526,0.526,4.763 -0.687,0.285,4.763 -0.744,0.0,4.763 -0.687,-0.285,4.763 -0.526,-0.526,4.763 -0.285,-0.687,4.763 0.0,-0.744,4.763 0.120,-0.710,4.763 0.285,-0.687,4.763 0.312,-0.645,4.763 0.526,-0.526,4.763 0.648,-0.285,4.763 &

b 0.679,0.0,5.604 0.676,0.280,5.604 0.518,0.518,5.604 0.280,0.676,5.604 0.0,0.732,5.604 -0.280,0.676,5.604 -0.518,0.518,5.604 -0.676,0.280,5.604 -0.732,0.0,5.604 -0.676,-0.280,5.604 -0.518,-0.518,5.604 -0.280,-0.676,5.604 0.0,-0.732,5.604 0.120,-0.710,5.604 0.280,-0.676,5.604 0.312,-0.645,5.604 0.518,-0.518,5.604 0.676,-0.280,5.604

range name 6th_7 x -0.744 0.744 y -0.744 0.744 z 4.763 5.604

;6th_8

poly prism a 0.674,0.0,5.604 0.674,0.280,5.604 0.518,0.518,5.604 0.280,0.676,5.604 0.0,0.732,5.604 -0.280,0.676,5.604 -0.518,0.518,5.604 -0.676,0.280,5.604 -0.722,0.0,5.604 -0.676,-0.280,5.604 -0.516,-0.519,5.604 -0.518,-0.518,5.604 -0.280,-0.676,5.604 -0.228,-0.696,5.604 -0.108,-0.724,5.604 0.0,-0.732,5.604 0.146,-0.717,5.604 0.280,-0.676,5.604 0.338,-0.610,5.604 0.518,-0.518,5.604 0.674,-0.280,5.604 &

b 0.655,0.0,6.421 0.654,0.271,6.421 0.501,0.501,6.421 0.271,0.654,6.421 0.0,0.708,6.421 -0.271,0.654,6.421 -0.501,0.501,6.421 -0.654,0.271,6.421 -0.708,0.0,6.421 -0.654,-0.271,6.421 -0.516,-0.450,6.421 -0.501,-0.475,6.421 -0.271,-0.635,6.421 -0.228,-0.640,6.421 -0.108,-0.680,6.421 0.0,-

0.708,6.421 0.146,-0.675,6.421 0.271,-0.654,6.421 0.338,-0.622,6.421 0.501,-0.501,6.421 0.654,-0.271,6.421
range name 6th_8 x -0.732 0.732 y -0.732 0.732 z 5.604 6.421

;6th_9

poly prism a 0.636,0.0,6.421 0.654,0.271,6.421 0.501,0.501,6.421 0.271,0.654,6.421 0.0,0.708,6.421 -0.271,0.654,6.421 -0.501,0.501,6.421 -0.654,0.271,6.421 -0.708,0.0,6.421 -0.654,-0.271,6.421 -0.573,-0.416,6.421 -0.501,-0.501,6.421 -0.309,-0.637,6.421 -0.271,-0.654,6.421 -0.118,-0.698,6.421 0.0,-0.708,6.421 0.262,-0.658,6.421 0.271,-0.654,6.421 0.501,-0.501,6.421 0.506,-0.470,6.421 0.654,-0.271,6.421 &
b 0.674,0.0,7.118 0.641,0.265,7.118 0.490,0.490,7.118 0.265,0.641,7.118 0.0,0.694,7.118 -0.265,0.641,7.118 -0.490,0.490,7.118 -0.641,0.265,7.118 -0.684,0.0,7.118 -0.641,-0.265,7.118 -0.573,-0.365,7.118 -0.490,-0.490,7.118 -0.309,-0.605,7.118 -0.265,-0.641,7.118 -0.118,-0.665,7.118 0.0,-0.694,7.118 0.262,-0.625,7.118 0.265,-0.641,7.118 0.490,-0.490,7.118 0.506,-0.474,7.118 0.641,-0.265,7.118
range name 6th_9 x -0.708 0.708 y -0.708 0.708 z 6.421 7.118

;6th_10

poly prism a 0.583,0.0,7.118 0.583,0.265,7.118 0.490,0.490,7.118 0.265,0.641,7.118 0.0,0.694,7.118 -0.265,0.641,7.118 -0.490,0.490,7.118 -0.641,0.265,7.118 -0.694,0.0,7.118 -0.669,-0.155,7.118 -0.641,-0.265,7.118 -0.588,-0.355,7.118 -0.490,-0.490,7.118 -0.392,-0.572,7.118 -0.265,-0.641,7.118 -0.106,-0.685,7.118 0.0,-0.694,7.118 0.265,-0.641,7.118 0.264,-0.641,7.118 0.307,-0.622,7.118 0.309,-0.605,7.118 0.478,-0.495,7.118 0.490,-0.490,7.118 0.583,-0.265,7.118 &
b 0.595,0.0,7.748 0.595,0.257,7.748 0.475,0.475,7.748 0.257,0.621,7.748 0.0,0.672,7.748 -0.257,0.621,7.748 -0.475,0.475,7.748 -0.621,0.257,7.748 -0.648,0.0,7.748 -0.648,-0.155,7.748 -0.621,-0.257,7.748 -0.588,-0.325,7.748 -0.475,-0.475,7.748 -0.392,-0.535,7.748 -0.257,-0.621,7.748 -0.106,-0.650,7.748 0.0,-0.672,7.748 0.257,-0.621,7.748 0.264,-0.600,7.748 0.307,-0.590,7.748 0.309,-0.597,7.748 0.478,-0.472,7.748 0.475,-0.475,7.748 0.595,-0.257,7.748
range name 6th_10 x -0.6935 0.6935 y -0.6935 0.6935 z 7.118 7.748

;6th_11

poly prism a 0.619,0.0,7.748 0.619,0.257,7.748 0.475,0.475,7.748 0.257,0.621,7.748 0.0,0.672,7.748 -0.257,0.621,7.748 -0.475,0.475,7.748 -0.621,0.257,7.748 -0.648,0.0,7.748 -0.621,-0.257,7.748 -0.610,-0.275,7.748 -0.571,-0.354,7.748 -0.475,-0.475,7.748 -0.288,-0.607,7.748 -0.257,-0.621,7.748 0.0,-0.672,7.748 0.101,-0.655,7.748 0.257,-0.621,7.748 0.288,-0.607,7.748 0.475,-0.475,7.748 0.461,-0.489,7.748 0.480,-0.460,7.748 0.619,-0.257,7.748 &
b 0.595,0.0,8.589 0.595,0.248,8.589 0.458,0.458,8.589 0.248,0.599,8.589 0.0,0.648,8.589 -0.248,0.599,8.589 -0.458,0.458,8.589 -0.599,0.248,8.589 -0.624,0.0,8.589 -0.610,-0.219,8.589 -0.599,-0.248,8.589 -0.571,-0.290,8.589 -0.458,-0.458,8.589 -0.288,-0.570,8.589 -0.248,-0.599,8.589 0.0,-0.648,8.589 0.101,-0.640,8.589 0.248,-0.599,8.589 0.288,-0.570,8.589 0.458,-0.458,8.589 0.461,-0.450,8.589 0.480,-0.435,8.589 0.595,-0.248,8.589
range name 6th_11 x -0.672 0.672 y -0.672 0.672 z 7.538 8.589

;6th_12

poly prism a 0.600,0.0,8.589 0.599,0.248,8.589 0.458,0.458,8.589 0.248,0.599,8.589 0.0,0.648,8.589 -0.248,0.599,8.589 -0.458,0.458,8.589 -0.599,0.248,8.589 -0.648,0.0,8.589 -0.599,-0.248,8.589 -0.576,-0.297,8.589 -0.552,-0.320,8.589 -0.458,-0.458,8.589 -0.456,-0.450,8.589 -0.248,-0.599,8.589 0.0,-0.648,8.589 0.248,-0.599,8.589 0.288,-0.570,8.589 0.355,-0.525,8.589 0.458,-0.458,8.589 0.595,-0.248,8.589 &
b 0.600,0.0,9.382 0.590,0.244,9.382 0.451,0.451,9.382 0.244,0.590,9.382 0.0,0.639,9.382 -0.244,0.590,9.382 -0.451,0.451,9.382 -0.590,0.244,9.382 -0.639,0.0,9.382 -0.590,-0.244,9.382 -0.576,-0.271,9.382 -0.552,-0.321,9.382 -0.456,-0.447,9.382 -0.451,-0.451,9.382 -0.244,-0.590,9.382 0.0,-

0.639,9.382 0.244,-0.590,9.382 0.288,-0.570,9.382 0.355,-0.520,9.382 0.451,-0.451,9.382 0.590,-0.244,9.382
range name 6th_12 x -0.648 0.648 y -0.648 0.648 z 8.589 9.382

;6th_y

poly prism a 0.543,0.0,9.382 0.590,0.244,9.382 0.451,0.451,9.382 0.244,0.590,9.382 0.0,0.639,9.382 -0.244,0.590,9.382 -0.451,0.451,9.382 -0.590,0.244,9.382 -0.639,0.0,9.382 -0.590,-0.244,9.382 -0.451,-0.451,9.382 -0.244,-0.590,9.382 0.0,-0.639,9.382 0.244,-0.590,9.382 0.451,-0.451,9.382 0.543,-0.244,9.382 &
b 0.562,0.0,9.527 0.599,0.248,9.527 0.458,0.458,9.527 0.248,0.599,9.527 0.0,0.648,9.527 -0.248,0.599,9.527 -0.458,0.458,9.527 -0.599,0.248,9.527 -0.648,0.0,9.527 -0.599,-0.248,9.527 -0.458,-0.458,9.527 -0.248,-0.599,9.527 0.0,-0.648,9.527 0.248,-0.599,9.527 0.458,-0.458,9.527 0.562,-0.248,9.527
range name 6th_y x -0.648 0.648 y -0.648 0.648 z 9.382 9.527
join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;6th_k1

poly prism a 0.542,0.0,9.527 0.599,0.248,9.527 0.458,0.458,9.527 0.248,0.599,9.527 0.0,0.648,9.527 -0.248,0.599,9.527 -0.458,0.458,9.527 -0.599,0.248,9.527 -0.648,0.0,9.527 -0.599,-0.248,9.527 -0.458,-0.458,9.527 -0.248,-0.599,9.527 0.0,-0.648,9.527 0.248,-0.599,9.527 0.458,-0.458,9.527 0.542,-0.248,9.527 &
b 0.533,0.0,9.576 0.614,0.257,9.576 0.475,0.475,9.576 0.257,0.621,9.576 0.0,0.672,9.576 -0.257,0.621,9.576 -0.475,0.475,9.576 -0.621,0.257,9.576 -0.672,0.0,9.576 -0.621,-0.257,9.576 -0.475,-0.475,9.576 -0.257,-0.621,9.576 0.0,-0.672,9.576 0.257,-0.621,9.576 0.475,-0.475,9.576 0.533,-0.257,9.576
range name 6th_k1 x -0.672 0.672 y -0.672 0.672 z 9.527 9.576
join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;6th_k2

poly prism a 0.523,0.0,9.576 0.552,0.257,9.576 0.475,0.475,9.576 0.257,0.621,9.576 0.0,0.672,9.576 -0.257,0.621,9.576 -0.475,0.475,9.576 -0.621,0.257,9.576 -0.672,0.0,9.576 -0.621,-0.257,9.576 -0.475,-0.475,9.576 -0.257,-0.621,9.576 0.0,-0.672,9.576 0.257,-0.621,9.576 0.475,-0.475,9.576 0.523,-0.257,9.576 &
b 0.610,0.0,9.793 0.672,0.321,9.793 0.594,0.594,9.793 0.321,0.776,9.793 0.0,0.840,9.793 -0.321,0.776,9.793 -0.594,0.594,9.793 -0.776,0.321,9.793 -0.840,0.0,9.793 -0.776,-0.321,9.793 -0.594,-0.594,9.793 -0.321,-0.776,9.793 0.0,-0.840,9.793 0.321,-0.776,9.793 0.594,-0.594,9.793 0.610,-0.321,9.793
range name 6th_k2 x -0.672 0.672 y -0.672 0.672 z 9.576 9.793
join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;6th_k3

poly prism a -0.852,-0.852,9.793 0.420,-0.825,9.793 0.660,0.0,9.793 0.660,0.852,9.793 -0.852,0.852,9.793 &
b -0.852,-0.852,10.081 0.321,-0.852,10.081 0.657,0.0,10.081 0.657,0.852,10.081 -0.852,0.852,10.081
range name 6th_k3 x -0.852 0.852 y -0.852 0.852 z 9.793 10.081
join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;left_

;left_b

poly prism a -4.862,-0.938,-0.420 -3.138,-0.938,-0.420 -3.138,0.938,-0.420 -4.862,0.938,-0.420 &
b -4.862,-0.938,0.0 -3.138,-0.938,0.0 -3.138,0.938,0.0 -4.862,0.938,0.0
range name l_b x -4.862 -3.138 y -0.938 0.938 z -0.420 0.0

;left_1

poly prism a -3.175,0.0,0.0 -3.238,0.316,0.0 -3.417,0.583,0.0 -3.684,0.762,0.0 -4.000,0.825,0.0 -4.316,0.762,0.0 -4.583,0.583,0.0 -4.762,0.316,0.0 -4.825,0.0,0.0 -4.762,-0.316,0.0 -4.583,-0.583,0.0 -4.316,-0.762,0.0 -4.000,-0.825,0.0 -3.684,-0.762,0.0 -3.417,-0.583,0.0 -3.238,-0.316,0.0 &
b -3.128,0.0,0.918 -3.246,0.312,0.918 -3.423,0.577,0.918 -3.688,0.754,0.918 -4.000,0.816,0.918 -4.312,0.754,0.918 -4.577,0.577,0.918 -4.754,0.312,0.918 -4.816,0.0,0.918 -4.754,-0.312,0.918 -4.577,-0.577,0.918 -4.312,-0.754,0.918 -4.000,-0.816,0.918 -3.688,-0.754,0.918 -3.423,-0.577,0.918 -3.246,-0.312,0.918
range name l_1 x -4.825 -3.175 y -0.825 0.825 z 0.0 0.918

;left_2

poly prism a -3.184,0.0,0.918 -3.246,0.312,0.918 -3.423,0.577,0.918 -3.688,0.754,0.918 -4.000,0.816,0.918 -4.312,0.754,0.918 -4.577,0.577,0.918 -4.754,0.312,0.918 -4.816,0.0,0.918 -4.754,-0.312,0.918 -4.577,-0.577,0.918 -4.312,-0.754,0.918 -4.000,-0.816,0.918 -3.688,-0.754,0.918 -3.423,-0.577,0.918 -3.246,-0.312,0.918 &
b -3.201,0.0,1.687 -3.262,0.306,1.687 -3.435,0.565,1.687 -3.694,0.738,1.687 -4.000,0.799,1.687 -4.306,0.738,1.687 -4.565,0.565,1.687 -4.738,0.306,1.687 -4.799,0.0,1.687 -4.738,-0.306,1.687 -4.565,-0.565,1.687 -4.306,-0.738,1.687 -4.000,-0.799,1.687 -3.694,-0.738,1.687 -3.435,-0.565,1.687 -3.262,-0.306,1.687
range name l_2 x -4.816 -3.184 y -0.816 0.816 z 0.918 1.687

;left_3

poly prism a -3.201,0.0,1.687 -3.262,0.306,1.687 -3.435,0.565,1.687 -3.694,0.738,1.687 -4.000,0.799,1.687 -4.306,0.738,1.687 -4.565,0.565,1.687 -4.738,0.306,1.687 -4.709,0.0,1.687 -4.738,-0.306,1.687 -4.565,-0.565,1.687 -4.306,-0.738,1.687 -4.000,-0.799,1.687 -3.694,-0.738,1.687 -3.435,-0.565,1.687 -3.262,-0.306,1.687 &
b -3.202,0.0,2.456 -3.275,0.300,2.456 -3.445,0.555,2.456 -3.700,0.725,2.456 -4.000,0.785,2.456 -4.300,0.725,2.456 -4.555,0.555,2.456 -4.725,0.300,2.456 -4.785,0.0,2.456 -4.725,-0.300,2.456 -4.555,-0.555,2.456 -4.300,-0.725,2.456 -4.000,-0.785,2.456 -3.700,-0.725,2.456 -3.445,-0.555,2.456 -3.275,-0.300,2.456
range name l_3 x -4.799 -3.201 y -0.799 0.799 z 1.687 2.456

;left_4

poly prism a -3.215,0.0,2.456 -3.275,0.300,2.456 -3.445,0.555,2.456 -3.700,0.725,2.456 -4.000,0.785,2.456 -4.300,0.725,2.456 -4.502,0.502,2.456 -4.725,0.300,2.456 -4.785,0.0,2.456 -4.725,-0.300,2.456 -4.555,-0.555,2.456 -4.300,-0.725,2.456 -4.000,-0.785,2.456 -3.700,-0.725,2.456 -3.445,-0.555,2.456 -3.275,-0.300,2.456 &
b -3.232,0.0,3.273 -3.364,0.263,3.273 -3.457,0.543,3.273 -3.706,0.710,3.273 -4.000,0.768,3.273 -4.294,0.710,3.273 -4.543,0.543,3.273 -4.710,0.294,3.273 -4.768,0.0,3.273 -4.710,-0.294,3.273 -4.543,-0.543,3.273 -4.294,-0.710,3.273 -4.000,-0.768,3.273 -3.706,-0.710,3.273 -3.457,-0.543,3.273 -3.290,-0.294,3.273
range name l_4 x -4.785 -3.215 y -0.785 0.785 z 2.456 3.273

;left_5

poly prism a -3.232,0.0,3.273 -3.290,0.294,3.273 -3.457,0.543,3.273 -3.706,0.710,3.273 -4.000,0.768,3.273 -4.294,0.710,3.273 -4.543,0.543,3.273 -4.710,0.294,3.273 -4.768,0.0,3.273 -4.710,-0.294,3.273 -4.508,-0.508,3.273 -4.294,-0.710,3.273 -4.000,-0.768,3.273 -3.706,-0.710,3.273 -3.457,-0.543,3.273 -3.290,-0.294,3.273 &

b -3.292,0.0,4.090 -3.304,0.288,4.090 -3.467,0.533,4.090 -3.712,0.696,4.090 -4.000,0.754,4.090 -4.288,0.696,4.090 -4.533,0.533,4.090 -4.696,0.288,4.090 -4.754,0.0,4.090 -4.696,-0.288,4.090 -4.533,-0.533,4.090 -4.288,-0.696,4.090 -4.000,-0.754,4.090 -3.712,-0.696,4.090 -3.532,-0.468,4.090 -3.304,-0.288,4.090

range name l_5 x -4.768 -3.232 y -0.768 0.768 z 3.273 4.090

;left_6

poly prism a -3.262,0.0,4.090 -3.304,0.288,4.090 -3.467,0.533,4.090 -3.712,0.696,4.090 -4.000,0.754,4.090 -4.288,0.696,4.090 -4.533,0.533,4.090 -4.696,0.288,4.090 -4.754,0.0,4.090 -4.696,-0.288,4.090 -4.533,-0.533,4.090 -4.288,-0.696,4.090 -4.000,-0.754,4.090 -3.712,-0.696,4.090 -3.467,-0.533,4.090 -3.304,-0.288,4.090 &

b -3.311,0.0,4.763 -3.313,0.285,4.763 -3.474,0.526,4.763 -3.715,0.687,4.763 -4.000,0.744,4.763 -4.285,0.687,4.763 -4.526,0.526,4.763 -4.687,0.285,4.763 -4.714,0.0,4.763 -4.687,-0.285,4.763 -4.526,-0.526,4.763 -4.285,-0.687,4.763 -4.000,-0.744,4.763 -3.715,-0.687,4.763 -3.474,-0.526,4.763 -3.313,-0.285,4.763

range name l_6 x -4.754 -3.247 y -0.7535 0.7535 z 4.090 4.763

;left_7

poly prism a -3.256,0.0,4.763 -3.313,0.285,4.763 -3.474,0.526,4.763 -3.715,0.687,4.763 -4.000,0.744,4.763 -4.285,0.687,4.763 -4.526,0.526,4.763 -4.687,0.285,4.763 -4.744,0.0,4.763 -4.687,-0.285,4.763 -4.526,-0.526,4.763 -4.285,-0.687,4.763 -4.000,-0.744,4.763 -3.715,-0.687,4.763 -3.474,-0.526,4.763 -3.313,-0.285,4.763 &

b -3.268,0.0,5.604 -3.324,0.280,5.604 -3.482,0.518,5.604 -3.720,0.676,5.604 -4.000,0.732,5.604 -4.280,0.676,5.604 -4.518,0.518,5.604 -4.676,0.280,5.604 -4.732,0.0,5.604 -4.676,-0.280,5.604 -4.518,-0.518,5.604 -4.280,-0.676,5.604 -4.000,-0.732,5.604 -3.720,-0.676,5.604 -3.482,-0.518,5.604 -3.324,-0.280,5.604

range name l_7 x -4.744 -3.256 y -0.744 0.744 z 4.763 5.604

;left_8

poly prism a -3.268,0.0,5.604 -3.324,0.280,5.604 -3.482,0.518,5.604 -3.720,0.676,5.604 -4.000,0.732,5.604 -4.280,0.676,5.604 -4.518,0.518,5.604 -4.676,0.280,5.604 -4.732,0.0,5.604 -4.676,-0.280,5.604 -4.518,-0.518,5.604 -4.280,-0.676,5.604 -4.000,-0.702,5.604 -3.720,-0.676,5.604 -3.482,-0.518,5.604 -3.324,-0.280,5.604 &

b -3.292,0.0,6.421 -3.346,0.271,6.421 -3.499,0.501,6.421 -3.729,0.654,6.421 -4.000,0.708,6.421 -4.271,0.654,6.421 -4.501,0.501,6.421 -4.654,0.271,6.421 -4.708,0.0,6.421 -4.654,-0.271,6.421 -4.501,-0.501,6.421 -4.271,-0.654,6.421 -4.000,-0.708,6.421 -3.729,-0.654,6.421 -3.531,-0.469,6.421 -3.346,-0.271,6.421

range name l_8 x -4.732 -3.268 y -0.732 0.732 z 5.604 6.421

;left_9

poly prism a -3.292,0.0,6.421 -3.346,0.271,6.421 -3.499,0.501,6.421 -3.729,0.654,6.421 -4.000,0.708,6.421 -4.271,0.654,6.421 -4.501,0.501,6.421 -4.654,0.271,6.421 -4.708,0.0,6.421 -4.654,-0.271,6.421 -4.501,-0.501,6.421 -4.271,-0.654,6.421 -4.000,-0.708,6.421 -3.729,-0.654,6.421 -3.499,-0.501,6.421 -3.346,-0.271,6.421 &

b -3.332,0.0,7.118 -3.359,0.265,7.118 -3.510,0.490,7.118 -3.735,0.641,7.118 -4.000,0.614,7.118 -4.265,0.641,7.118 -4.490,0.490,7.118 -4.641,0.265,7.118 -4.694,0.0,7.118 -4.641,-0.265,7.118 -4.490,-

0.490,7.118 -4.265,-0.641,7.118 -4.000,-0.694,7.118 -3.735,-0.641,7.118 -3.510,-0.490,7.118 -3.359,-0.265,7.118
range name l_9 x -4.708 -3.292 y -0.708 0.708 z 6.421 7.118

;left_10

poly prism a -3.307,0.0,7.118 -3.359,0.265,7.118 -3.510,0.490,7.118 -3.735,0.641,7.118 -4.000,0.694,7.118 -4.265,0.641,7.118 -4.490,0.490,7.118 -4.641,0.265,7.118 -4.694,0.0,7.118 -4.641,-0.265,7.118 -4.448,-0.448,7.118 -4.265,-0.641,7.118 -4.000,-0.694,7.118 -3.735,-0.641,7.118 -3.510,-0.490,7.118 -3.359,-0.265,7.118 &
b -3.388,0.0,7.748 -3.379,0.257,7.748 -3.525,0.475,7.748 -3.743,0.621,7.748 -4.000,0.672,7.748 -4.257,0.621,7.748 -4.475,0.475,7.748 -4.621,0.257,7.748 -4.672,0.0,7.748 -4.621,-0.257,7.748 -4.475,-0.475,7.748 -4.257,-0.621,7.748 -4.000,-0.672,7.748 -3.743,-0.621,7.748 -3.525,-0.475,7.748 -3.379,-0.257,7.748
range name l_10 x -4.694 -3.307 y -0.6935 0.6935 z 7.118 7.748

;left_11

poly prism a -3.348,0.0,7.748 -3.379,0.257,7.748 -3.525,0.475,7.748 -3.743,0.621,7.748 -4.000,0.672,7.748 -4.257,0.621,7.748 -4.475,0.475,7.748 -4.621,0.257,7.748 -4.672,0.0,7.748 -4.621,-0.257,7.748 -4.475,-0.475,7.748 -4.257,-0.621,7.748 -4.000,-0.672,7.748 -3.743,-0.621,7.748 -3.525,-0.475,7.748 -3.379,-0.257,7.748 &
b -3.392,0.0,8.589 -3.401,0.248,8.589 -3.542,0.458,8.589 -3.771,0.580,8.589 -4.000,0.648,8.589 -4.248,0.599,8.589 -4.458,0.458,8.589 -4.599,0.248,8.589 -4.648,0.0,8.589 -4.599,-0.248,8.589 -4.458,-0.458,8.589 -4.248,-0.599,8.589 -4.000,-0.648,8.589 -3.752,-0.599,8.589 -3.542,-0.458,8.589 -3.401,-0.248,8.589
range name l_11 x -4.672 -3.328 y -0.672 0.672 z 7.538 8.589

;left_12
poly prism a -3.392,0.0,8.589 -3.401,0.248,8.589 -3.542,0.458,8.589 -3.752,0.599,8.589 -4.000,0.648,8.589 -4.248,0.599,8.589 -4.458,0.458,8.589 -4.599,0.248,8.589 -4.618,0.0,8.589 -4.599,-0.248,8.589 -4.458,-0.458,8.589 -4.248,-0.599,8.589 -4.000,-0.648,8.589 -3.752,-0.599,8.589 -3.542,-0.458,8.589 -3.401,-0.248,8.589 &
b -3.362,0.0,9.382 -3.410,0.244,9.382 -3.549,0.451,9.382 -3.756,0.590,9.382 -4.000,0.639,9.382 -4.244,0.590,9.382 -4.451,0.451,9.382 -4.590,0.244,9.382 -4.639,0.0,9.382 -4.590,-0.244,9.382 -4.451,-0.451,9.382 -4.244,-0.590,9.382 -4.000,-0.639,9.382 -3.756,-0.590,9.382 -3.606,-0.394,9.382 -3.410,-0.244,9.382
range name l_12 x -4.648 -3.352 y -0.648 0.648 z 8.589 9.382

;left_y

poly prism a -3.362,0.0,9.382 -3.410,0.244,9.382 -3.549,0.451,9.382 -3.756,0.590,9.382 -4.000,0.639,9.382 -4.244,0.590,9.382 -4.451,0.451,9.382 -4.590,0.244,9.382 -4.639,0.0,9.382 -4.590,-0.244,9.382 -4.451,-0.451,9.382 -4.244,-0.590,9.382 -4.000,-0.639,9.382 -3.756,-0.590,9.382 -3.549,-0.451,9.382 -3.410,-0.244,9.382 &
b -3.487,0.0,9.527 -3.401,0.248,9.527 -3.542,0.458,9.527 -3.752,0.599,9.527 -4.000,0.648,9.527 -4.248,0.599,9.527 -4.458,0.458,9.527 -4.599,0.248,9.527 -4.648,0.0,9.527 -4.599,-0.248,9.527 -4.458,-0.458,9.527 -4.248,-0.599,9.527 -4.000,-0.648,9.527 -3.752,-0.599,9.527 -3.542,-0.458,9.527 -3.401,-0.248,9.527
range name l_y x -4.648 -3.352 y -0.648 0.648 z 9.382 9.527
join_contact on range x -4.852 -3.148 y -0.852 0.852 z 9.383 10.081

;left_k1

poly prism a -3.352,0.0,9.527 -3.401,0.248,9.527 -3.542,0.458,9.527 -3.752,0.599,9.527 -4.000,0.648,9.527 -4.248,0.599,9.527 -4.458,0.458,9.527 -4.599,0.248,9.527 -4.648,0.0,9.527 -4.599,-0.248,9.527 -4.458,-0.458,9.527 -4.248,-0.599,9.527 -4.000,-0.648,9.527 -3.752,-0.599,9.527 -3.542,-0.458,9.527 -3.401,-0.248,9.527 &
b -3.328,0.0,9.576 -3.379,0.257,9.576 -3.525,0.475,9.576 -3.743,0.621,9.576 -4.000,0.672,9.576 -4.257,0.621,9.576 -4.475,0.475,9.576 -4.621,0.257,9.576 -4.672,0.0,9.576 -4.621,-0.257,9.576 -4.475,-0.475,9.576 -4.257,-0.621,9.576 -4.000,-0.572,9.576 -3.743,-0.621,9.576 -3.525,-0.475,9.576 -3.379,-0.257,9.576
range name l_k1 x -4.672 -3.328 y -0.672 0.672 z 9.527 9.576
join_contact on range x -4.852 -3.148 y -0.852 0.852 z 9.383 10.081

;left_k2

poly prism a -3.328,0.0,9.576 -3.379,0.257,9.576 -3.525,0.475,9.576 -3.743,0.621,9.576 -4.000,0.672,9.576 -4.257,0.621,9.576 -4.475,0.475,9.576 -4.621,0.257,9.576 -4.672,0.0,9.576 -4.621,-0.257,9.576 -4.475,-0.475,9.576 -4.257,-0.621,9.576 -4.000,-0.582,9.576 -3.743,-0.621,9.576 -3.525,-0.475,9.576 -3.379,-0.257,9.576 &
b -3.310,0.0,9.793 -3.224,0.321,9.793 -3.406,0.594,9.793 -3.679,0.776,9.793 -4.000,0.840,9.793 -4.321,0.776,9.793 -4.594,0.594,9.793 -4.776,0.321,9.793 -4.840,0.0,9.793 -4.776,-0.321,9.793 -4.594,-0.594,9.793 -4.321,-0.776,9.793 -4.000,-0.840,9.793 -3.679,-0.776,9.793 -3.406,-0.594,9.793 -3.224,-0.321,9.793
range name l_k2 x -4.840 -3.160 y -0.840 0.840 z 9.576 9.793
join_contact on range x -4.852 -3.148 y -0.852 0.852 z 9.383 10.081

;left_k3

poly prism a -4.852,-0.852,9.793 -3.348,-0.852,9.793 -3.148,-0.702,9.793 -3.148,0.852,9.793 -4.852,0.852,9.793 &
b -4.852,-0.852,10.081 -3.348,-0.852,10.081 -3.148,-0.702,10.081 -3.148,0.852,10.081 -4.852,0.852,10.081
range name l_k3 x -4.852 -3.148 y -0.852 0.852 z 9.793 10.081
join_contact on range x -4.852 -3.148 y -0.852 0.852 z 9.383 10.081

;right_

;right_b

poly prism a 4.862,-0.938,-0.420 3.138,-0.938,-0.420 3.138,0.938,-0.420 4.862,0.938,-0.420 &
b 4.862,-0.938,0.0 3.138,-0.938,0.0 3.138,0.938,0.0 4.862,0.938,0.0
range name r_b x 3.138 4.862 y -0.938 0.938 z -0.420 0.0

;right_1

poly prism a 3.175,0.0,0.0 3.238,0.316,0.0 3.417,0.583,0.0 3.684,0.762,0.0 4.000,0.825,0.0 4.316,0.762,0.0 4.583,0.583,0.0 4.762,0.316,0.0 4.825,0.0,0.0 4.762,-0.316,0.0 4.583,-0.583,0.0 4.316,-0.762,0.0 4.000,-0.825,0.0 3.684,-0.762,0.0 3.417,-0.583,0.0 3.238,-0.316,0.0 &
b 3.184,0.0,0.918 3.246,0.312,0.918 3.423,0.577,0.918 3.688,0.754,0.918 4.000,0.816,0.918 4.312,0.754,0.918 4.577,0.577,0.918 4.754,0.312,0.918 4.760,0.0,0.918 4.754,-0.312,0.918 4.577,-0.577,0.918 4.312,-0.754,0.918 4.000,-0.816,0.918 3.688,-0.754,0.918 3.423,-0.577,0.918 3.246,-0.312,0.918
range name r_1 x 3.175 4.825 y -0.825 0.825 z 0.0 0.918

;right_2

poly prism a 3.184,0.0,0.918 3.246,0.312,0.918 3.423,0.577,0.918 3.688,0.754,0.918 4.000,0.816,0.918 4.312,0.754,0.918 4.577,0.577,0.918 4.754,0.312,0.918 4.816,0.0,0.918 4.754,-0.312,0.918 4.577,-0.577,0.918 4.312,-0.754,0.918 4.000,-0.816,0.918 3.688,-0.754,0.918 3.423,-0.577,0.918 3.246,-0.312,0.918 &

b 3.201,0.0,1.687 3.262,0.306,1.687 3.435,0.565,1.687 3.694,0.738,1.687 4.000,0.799,1.687 4.306,0.738,1.687 4.565,0.565,1.687 4.738,0.306,1.687 4.799,0.0,1.687 4.738,-0.306,1.687 4.565,-0.565,1.687 4.306,-0.738,1.687 4.000,-0.799,1.687 3.694,-0.738,1.687 3.435,-0.565,1.687 3.262,-0.306,1.687

range name r_2 x 3.184 4.816 y -0.816 0.816 z 0.918 1.687

;right_3

poly prism a 3.291,0.0,1.687 3.262,0.306,1.687 3.435,0.565,1.687 3.694,0.738,1.687 4.000,0.799,1.687 4.306,0.738,1.687 4.565,0.565,1.687 4.738,0.306,1.687 4.799,0.0,1.687 4.738,-0.306,1.687 4.565,-0.565,1.687 4.306,-0.738,1.687 4.000,-0.799,1.687 3.694,-0.738,1.687 3.435,-0.565,1.687 3.262,-0.306,1.687 &

b 3.215,0.0,2.456 3.275,0.300,2.456 3.445,0.555,2.456 3.700,0.725,2.456 4.000,0.785,2.456 4.300,0.725,2.456 4.555,0.555,2.456 4.725,0.300,2.456 4.708,0.0,2.456 4.725,-0.300,2.456 4.555,-0.555,2.456 4.300,-0.725,2.456 4.000,-0.785,2.456 3.700,-0.725,2.456 3.445,-0.555,2.456 3.275,-0.300,2.456

range name r_3 x 3.201 4.799 y -0.799 0.799 z 1.687 2.456

;right_4

poly prism a 3.215,0.0,2.456 3.275,0.300,2.456 3.498,0.502,2.456 3.700,0.725,2.456 4.000,0.785,2.456 4.300,0.725,2.456 4.555,0.555,2.456 4.725,0.300,2.456 4.785,0.0,2.456 4.725,-0.300,2.456 4.555,-0.555,2.456 4.300,-0.725,2.456 4.000,-0.785,2.456 3.700,-0.725,2.456 3.445,-0.555,2.456 3.275,-0.300,2.456 &

b 3.232,0.0,3.273 3.290,0.294,3.273 3.457,0.543,3.273 3.706,0.710,3.273 4.000,0.768,3.273 4.294,0.710,3.273 4.543,0.543,3.273 4.636,0.263,3.273 4.768,0.0,3.273 4.710,-0.294,3.273 4.543,-0.543,3.273 4.294,-0.710,3.273 4.000,-0.768,3.273 3.706,-0.710,3.273 3.457,-0.543,3.273 3.290,-0.294,3.273

range name r_4 x 3.215 4.785 y -0.785 0.785 z 2.456 3.273

;right_5

poly prism a 3.232,0.0,3.273 3.290,0.294,3.273 3.457,0.543,3.273 3.706,0.710,3.273 4.000,0.768,3.273 4.294,0.710,3.273 4.543,0.543,3.273 4.710,0.294,3.273 4.768,0.0,3.273 4.710,-0.294,3.273 4.543,-0.543,3.273 4.294,-0.710,3.273 4.000,-0.768,3.273 3.706,-0.710,3.273 3.492,-0.508,3.273 3.290,-0.294,3.273 &

b 3.247,0.0,4.090 3.304,0.288,4.090 3.467,0.533,4.090 3.712,0.696,4.090 4.000,0.754,4.090 4.288,0.696,4.090 4.533,0.533,4.090 4.696,0.288,4.090 4.709,0.0,4.090 4.696,-0.288,4.090 4.468,-0.468,4.090 4.288,-0.696,4.090 4.000,-0.754,4.090 3.712,-0.696,4.090 3.467,-0.533,4.090 3.304,-0.288,4.090

range name r_5 x 3.232 4.768 y -0.768 0.768 z 3.273 4.090

;right_6

poly prism a 3.247,0.0,4.090 3.304,0.288,4.090 3.467,0.533,4.090 3.712,0.696,4.090 4.000,0.754,4.090 4.288,0.696,4.090 4.533,0.533,4.090 4.696,0.288,4.090 4.739,0.0,4.090 4.696,-0.288,4.090 4.533,-0.533,4.090 4.288,-0.696,4.090 4.000,-0.754,4.090 3.712,-0.696,4.090 3.467,-0.533,4.090 3.304,-0.288,4.090 &

b 3.226,0.0,4.763 3.313,0.285,4.763 3.474,0.526,4.763 3.715,0.687,4.763 4.000,0.744,4.763 4.285,0.687,4.763 4.526,0.526,4.763 4.687,0.285,4.763 4.689,0.0,4.763 4.687,-0.285,4.763 4.526,-

0.526,4.763 4.285,-0.687,4.763 4.000,-0.744,4.763 3.715,-0.687,4.763 3.474,-0.526,4.763 3.313,-0.285,4.763
range name r_6 x 3.247 4.754 y -0.7535 0.7535 z 4.090 4.763

;right_7

poly prism a 3.256,0.0,4.763 3.313,0.285,4.763 3.474,0.526,4.763 3.715,0.687,4.763 4.000,0.744,4.763 4.285,0.687,4.763 4.526,0.526,4.763 4.687,0.285,4.763 4.744,0.0,4.763 4.687,-0.285,4.763 4.526,-0.526,4.763 4.285,-0.687,4.763 4.000,-0.744,4.763 3.715,-0.687,4.763 3.474,-0.526,4.763 3.313,-0.285,4.763 &
b 3.268,0.0,5.604 3.324,0.280,5.604 3.482,0.518,5.604 3.720,0.676,5.604 4.000,0.732,5.604 4.280,0.676,5.604 4.518,0.518,5.604 4.676,0.280,5.604 4.732,0.0,5.604 4.676,-0.280,5.604 4.518,-0.518,5.604 4.280,-0.676,5.604 4.000,-0.732,5.604 3.720,-0.676,5.604 3.482,-0.518,5.604 3.324,-0.280,5.604
range name r_7 x 3.256 4.744 y -0.744 0.744 z 4.763 5.604

;right_8

poly prism a 3.268,0.0,5.604 3.324,0.280,5.604 3.482,0.518,5.604 3.720,0.676,5.604 4.000,0.732,5.604 4.280,0.676,5.604 4.518,0.518,5.604 4.676,0.280,5.604 4.732,0.0,5.604 4.676,-0.280,5.604 4.518,-0.518,5.604 4.280,-0.676,5.604 4.000,-0.702,5.604 3.720,-0.676,5.604 3.482,-0.518,5.604 3.324,-0.280,5.604 &
b 3.292,0.0,6.421 3.346,0.271,6.421 3.499,0.501,6.421 3.729,0.654,6.421 4.000,0.708,6.421 4.271,0.654,6.421 4.501,0.501,6.421 4.654,0.271,6.421 4.708,0.0,6.421 4.654,-0.271,6.421 4.469,-0.469,6.421 4.271,-0.654,6.421 4.000,-0.708,6.421 3.729,-0.654,6.421 3.499,-0.501,6.421 3.346,-0.271,6.421
range name r_8 x 3.268 4.732 y -0.732 0.732 z 5.604 6.421

;right_9

poly prism a 3.292,0.0,6.421 3.346,0.271,6.421 3.499,0.501,6.421 3.729,0.654,6.421 4.000,0.708,6.421 4.271,0.654,6.421 4.501,0.501,6.421 4.654,0.271,6.421 4.708,0.0,6.421 4.654,-0.271,6.421 4.501,-0.501,6.421 4.271,-0.654,6.421 4.000,-0.708,6.421 3.729,-0.654,6.421 3.499,-0.501,6.421 3.346,-0.271,6.421 &
b 3.307,0.0,7.118 3.359,0.265,7.118 3.510,0.490,7.118 3.735,0.641,7.118 4.000,0.614,7.118 4.265,0.641,7.118 4.490,0.490,7.118 4.641,0.265,7.118 4.669,0.0,7.118 4.641,-0.265,7.118 4.490,-0.490,7.118 4.265,-0.641,7.118 4.000,-0.694,7.118 3.735,-0.641,7.118 3.510,-0.490,7.118 3.359,-0.265,7.118
range name r_9 x 3.292 4.708 y -0.708 0.708 z 6.421 7.118

;right_10

poly prism a 3.307,0.0,7.118 3.359,0.265,7.118 3.510,0.490,7.118 3.735,0.641,7.118 4.000,0.694,7.118 4.265,0.641,7.118 4.490,0.490,7.118 4.641,0.265,7.118 4.694,0.0,7.118 4.641,-0.265,7.118 4.490,-0.490,7.118 4.265,-0.641,7.118 4.000,-0.694,7.118 3.735,-0.641,7.118 3.552,-0.448,7.118 3.359,-0.265,7.118 &
b 3.328,0.0,7.748 3.379,0.257,7.748 3.525,0.475,7.748 3.743,0.621,7.748 4.000,0.672,7.748 4.257,0.621,7.748 4.475,0.475,7.748 4.621,0.257,7.748 4.612,0.0,7.748 4.621,-0.257,7.748 4.475,-0.475,7.748 4.257,-0.621,7.748 4.000,-0.672,7.748 3.743,-0.621,7.748 3.525,-0.475,7.748 3.379,-0.257,7.748
range name r_10 x 3.307 4.694 y -0.6935 0.6935 z 7.118 7.748

;right_11

poly prism a 3.328,0.0,7.748 3.379,0.257,7.748 3.525,0.475,7.748 3.743,0.621,7.748 4.000,0.672,7.748 4.257,0.621,7.748 4.475,0.475,7.748 4.621,0.257,7.748 4.652,0.0,7.748 4.621,-0.257,7.748 4.475,-

0.475,7.748 4.257,-0.621,7.748 4.000,-0.672,7.748 3.743,-0.621,7.748 3.525,-0.475,7.748 3.379,-0.257,7.748 &
b 3.352,0.0,8.589 3.401,0.248,8.589 3.542,0.458,8.589 3.752,0.599,8.589 4.000,0.648,8.589 4.248,0.599,8.589 4.439,0.439,8.589 4.599,0.248,8.589 4.608,0.0,8.589 4.599,-0.248,8.589 4.458,-0.458,8.589 4.248,-0.599,8.589 4.000,-0.648,8.589 3.752,-0.599,8.589 3.542,-0.458,8.589 3.401,-0.248,8.589
range name r_11 x 3.328 4.672 y -0.672 0.672 z 7.538 8.589

;right_12

poly prism a 3.382,0.0,8.589 3.401,0.248,8.589 3.542,0.458,8.589 3.752,0.599,8.589 4.000,0.648,8.589 4.248,0.599,8.589 4.458,0.458,8.589 4.599,0.248,8.589 4.608,0.0,8.589 4.599,-0.248,8.589 4.458,-0.458,8.589 4.248,-0.599,8.589 4.000,-0.648,8.589 3.752,-0.599,8.589 3.542,-0.458,8.589 3.401,-0.248,8.589 &
b 3.362,0.0,9.382 3.410,0.244,9.382 3.549,0.451,9.382 3.756,0.590,9.382 4.000,0.639,9.382 4.244,0.590,9.382 4.451,0.451,9.382 4.590,0.244,9.382 4.639,0.0,9.382 4.590,-0.244,9.382 4.394,-0.394,9.382 4.244,-0.590,9.382 4.000,-0.639,9.382 3.756,-0.590,9.382 3.549,-0.451,9.382 3.410,-0.244,9.382
range name r_12 x 3.352 4.648 y -0.648 0.648 z 8.589 9.382

;right_y

poly prism a 3.362,0.0,9.382 3.410,0.244,9.382 3.549,0.451,9.382 3.756,0.590,9.382 4.000,0.639,9.382 4.244,0.590,9.382 4.451,0.451,9.382 4.590,0.244,9.382 4.639,0.0,9.382 4.590,-0.244,9.382 4.451,-0.451,9.382 4.244,-0.590,9.382 4.000,-0.639,9.382 3.756,-0.590,9.382 3.549,-0.451,9.382 3.410,-0.244,9.382 &
b 3.352,0.0,9.527 3.401,0.248,9.527 3.542,0.458,9.527 3.752,0.599,9.527 4.000,0.648,9.527 4.248,0.599,9.527 4.458,0.458,9.527 4.599,0.248,9.527 4.513,0.0,9.527 4.599,-0.248,9.527 4.458,-0.458,9.527 4.248,-0.599,9.527 4.000,-0.648,9.527 3.752,-0.599,9.527 3.542,-0.458,9.527 3.401,-0.248,9.527
range name r_y x 3.352 4.648 y -0.648 0.648 z 9.382 9.527
join_contact on range x 3.148 4.852 y -0.852 0.852 z 9.383 10.081

;right_k1

poly prism a 3.352,0.0,9.527 3.401,0.248,9.527 3.542,0.458,9.527 3.752,0.599,9.527 4.000,0.648,9.527 4.248,0.599,9.527 4.458,0.458,9.527 4.599,0.248,9.527 4.648,0.0,9.527 4.599,-0.248,9.527 4.458,-0.458,9.527 4.248,-0.599,9.527 4.000,-0.648,9.527 3.752,-0.599,9.527 3.542,-0.458,9.527 3.401,-0.248,9.527 &
b 3.328,0.0,9.576 3.379,0.257,9.576 3.525,0.475,9.576 3.743,0.621,9.576 4.000,0.672,9.576 4.257,0.621,9.576 4.475,0.475,9.576 4.621,0.257,9.576 4.672,0.0,9.576 4.621,-0.257,9.576 4.475,-0.475,9.576 4.257,-0.621,9.576 4.000,-0.572,9.576 3.743,-0.621,9.576 3.525,-0.475,9.576 3.379,-0.257,9.576
range name r_k1 x 3.328 4.672 y -0.672 0.672 z 9.527 9.576
join_contact on range x 3.148 4.852 y -0.852 0.852 z 9.383 10.081

;right_k2

poly prism a 3.328,0.0,9.576 3.379,0.257,9.576 3.525,0.475,9.576 3.743,0.621,9.576 4.000,0.672,9.576 4.257,0.621,9.576 4.475,0.475,9.576 4.621,0.257,9.576 4.672,0.0,9.576 4.621,-0.257,9.576 4.475,-0.475,9.576 4.257,-0.621,9.576 4.000,-0.582,9.576 3.743,-0.621,9.576 3.525,-0.475,9.576 3.379,-0.257,9.576 &
b 3.160,0.0,9.793 3.224,0.321,9.793 3.406,0.594,9.793 3.679,0.776,9.793 4.000,0.840,9.793 4.321,0.776,9.793 4.594,0.594,9.793 4.776,0.321,9.793 4.690,0.0,9.793 4.776,-0.321,9.793 4.594,-

0.594,9.793 4.321,-0.776,9.793 4.000,-0.840,9.793 3.679,-0.776,9.793 3.406,-0.594,9.793 3.224,-0.321,9.793
range name r_k2 x 3.160 4.840 y -0.840 0.840 z 9.576 9.793
join_contact on range x 3.148 4.852 y -0.852 0.852 z 9.383 10.081

;right_k3

poly prism a 4.852,-0.702,9.793 4.622,-0.852,9.793 3.148,-0.852,9.793 3.148,0.852,9.793 4.852,0.852,9.793 &
b 4.852,-0.702,10.081 4.622,-0.852,10.081 3.148,-0.852,10.081 3.148,0.852,10.081 4.852,0.852,10.081
range name r_k3 x 3.148 4.852 y -0.852 0.852 z 9.793 10.081
join_contact on range x 3.148 4.852 y -0.852 0.852 z 9.383 10.081

## *Colonnade in a corner arrangement*

;corner_(6th)

;6th_b

poly prism a -0.862,-0.938,-0.420 -0.670,-0.930,-0.420 0.718,-0.938,-0.420 0.862,-0.938,-0.420 0.862,0.938,-0.420 -0.862,0.938,-0.420 &
b -0.862,-0.938,0.0 -0.670,-0.938,0.0 0.718,-0.938,0.0 0.862,-0.782,0.0 0.862,0.938,0.0 -0.862,0.938,0.0
range name 6th_b x -0.862 0.862 y -0.938 0.938 z -0.420 0.0

;6th_1

poly prism a 0.825,0.0,0.0 0.762,0.316,0.0 0.583,0.583,0.0 0.316,0.762,0.0 0.0,0.825,0.0 -0.316,0.762,0.0 -0.583,0.583,0.0 -0.762,0.316,0.0 -0.825,0.0,0.0 -0.762,-0.316,0.0 -0.583,-0.583,0.0 -0.369,-0.730,0.0 -0.316,-0.762,0.0 0.0,-0.825,0.0 0.316,-0.762,0.0 0.583,-0.583,0.0 0.681,-0.300,0.0 &
b 0.768,0.0,0.918 0.754,0.312,0.918 0.577,0.577,0.918 0.312,0.754,0.918 0.0,0.816,0.918 -0.312,0.754,0.918 -0.577,0.577,0.918 -0.754,0.312,0.918 -0.816,0.0,0.918 -0.754,-0.312,0.918 -0.577,-0.577,0.918 -0.369,-0.728,0.918 -0.312,-0.754,0.918 0.0,-0.816,0.918 0.312,-0.754,0.918 0.577,-0.577,0.918 0.667,-0.312,0.918
range name 6th_1 x -0.825 0.825 y -0.825 0.825 z 0.0 0.918

;6th_2

poly prism a 0.768,0.0,0.918 0.754,0.312,0.918 0.577,0.577,0.918 0.312,0.754,0.918 0.0,0.816,0.918 -0.312,0.754,0.918 -0.577,0.577,0.918 -0.754,0.312,0.918 -0.816,0.0,0.918 -0.754,-0.312,0.918 -0.577,-0.577,0.918 -0.312,-0.754,0.918 0.0,-0.816,0.918 0.312,-0.754,0.918 0.367,-0.710,0.918 0.577,-0.577,0.918 0.667,-0.312,0.918 &
b 0.751,0.0,1.687 0.738,0.306,1.687 0.565,0.565,1.687 0.306,0.738,1.687 0.0,0.799,1.687 -0.306,0.738,1.687 -0.565,0.565,1.687 -0.738,0.306,1.687 -0.799,0.0,1.687 -0.738,-0.306,1.687 -0.565,-0.565,1.687 -0.306,-0.738,1.687 0.0,-0.799,1.687 0.306,-0.738,1.687 0.367,-0.700,1.687 0.565,-0.565,1.687 0.712,-0.306,1.687
range name 6th_2 x -0.816 0.816 y -0.816 0.816 z 0.918 1.687

;6th_3

poly prism a 0.727,0.0,1.687 0.727,0.306,1.687 0.565,0.565,1.687 0.306,0.738,1.687 0.0,0.799,1.687 -0.306,0.738,1.687 -0.565,0.565,1.687 -0.738,0.306,1.687 -0.799,0.0,1.687 -0.738,-0.306,1.687 -0.565,-0.565,1.687 -0.306,-0.738,1.687 0.0,-0.799,1.687 0.306,-0.738,1.687 0.565,-0.565,1.687 0.720,-0.306,1.687 &
b 0.708,0.0,2.456 0.708,0.300,2.456 0.555,0.555,2.456 0.300,0.725,2.456 0.0,0.785,2.456 -0.300,0.725,2.456 -0.555,0.555,2.456 -0.725,0.300,2.456 -0.761,0.0,2.456 -0.725,-0.300,2.456 -0.555,-0.555,2.456 -0.300,-0.725,2.456 0.0,-0.785,2.456 0.300,-0.725,2.456 0.555,-0.555,2.456 0.641,-0.290,2.456
range name 6th_3 x -0.799 0.799 y -0.799 0.799 z 1.687 2.456

;6th_4

poly prism a 0.720,0.0,2.456 0.720,0.300,2.456 0.555,0.555,2.456 0.300,0.725,2.456 0.0,0.785,2.456 -0.300,0.725,2.456 -0.555,0.555,2.456 -0.725,0.300,2.456 -0.785,0.0,2.456 -0.725,-0.300,2.456 -0.555,-0.555,2.456 -0.300,-0.725,2.456 0.0,-0.785,2.456 0.300,-0.725,2.456 0.545,-0.560,2.456 0.555,-0.555,2.456 0.720,-0.290,2.456 &
b 0.720,0.0,3.273 0.710,0.294,3.273 0.543,0.543,3.273 0.294,0.710,3.273 0.0,0.768,3.273 -0.294,0.710,3.273 -0.543,0.543,3.273 -0.710,0.294,3.273 -0.720,0.0,3.273 -0.710,-0.280,3.273 -0.543,-0.525,3.273 -0.294,-0.700,3.273 0.0,-0.755,3.273 0.294,-0.706,3.273 0.545,-0.541,3.273 0.543,-0.543,3.273 0.672,-0.289,3.273
range name 6th_4 x -0.785 0.785 y -0.785 0.785 z 2.456 3.273

;6th_5

poly prism a 0.725,0.0,3.273 0.710,0.294,3.273 0.543,0.543,3.273 0.294,0.710,3.273 0.0,0.768,3.273 -0.294,0.710,3.273 -0.543,0.543,3.273 -0.710,0.294,3.273 -0.768,0.0,3.273 -0.710,-0.294,3.273 -0.543,-0.543,3.273 -0.294,-0.695,3.273 0.0,-0.768,3.273 0.105,-0.761,3.273 0.294,-0.725,3.273 0.543,-0.543,3.273 0.710,-0.294,3.273 &
b 0.701,0.0,4.090 0.696,0.288,4.090 0.533,0.533,4.090 0.288,0.696,4.090 0.0,0.754,4.090 -0.288,0.696,4.090 -0.533,0.533,4.090 -0.696,0.288,4.090 -0.754,0.0,4.090 -0.696,-0.288,4.090 -0.533,-0.533,4.090 -0.288,-0.670,4.090 0.0,-0.754,4.090 0.105,-0.730,4.090 0.288,-0.696,4.090 0.533,-0.533,4.090 0.696,-0.288,4.090
range name 6th_5 x -0.768 0.768 y -0.768 0.768 z 3.273 4.090

;6th_6

poly prism a 0.739,0.0,4.090 0.696,0.288,4.090 0.533,0.533,4.090 0.288,0.696,4.090 0.0,0.754,4.090 -0.288,0.696,4.090 -0.533,0.533,4.090 -0.696,0.288,4.090 -0.754,0.0,4.090 -0.696,-0.288,4.090 -0.533,-0.510,4.090 -0.288,-0.625,4.090 0.0,-0.754,4.090 0.288,-0.640,4.090 0.504,-0.560,4.090 0.533,-0.533,4.090 0.696,-0.288,4.090 &
b 0.696,0.0,4.763 0.687,0.285,4.763 0.526,0.526,4.763 0.285,0.687,4.763 0.0,0.744,4.763 -0.285,0.687,4.763 -0.526,0.526,4.763 -0.687,0.285,4.763 -0.744,0.0,4.763 -0.687,-0.270,4.763 -0.526,-0.490,4.763 -0.285,-0.640,4.763 0.0,-0.690,4.763 0.285,-0.650,4.763 0.504,-0.580,4.763 0.526,-0.526,4.763 0.687,-0.285,4.763
range name 6th_6 x -0.7535 0.7535 y -0.7535 0.7535 z 4.090 4.763

;6th_7

poly prism a 0.648,0.0,4.763 0.648,0.285,4.763 0.526,0.526,4.763 0.285,0.687,4.763 0.0,0.744,4.763 -0.285,0.687,4.763 -0.526,0.526,4.763 -0.687,0.285,4.763 -0.744,0.0,4.763 -0.687,-0.285,4.763 -0.526,-0.526,4.763 -0.285,-0.687,4.763 0.0,-0.744,4.763 0.120,-0.710,4.763 0.285,-0.687,4.763 0.312,-0.645,4.763 0.526,-0.526,4.763 0.648,-0.285,4.763 &
b 0.679,0.0,5.604 0.676,0.280,5.604 0.518,0.518,5.604 0.280,0.676,5.604 0.0,0.732,5.604 -0.280,0.676,5.604 -0.518,0.518,5.604 -0.676,0.280,5.604 -0.732,0.0,5.604 -0.676,-0.280,5.604 -0.518,-

0.518,5.604 -0.280,-0.676,5.604 0.0,-0.732,5.604 0.120,-0.710,5.604 0.280,-0.676,5.604 0.312,-0.645,5.604 0.518,-0.518,5.604 0.676,-0.280,5.604
range name 6th_7 x -0.744 0.744 y -0.744 0.744 z 4.763 5.604

;6th_8

poly prism a 0.674,0.0,5.604 0.674,0.280,5.604 0.518,0.518,5.604 0.280,0.676,5.604 0.0,0.732,5.604 -0.280,0.676,5.604 -0.518,0.518,5.604 -0.676,0.280,5.604 -0.722,0.0,5.604 -0.676,-0.280,5.604 -0.516,-0.519,5.604 -0.518,-0.518,5.604 -0.280,-0.676,5.604 -0.228,-0.696,5.604 -0.108,-0.724,5.604 0.0,-0.732,5.604 0.146,-0.717,5.604 0.280,-0.676,5.604 0.338,-0.610,5.604 0.518,-0.518,5.604 0.674,-0.280,5.604 &

b 0.655,0.0,6.421 0.654,0.271,6.421 0.501,0.501,6.421 0.271,0.654,6.421 0.0,0.708,6.421 -0.271,0.654,6.421 -0.501,0.501,6.421 -0.654,0.271,6.421 -0.708,0.0,6.421 -0.654,-0.271,6.421 -0.516,-0.450,6.421 -0.501,-0.475,6.421 -0.271,-0.635,6.421 -0.228,-0.640,6.421 -0.108,-0.680,6.421 0.0,-0.708,6.421 0.146,-0.675,6.421 0.271,-0.654,6.421 0.338,-0.622,6.421 0.501,-0.501,6.421 0.654,-0.271,6.421
range name 6th_8 x -0.732 0.732 y -0.732 0.732 z 5.604 6.421

;6th_9

poly prism a 0.636,0.0,6.421 0.654,0.271,6.421 0.501,0.501,6.421 0.271,0.654,6.421 0.0,0.708,6.421 -0.271,0.654,6.421 -0.501,0.501,6.421 -0.654,0.271,6.421 -0.708,0.0,6.421 -0.654,-0.271,6.421 -0.573,-0.416,6.421 -0.501,-0.501,6.421 -0.309,-0.637,6.421 -0.271,-0.654,6.421 -0.118,-0.698,6.421 0.0,-0.708,6.421 0.262,-0.658,6.421 0.271,-0.654,6.421 0.501,-0.501,6.421 0.506,-0.470,6.421 0.654,-0.271,6.421 &

b 0.674,0.0,7.118 0.641,0.265,7.118 0.490,0.490,7.118 0.265,0.641,7.118 0.0,0.694,7.118 -0.265,0.641,7.118 -0.490,0.490,7.118 -0.641,0.265,7.118 -0.684,0.0,7.118 -0.641,-0.265,7.118 -0.573,-0.365,7.118 -0.490,-0.490,7.118 -0.309,-0.605,7.118 -0.265,-0.641,7.118 -0.118,-0.665,7.118 0.0,-0.694,7.118 0.262,-0.625,7.118 0.265,-0.641,7.118 0.490,-0.490,7.118 0.506,-0.474,7.118 0.641,-0.265,7.118
range name 6th_9 x -0.708 0.708 y -0.708 0.708 z 6.421 7.118

;6th_10

poly prism a 0.583,0.0,7.118 0.583,0.265,7.118 0.490,0.490,7.118 0.265,0.641,7.118 0.0,0.694,7.118 -0.265,0.641,7.118 -0.490,0.490,7.118 -0.641,0.265,7.118 -0.694,0.0,7.118 -0.669,-0.155,7.118 -0.641,-0.265,7.118 -0.588,-0.355,7.118 -0.490,-0.490,7.118 -0.392,-0.572,7.118 -0.265,-0.641,7.118 -0.106,-0.685,7.118 0.0,-0.694,7.118 0.265,-0.641,7.118 0.264,-0.641,7.118 0.307,-0.622,7.118 0.309,-0.605,7.118 0.478,-0.495,7.118 0.490,-0.490,7.118 0.583,-0.265,7.118 &

b 0.595,0.0,7.748 0.595,0.257,7.748 0.475,0.475,7.748 0.257,0.621,7.748 0.0,0.672,7.748 -0.257,0.621,7.748 -0.475,0.475,7.748 -0.621,0.257,7.748 -0.648,0.0,7.748 -0.648,-0.155,7.748 -0.621,-0.257,7.748 -0.588,-0.325,7.748 -0.475,-0.475,7.748 -0.392,-0.535,7.748 -0.257,-0.621,7.748 -0.106,-0.650,7.748 0.0,-0.672,7.748 0.257,-0.621,7.748 0.264,-0.600,7.748 0.307,-0.590,7.748 0.309,-0.597,7.748 0.478,-0.472,7.748 0.475,-0.475,7.748 0.595,-0.257,7.748
range name 6th_10 x -0.6935 0.6935 y -0.6935 0.6935 z 7.118 7.748

;6th_11

poly prism a 0.619,0.0,7.748 0.619,0.257,7.748 0.475,0.475,7.748 0.257,0.621,7.748 0.0,0.672,7.748 -0.257,0.621,7.748 -0.475,0.475,7.748 -0.621,0.257,7.748 -0.648,0.0,7.748 -0.621,-0.257,7.748 -0.610,-0.275,7.748 -0.571,-0.354,7.748 -0.475,-0.475,7.748 -0.288,-0.607,7.748 -0.257,-0.621,7.748 0.0,-0.672,7.748 0.101,-0.655,7.748 0.257,-0.621,7.748 0.288,-0.607,7.748 0.475,-0.475,7.748 0.461,-0.489,7.748 0.480,-0.460,7.748 0.619,-0.257,7.748 &

b 0.595,0.0,8.589 0.595,0.248,8.589 0.458,0.458,8.589 0.248,0.599,8.589 0.0,0.648,8.589 -0.248,0.599,8.589 -0.458,0.458,8.589 -0.599,0.248,8.589 -0.624,0.0,8.589 -0.610,-0.219,8.589 -0.599,-0.248,8.589 -0.571,-0.290,8.589 -0.458,-0.458,8.589 -0.288,-0.570,8.589 -0.248,-0.599,8.589 0.0,-

0.648,8.589 0.101,-0.640,8.589 0.248,-0.599,8.589 0.288,-0.570,8.589 0.458,-0.458,8.589 0.461,-0.450,8.589 0.480,-0.435,8.589 0.595,-0.248,8.589
range name 6th_11 x -0.672 0.672 y -0.672 0.672 z 7.538 8.589

;6th_12

poly prism a 0.600,0.0,8.589 0.599,0.248,8.589 0.458,0.458,8.589 0.248,0.599,8.589 0.0,0.648,8.589 -0.248,0.599,8.589 -0.458,0.458,8.589 -0.599,0.248,8.589 -0.648,0.0,8.589 -0.599,-0.248,8.589 -0.576,-0.297,8.589 -0.552,-0.320,8.589 -0.458,-0.458,8.589 -0.456,-0.450,8.589 -0.248,-0.599,8.589 0.0,-0.648,8.589 0.248,-0.599,8.589 0.288,-0.570,8.589 0.355,-0.525,8.589 0.458,-0.458,8.589 0.595,-0.248,8.589 &
b 0.600,0.0,9.382 0.590,0.244,9.382 0.451,0.451,9.382 0.244,0.590,9.382 0.0,0.639,9.382 -0.244,0.590,9.382 -0.451,0.451,9.382 -0.590,0.244,9.382 -0.639,0.0,9.382 -0.590,-0.244,9.382 -0.576,-0.271,9.382 -0.552,-0.321,9.382 -0.456,-0.447,9.382 -0.451,-0.451,9.382 -0.244,-0.590,9.382 0.0,-0.639,9.382 0.244,-0.590,9.382 0.288,-0.570,9.382 0.355,-0.520,9.382 0.451,-0.451,9.382 0.590,-0.244,9.382
range name 6th_12 x -0.648 0.648 y -0.648 0.648 z 8.589 9.382

;6th_y

poly prism a 0.543,0.0,9.382 0.590,0.244,9.382 0.451,0.451,9.382 0.244,0.590,9.382 0.0,0.639,9.382 -0.244,0.590,9.382 -0.451,0.451,9.382 -0.590,0.244,9.382 -0.639,0.0,9.382 -0.590,-0.244,9.382 -0.451,-0.451,9.382 -0.244,-0.590,9.382 0.0,-0.639,9.382 0.244,-0.590,9.382 0.451,-0.451,9.382 0.543,-0.244,9.382 &
b 0.562,0.0,9.527 0.599,0.248,9.527 0.458,0.458,9.527 0.248,0.599,9.527 0.0,0.648,9.527 -0.248,0.599,9.527 -0.458,0.458,9.527 -0.599,0.248,9.527 -0.648,0.0,9.527 -0.599,-0.248,9.527 -0.458,-0.458,9.527 -0.248,-0.599,9.527 0.0,-0.648,9.527 0.248,-0.599,9.527 0.458,-0.458,9.527 0.562,-0.248,9.527
range name 6th_y x -0.648 0.648 y -0.648 0.648 z 9.382 9.527
join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;6th_k1

poly prism a 0.542,0.0,9.527 0.599,0.248,9.527 0.458,0.458,9.527 0.248,0.599,9.527 0.0,0.648,9.527 -0.248,0.599,9.527 -0.458,0.458,9.527 -0.599,0.248,9.527 -0.648,0.0,9.527 -0.599,-0.248,9.527 -0.458,-0.458,9.527 -0.248,-0.599,9.527 0.0,-0.648,9.527 0.248,-0.599,9.527 0.458,-0.458,9.527 0.542,-0.248,9.527 &
b 0.533,0.0,9.576 0.614,0.257,9.576 0.475,0.475,9.576 0.257,0.621,9.576 0.0,0.672,9.576 -0.257,0.621,9.576 -0.475,0.475,9.576 -0.621,0.257,9.576 -0.672,0.0,9.576 -0.621,-0.257,9.576 -0.475,-0.475,9.576 -0.257,-0.621,9.576 0.0,-0.672,9.576 0.257,-0.621,9.576 0.475,-0.475,9.576 0.533,-0.257,9.576
range name 6th_k1 x -0.672 0.672 y -0.672 0.672 z 9.527 9.576
join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;6th_k2

poly prism a 0.523,0.0,9.576 0.552,0.257,9.576 0.475,0.475,9.576 0.257,0.621,9.576 0.0,0.672,9.576 -0.257,0.621,9.576 -0.475,0.475,9.576 -0.621,0.257,9.576 -0.672,0.0,9.576 -0.621,-0.257,9.576 -0.475,-0.475,9.576 -0.257,-0.621,9.576 0.0,-0.672,9.576 0.257,-0.621,9.576 0.475,-0.475,9.576 0.523,-0.257,9.576 &
b 0.610,0.0,9.793 0.672,0.321,9.793 0.594,0.594,9.793 0.321,0.776,9.793 0.0,0.840,9.793 -0.321,0.776,9.793 -0.594,0.594,9.793 -0.776,0.321,9.793 -0.840,0.0,9.793 -0.776,-0.321,9.793 -0.594,-0.594,9.793 -0.321,-0.776,9.793 0.0,-0.840,9.793 0.321,-0.776,9.793 0.594,-0.594,9.793 0.610,-0.321,9.793
range name 6th_k2 x -0.672 0.672 y -0.672 0.672 z 9.576 9.793

join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;6th_k3

poly prism a -0.852,-0.852,9.793 0.420,-0.825,9.793 0.660,0.0,9.793 0.660,0.852,9.793 -0.852,0.852,9.793 &
b -0.852,-0.852,10.081 0.321,-0.852,10.081 0.657,0.0,10.081 0.657,0.852,10.081 -0.852,0.852,10.081
range name 6th_k3 x -0.852 0.852 y -0.852 0.852 z 9.793 10.081
join_contact on range x -0.852 0.852 y -0.852 0.852 z 9.383 10.081

;right_

;right_b

poly prism a 4.862,-0.938,-0.420 3.138,-0.938,-0.420 3.138,0.938,-0.420 4.862,0.938,-0.420 &
b 4.862,-0.938,0.0 3.138,-0.938,0.0 3.138,0.938,0.0 4.862,0.938,0.0
range name r_b x 3.138 4.862 y -0.938 0.938 z -0.420 0.0

;right_1

poly prism a 3.175,0.0,0.0 3.238,0.316,0.0 3.417,0.583,0.0 3.684,0.762,0.0 4.000,0.825,0.0 4.316,0.762,0.0 4.583,0.583,0.0 4.762,0.316,0.0 4.825,0.0,0.0 4.762,-0.316,0.0 4.583,-0.583,0.0 4.316,-0.762,0.0 4.000,-0.825,0.0 3.684,-0.762,0.0 3.417,-0.583,0.0 3.238,-0.316,0.0 &
b 3.184,0.0,0.918 3.246,0.312,0.918 3.423,0.577,0.918 3.688,0.754,0.918 4.000,0.816,0.918 4.312,0.754,0.918 4.577,0.577,0.918 4.754,0.312,0.918 4.760,0.0,0.918 4.754,-0.312,0.918 4.577,-0.577,0.918 4.312,-0.754,0.918 4.000,-0.816,0.918 3.688,-0.754,0.918 3.423,-0.577,0.918 3.246,-0.312,0.918
range name r_1 x 3.175 4.825 y -0.825 0.825 z 0.0 0.918

;right_2

poly prism a 3.184,0.0,0.918 3.246,0.312,0.918 3.423,0.577,0.918 3.688,0.754,0.918 4.000,0.816,0.918 4.312,0.754,0.918 4.577,0.577,0.918 4.754,0.312,0.918 4.816,0.0,0.918 4.754,-0.312,0.918 4.577,-0.577,0.918 4.312,-0.754,0.918 4.000,-0.816,0.918 3.688,-0.754,0.918 3.423,-0.577,0.918 3.246,-0.312,0.918 &
b 3.201,0.0,1.687 3.262,0.306,1.687 3.435,0.565,1.687 3.694,0.738,1.687 4.000,0.799,1.687 4.306,0.738,1.687 4.565,0.565,1.687 4.738,0.306,1.687 4.799,0.0,1.687 4.738,-0.306,1.687 4.565,-0.565,1.687 4.306,-0.738,1.687 4.000,-0.799,1.687 3.694,-0.738,1.687 3.435,-0.565,1.687 3.262,-0.306,1.687
range name r_2 x 3.184 4.816 y -0.816 0.816 z 0.918 1.687

;right_3

poly prism a 3.291,0.0,1.687 3.262,0.306,1.687 3.435,0.565,1.687 3.694,0.738,1.687 4.000,0.799,1.687 4.306,0.738,1.687 4.565,0.565,1.687 4.738,0.306,1.687 4.799,0.0,1.687 4.738,-0.306,1.687 4.565,-0.565,1.687 4.306,-0.738,1.687 4.000,-0.799,1.687 3.694,-0.738,1.687 3.435,-0.565,1.687 3.262,-0.306,1.687 &
b 3.215,0.0,2.456 3.275,0.300,2.456 3.445,0.555,2.456 3.700,0.725,2.456 4.000,0.785,2.456 4.300,0.725,2.456 4.555,0.555,2.456 4.725,0.300,2.456 4.708,0.0,2.456 4.725,-0.300,2.456 4.555,-0.555,2.456 4.300,-0.725,2.456 4.000,-0.785,2.456 3.700,-0.725,2.456 3.445,-0.555,2.456 3.275,-0.300,2.456
range name r_3 x 3.201 4.799 y -0.799 0.799 z 1.687 2.456

;right_4

poly prism a 3.215,0.0,2.456 3.275,0.300,2.456 3.498,0.502,2.456 3.700,0.725,2.456 4.000,0.785,2.456 4.300,0.725,2.456 4.555,0.555,2.456 4.725,0.300,2.456 4.785,0.0,2.456 4.725,-0.300,2.456 4.555,-0.555,2.456 4.300,-0.725,2.456 4.000,-0.785,2.456 3.700,-0.725,2.456 3.445,-0.555,2.456 3.275,-0.300,2.456 &
b 3.232,0.0,3.273 3.290,0.294,3.273 3.457,0.543,3.273 3.706,0.710,3.273 4.000,0.768,3.273 4.294,0.710,3.273 4.543,0.543,3.273 4.636,0.263,3.273 4.768,0.0,3.273 4.710,-0.294,3.273 4.543,-0.543,3.273 4.294,-0.710,3.273 4.000,-0.768,3.273 3.706,-0.710,3.273 3.457,-0.543,3.273 3.290,-0.294,3.273
range name r_4 x 3.215 4.785 y -0.785 0.785 z 2.456 3.273

;right_5

poly prism a 3.232,0.0,3.273 3.290,0.294,3.273 3.457,0.543,3.273 3.706,0.710,3.273 4.000,0.768,3.273 4.294,0.710,3.273 4.543,0.543,3.273 4.710,0.294,3.273 4.768,0.0,3.273 4.710,-0.294,3.273 4.543,-0.543,3.273 4.294,-0.710,3.273 4.000,-0.768,3.273 3.706,-0.710,3.273 3.492,-0.508,3.273 3.290,-0.294,3.273 &
b 3.247,0.0,4.090 3.304,0.288,4.090 3.467,0.533,4.090 3.712,0.696,4.090 4.000,0.754,4.090 4.288,0.696,4.090 4.533,0.533,4.090 4.696,0.288,4.090 4.709,0.0,4.090 4.696,-0.288,4.090 4.468,-0.468,4.090 4.288,-0.696,4.090 4.000,-0.754,4.090 3.712,-0.696,4.090 3.467,-0.533,4.090 3.304,-0.288,4.090
range name r_5 x 3.232 4.768 y -0.768 0.768 z 3.273 4.090

;right_6

poly prism a 3.247,0.0,4.090 3.304,0.288,4.090 3.467,0.533,4.090 3.712,0.696,4.090 4.000,0.754,4.090 4.288,0.696,4.090 4.533,0.533,4.090 4.696,0.288,4.090 4.739,0.0,4.090 4.696,-0.288,4.090 4.533,-0.533,4.090 4.288,-0.696,4.090 4.000,-0.754,4.090 3.712,-0.696,4.090 3.467,-0.533,4.090 3.304,-0.288,4.090 &
b 3.226,0.0,4.763 3.313,0.285,4.763 3.474,0.526,4.763 3.715,0.687,4.763 4.000,0.744,4.763 4.285,0.687,4.763 4.526,0.526,4.763 4.687,0.285,4.763 4.689,0.0,4.763 4.687,-0.285,4.763 4.526,-0.526,4.763 4.285,-0.687,4.763 4.000,-0.744,4.763 3.715,-0.687,4.763 3.474,-0.526,4.763 3.313,-0.285,4.763
range name r_6 x 3.247 4.754 y -0.7535 0.7535 z 4.090 4.763

;right_7

poly prism a 3.256,0.0,4.763 3.313,0.285,4.763 3.474,0.526,4.763 3.715,0.687,4.763 4.000,0.744,4.763 4.285,0.687,4.763 4.526,0.526,4.763 4.687,0.285,4.763 4.744,0.0,4.763 4.687,-0.285,4.763 4.526,-0.526,4.763 4.285,-0.687,4.763 4.000,-0.744,4.763 3.715,-0.687,4.763 3.474,-0.526,4.763 3.313,-0.285,4.763 &
b 3.268,0.0,5.604 3.324,0.280,5.604 3.482,0.518,5.604 3.720,0.676,5.604 4.000,0.732,5.604 4.280,0.676,5.604 4.518,0.518,5.604 4.676,0.280,5.604 4.732,0.0,5.604 4.676,-0.280,5.604 4.518,-0.518,5.604 4.280,-0.676,5.604 4.000,-0.732,5.604 3.720,-0.676,5.604 3.482,-0.518,5.604 3.324,-0.280,5.604
range name r_7 x 3.256 4.744 y -0.744 0.744 z 4.763 5.604

;right_8

poly prism a 3.268,0.0,5.604 3.324,0.280,5.604 3.482,0.518,5.604 3.720,0.676,5.604 4.000,0.732,5.604 4.280,0.676,5.604 4.518,0.518,5.604 4.676,0.280,5.604 4.732,0.0,5.604 4.676,-0.280,5.604 4.518,-0.518,5.604 4.280,-0.676,5.604 4.000,-0.702,5.604 3.720,-0.676,5.604 3.482,-0.518,5.604 3.324,-0.280,5.604 &

b 3.292,0.0,6.421 3.346,0.271,6.421 3.499,0.501,6.421 3.729,0.654,6.421 4.000,0.708,6.421 4.271,0.654,6.421 4.501,0.501,6.421 4.654,0.271,6.421 4.708,0.0,6.421 4.654,-0.271,6.421 4.469,-0.469,6.421 4.271,-0.654,6.421 4.000,-0.708,6.421 3.729,-0.654,6.421 3.499,-0.501,6.421 3.346,-0.271,6.421
range name r_8 x 3.268 4.732 y -0.732 0.732 z 5.604 6.421

;right_9

poly prism a 3.292,0.0,6.421 3.346,0.271,6.421 3.499,0.501,6.421 3.729,0.654,6.421 4.000,0.708,6.421 4.271,0.654,6.421 4.501,0.501,6.421 4.654,0.271,6.421 4.708,0.0,6.421 4.654,-0.271,6.421 4.501,-0.501,6.421 4.271,-0.654,6.421 4.000,-0.708,6.421 3.729,-0.654,6.421 3.499,-0.501,6.421 3.346,-0.271,6.421 &
b 3.307,0.0,7.118 3.359,0.265,7.118 3.510,0.490,7.118 3.735,0.641,7.118 4.000,0.614,7.118 4.265,0.641,7.118 4.490,0.490,7.118 4.641,0.265,7.118 4.669,0.0,7.118 4.641,-0.265,7.118 4.490,-0.490,7.118 4.265,-0.641,7.118 4.000,-0.694,7.118 3.735,-0.641,7.118 3.510,-0.490,7.118 3.359,-0.265,7.118
range name r_9 x 3.292 4.708 y -0.708 0.708 z 6.421 7.118

;right_10

poly prism a 3.307,0.0,7.118 3.359,0.265,7.118 3.510,0.490,7.118 3.735,0.641,7.118 4.000,0.694,7.118 4.265,0.641,7.118 4.490,0.490,7.118 4.641,0.265,7.118 4.694,0.0,7.118 4.641,-0.265,7.118 4.490,-0.490,7.118 4.265,-0.641,7.118 4.000,-0.694,7.118 3.735,-0.641,7.118 3.552,-0.448,7.118 3.359,-0.265,7.118 &
b 3.328,0.0,7.748 3.379,0.257,7.748 3.525,0.475,7.748 3.743,0.621,7.748 4.000,0.672,7.748 4.257,0.621,7.748 4.475,0.475,7.748 4.621,0.257,7.748 4.612,0.0,7.748 4.621,-0.257,7.748 4.475,-0.475,7.748 4.257,-0.621,7.748 4.000,-0.672,7.748 3.743,-0.621,7.748 3.525,-0.475,7.748 3.379,-0.257,7.748
range name r_10 x 3.307 4.694 y -0.6935 0.6935 z 7.118 7.748

;right_11

poly prism a 3.328,0.0,7.748 3.379,0.257,7.748 3.525,0.475,7.748 3.743,0.621,7.748 4.000,0.672,7.748 4.257,0.621,7.748 4.475,0.475,7.748 4.621,0.257,7.748 4.652,0.0,7.748 4.621,-0.257,7.748 4.475,-0.475,7.748 4.257,-0.621,7.748 4.000,-0.672,7.748 3.743,-0.621,7.748 3.525,-0.475,7.748 3.379,-0.257,7.748 &
b 3.352,0.0,8.589 3.401,0.248,8.589 3.542,0.458,8.589 3.752,0.599,8.589 4.000,0.648,8.589 4.248,0.599,8.589 4.439,0.439,8.589 4.599,0.248,8.589 4.608,0.0,8.589 4.599,-0.248,8.589 4.458,-0.458,8.589 4.248,-0.599,8.589 4.000,-0.648,8.589 3.752,-0.599,8.589 3.542,-0.458,8.589 3.401,-0.248,8.589
range name r_11 x 3.328 4.672 y -0.672 0.672 z 7.538 8.589

;right_12

poly prism a 3.382,0.0,8.589 3.401,0.248,8.589 3.542,0.458,8.589 3.752,0.599,8.589 4.000,0.648,8.589 4.248,0.599,8.589 4.458,0.458,8.589 4.599,0.248,8.589 4.608,0.0,8.589 4.599,-0.248,8.589 4.458,-0.458,8.589 4.248,-0.599,8.589 4.000,-0.648,8.589 3.752,-0.599,8.589 3.542,-0.458,8.589 3.401,-0.248,8.589 &
b 3.362,0.0,9.382 3.410,0.244,9.382 3.549,0.451,9.382 3.756,0.590,9.382 4.000,0.639,9.382 4.244,0.590,9.382 4.451,0.451,9.382 4.590,0.244,9.382 4.639,0.0,9.382 4.590,-0.244,9.382 4.394,-0.394,9.382 4.244,-0.590,9.382 4.000,-0.639,9.382 3.756,-0.590,9.382 3.549,-0.451,9.382 3.410,-0.244,9.382
range name r_12 x 3.352 4.648 y -0.648 0.648 z 8.589 9.382

;right_y

poly prism a 3.362,0.0,9.382 3.410,0.244,9.382 3.549,0.451,9.382 3.756,0.590,9.382 4.000,0.639,9.382 4.244,0.590,9.382 4.451,0.451,9.382 4.590,0.244,9.382 4.639,0.0,9.382 4.590,-0.244,9.382 4.451,-0.451,9.382 4.244,-0.590,9.382 4.000,-0.639,9.382 3.756,-0.590,9.382 3.549,-0.451,9.382 3.410,-0.244,9.382 &

b 3.352,0.0,9.527 3.401,0.248,9.527 3.542,0.458,9.527 3.752,0.599,9.527 4.000,0.648,9.527 4.248,0.599,9.527 4.458,0.458,9.527 4.599,0.248,9.527 4.513,0.0,9.527 4.599,-0.248,9.527 4.458,-0.458,9.527 4.248,-0.599,9.527 4.000,-0.648,9.527 3.752,-0.599,9.527 3.542,-0.458,9.527 3.401,-0.248,9.527

range name r_y x 3.352 4.648 y -0.648 0.648 z 9.382 9.527

join_contact on range x 3.148 4.852 y -0.852 0.852 z 9.383 10.081

;right_k1

poly prism a 3.352,0.0,9.527 3.401,0.248,9.527 3.542,0.458,9.527 3.752,0.599,9.527 4.000,0.648,9.527 4.248,0.599,9.527 4.458,0.458,9.527 4.599,0.248,9.527 4.648,0.0,9.527 4.599,-0.248,9.527 4.458,-0.458,9.527 4.248,-0.599,9.527 4.000,-0.648,9.527 3.752,-0.599,9.527 3.542,-0.458,9.527 3.401,-0.248,9.527 &

b 3.328,0.0,9.576 3.379,0.257,9.576 3.525,0.475,9.576 3.743,0.621,9.576 4.000,0.672,9.576 4.257,0.621,9.576 4.475,0.475,9.576 4.621,0.257,9.576 4.672,0.0,9.576 4.621,-0.257,9.576 4.475,-0.475,9.576 4.257,-0.621,9.576 4.000,-0.572,9.576 3.743,-0.621,9.576 3.525,-0.475,9.576 3.379,-0.257,9.576

range name r_k1 x 3.328 4.672 y -0.672 0.672 z 9.527 9.576

join_contact on range x 3.148 4.852 y -0.852 0.852 z 9.383 10.081

;right_k2

poly prism a 3.328,0.0,9.576 3.379,0.257,9.576 3.525,0.475,9.576 3.743,0.621,9.576 4.000,0.672,9.576 4.257,0.621,9.576 4.475,0.475,9.576 4.621,0.257,9.576 4.672,0.0,9.576 4.621,-0.257,9.576 4.475,-0.475,9.576 4.257,-0.621,9.576 4.000,-0.582,9.576 3.743,-0.621,9.576 3.525,-0.475,9.576 3.379,-0.257,9.576 &

b 3.160,0.0,9.793 3.224,0.321,9.793 3.406,0.594,9.793 3.679,0.776,9.793 4.000,0.840,9.793 4.321,0.776,9.793 4.594,0.594,9.793 4.776,0.321,9.793 4.690,0.0,9.793 4.776,-0.321,9.793 4.594,-0.594,9.793 4.321,-0.776,9.793 4.000,-0.840,9.793 3.679,-0.776,9.793 3.406,-0.594,9.793 3.224,-0.321,9.793

range name r_k2 x 3.160 4.840 y -0.840 0.840 z 9.576 9.793

join_contact on range x 3.148 4.852 y -0.852 0.852 z 9.383 10.081

;right_k3

poly prism a 4.852,-0.702,9.793 4.622,-0.852,9.793 3.148,-0.852,9.793 3.148,0.852,9.793 4.852,0.852,9.793 &

b 4.852,-0.702,10.081 4.622,-0.852,10.081 3.148,-0.852,10.081 3.148,0.852,10.081 4.852,0.852,10.081

range name r_k3 x 3.148 4.852 y -0.852 0.852 z 9.793 10.081

join_contact on range x 3.148 4.852 y -0.852 0.852 z 9.383 10.081

;behind

;behind_b

poly prism a -0.862,3.062,-0.420 0.862,3.062,-0.420 0.862,4.938,-0.420 -0.862,4.938,-0.420 &

b -0.862,3.062,0.0 0.862,3.062,0.0 0.862,4.938,0.0 -0.862,4.938,0.0
range name b_b x -0.862 0.862 y 3.062 4.938 z -0.420 0.0

;behind_1

poly prism a 0.825,4.000,0.0 0.762,4.316,0.0 0.583,4.583,0.0 0.316,4.762,0.0 0.0,4.825,0.0 -0.316,4.762,0.0 -0.583,4.583,0.0 -0.762,4.316,0.0 -0.825,4.000,0.0 -0.762,3.684,0.0 -0.583,3.417,0.0 -0.316,3.238,0.0 0.0,3.175,0.0 0.316,3.238,0.0 0.583,3.417,0.0 0.762,3.684,0.0 &
b 0.760,4.000,0.918 0.754,4.312,0.918 0.577,4.577,0.918 0.312,4.754,0.918 0.0,4.816,0.918 -0.312,4.754,0.918 -0.577,4.577,0.918 -0.754,4.312,0.918 -0.816,4.000,0.918 -0.754,3.688,0.918 -0.577,3.423,0.918 -0.312,3.246,0.918 0.0,3.184,0.918 0.312,3.246,0.918 0.577,3.423,0.918 0.754,3.688,0.918
range name b_1 x -0.825 0.825 y 3.175 4.825 z 0.0 0.918

;behind_2

poly prism a 0.816,4.000,0.918 0.754,4.312,0.918 0.577,4.577,0.918 0.312,4.754,0.918 0.0,4.816,0.918 -0.312,4.754,0.918 -0.577,4.577,0.918 -0.754,4.312,0.918 -0.816,4.000,0.918 -0.754,3.688,0.918 -0.577,3.423,0.918 -0.312,3.246,0.918 0.0,3.184,0.918 0.312,3.246,0.918 0.577,3.423,0.918 0.754,3.688,0.918 &
b 0.799,4.000,1.687 0.738,4.306,1.687 0.565,4.565,1.687 0.306,4.738,1.687 0.0,4.799,1.687 -0.306,4.738,1.687 -0.565,4.565,1.687 -0.738,4.306,1.687 -0.799,4.000,1.687 -0.738,3.694,1.687 -0.565,3.435,1.687 -0.306,3.262,1.687 0.0,3.201,1.687 0.306,3.262,1.687 0.565,3.435,1.687 0.738,3.694,1.687
range name b_2 x -0.816 0.816 y 3.184 4.816 z 0.918 1.687

;behind_3

poly prism a 0.799,4.000,1.687 0.738,4.306,1.687 0.565,4.565,1.687 0.306,4.738,1.687 0.0,4.799,1.687 -0.306,4.738,1.687 -0.565,4.565,1.687 -0.738,4.306,1.687 -0.709,4.000,1.687 -0.738,3.694,1.687 -0.565,3.435,1.687 -0.306,3.262,1.687 0.0,3.201,1.687 0.306,3.262,1.687 0.565,3.435,1.687 0.738,3.694,1.687 &
b 0.708,4.000,2.456 0.725,4.300,2.456 0.555,4.555,2.456 0.300,4.725,2.456 0.0,4.785,2.456 -0.300,4.725,2.456 -0.555,4.555,2.456 -0.725,4.300,2.456 -0.785,4.000,2.456 -0.725,3.700,2.456 -0.555,3.445,2.456 -0.300,3.275,2.456 0.0,3.215,2.456 0.300,3.275,2.456 0.555,3.445,2.456 0.725,3.700,2.456
range name b_3 x -0.799 0.799 y 3.201 4.799 z 1.687 2.456

;behind_4

poly prism a 0.785,4.000,2.456 0.725,4.300,2.456 0.555,4.555,2.456 0.300,4.725,2.456 0.0,4.785,2.456 -0.300,4.725,2.456 -0.480,4.480,2.456 -0.725,4.300,2.456 -0.785,4.000,2.456 -0.725,3.700,2.456 -0.555,3.445,2.456 -0.300,3.275,2.456 0.0,3.215,2.456 0.300,3.275,2.456 0.555,3.445,2.456 0.725,3.700,2.456 &
b 0.768,4.000,3.273 0.636,4.263,3.273 0.543,4.543,3.273 0.294,4.710,3.273 0.0,4.768,3.273 -0.294,4.710,3.273 -0.543,4.543,3.273 -0.710,4.294,3.273 -0.768,4.000,3.273 -0.710,3.706,3.273 -0.543,3.457,3.273 -0.294,3.290,3.273 0.0,3.232,3.273 0.294,3.290,3.273 0.543,3.457,3.273 0.710,3.706,3.273
range name b_4 x -0.785 0.785 y 3.215 4.785 z 2.456 3.273

;behind_5

poly prism a 0.768,4.000,3.273 0.710,4.294,3.273 0.543,4.543,3.273 0.294,4.710,3.273 0.0,4.768,3.273 -0.294,4.710,3.273 -0.543,4.543,3.273 -0.710,4.294,3.273 -0.768,4.000,3.273 -0.710,3.706,3.273 -0.508,3.492,3.273 -0.294,3.290,3.273 0.0,3.232,3.273 0.294,3.290,3.273 0.543,3.457,3.273 0.710,3.706,3.273 &

b 0.709,4.000,4.090 0.696,4.288,4.090 0.533,4.533,4.090 0.288,4.696,4.090 0.0,4.754,4.090 -0.288,4.696,4.090 -0.533,4.533,4.090 -0.696,4.288,4.090 -0.754,4.000,4.090 -0.696,3.712,4.090 -0.533,3.467,4.090 -0.288,3.304,4.090 0.0,3.247,4.090 0.288,3.304,4.090 0.468,3.532,4.090 0.696,3.712,4.090
range name b_5 x -0.768 0.768 y 3.232 4.768 z 3.273 4.090
;behind_6

poly prism a 0.739,4.000,4.090 0.696,4.288,4.090 0.533,4.533,4.090 0.288,4.696,4.090 0.0,4.754,4.090 -0.288,4.696,4.090 -0.533,4.533,4.090 -0.696,4.288,4.090 -0.754,4.000,4.090 -0.696,3.712,4.090 -0.533,3.467,4.090 -0.288,3.304,4.090 0.0,3.247,4.090 0.288,3.304,4.090 0.533,3.467,4.090 0.696,3.712,4.090 &
b 0.689,4.000,4.763 0.687,4.285,4.763 0.526,4.526,4.763 0.285,4.687,4.763 0.0,4.744,4.763 -0.285,4.687,4.763 -0.526,4.526,4.763 -0.687,4.285,4.763 -0.714,4.000,4.763 -0.687,3.715,4.763 -0.526,3.474,4.763 -0.285,3.313,4.763 0.0,3.256,4.763 0.285,3.313,4.763 0.526,3.474,4.763 0.687,3.715,4.763
range name b_6 x -0.7535 0.7535 y 3.247 4.754 z 4.090 4.763

;behind_7

poly prism a 0.744,4.000,4.763 0.687,4.285,4.763 0.526,4.526,4.763 0.285,4.687,4.763 0.0,4.744,4.763 -0.285,4.687,4.763 -0.526,4.526,4.763 -0.687,4.285,4.763 -0.744,4.000,4.763 -0.687,3.715,4.763 -0.526,3.474,4.763 -0.285,3.313,4.763 0.0,3.256,4.763 0.285,3.313,4.763 0.526,3.474,4.763 0.687,3.715,4.763 &
b 0.732,4.000,5.604 0.676,4.280,5.604 0.518,4.518,5.604 0.280,4.676,5.604 0.0,4.732,5.604 -0.280,4.676,5.604 -0.518,4.518,5.604 -0.676,4.280,5.604 -0.732,4.000,5.604 -0.676,3.720,5.604 -0.518,3.482,5.604 -0.280,3.324,5.604 0.0,3.268,5.604 0.280,3.324,5.604 0.518,3.482,5.604 0.676,3.720,5.604
range name b_7 x -0.744 0.744 y 3.256 4.744 z 4.763 5.604

;behind_8

poly prism a 0.732,4.000,5.604 0.676,4.280,5.604 0.518,4.518,5.604 0.280,4.676,5.604 0.0,4.732,5.604 -0.280,4.676,5.604 -0.518,4.518,5.604 -0.676,4.280,5.604 -0.732,4.000,5.604 -0.676,3.720,5.604 -0.518,3.482,5.604 -0.280,3.324,5.604 0.0,3.298,5.604 0.280,3.324,5.604 0.518,3.482,5.604 0.676,3.720,5.604 &
b 0.708,4.000,6.421 0.654,4.271,6.421 0.501,4.501,6.421 0.271,4.654,6.421 0.0,4.708,6.421 -0.271,4.654,6.421 -0.501,4.501,6.421 -0.654,4.271,6.421 -0.708,4.000,6.421 -0.654,3.729,6.421 -0.501,3.499,6.421 -0.271,3.346,6.421 0.0,3.292,6.421 0.271,3.346,6.421 0.469,3.531,6.421 0.654,3.729,6.421
range name b_8 x -0.732 0.732 y 3.268 4.732 z 5.604 6.421

;behind_9

poly prism a 0.708,4.000,6.421 0.654,4.271,6.421 0.501,4.501,6.421 0.271,4.654,6.421 0.0,4.708,6.421 -0.271,4.654,6.421 -0.501,4.501,6.421 -0.654,4.271,6.421 -0.708,4.000,6.421 -0.654,3.729,6.421 -0.501,3.499,6.421 -0.271,3.346,6.421 0.0,3.292,6.421 0.271,3.346,6.421 0.501,3.499,6.421 0.654,3.729,6.421 &
b 0.669,4.000,7.118 0.641,4.265,7.118 0.490,4.490,7.118 0.265,4.641,7.118 0.0,4.614,7.118 -0.265,4.641,7.118 -0.490,4.490,7.118 -0.641,4.265,7.118 -0.694,4.000,7.118 -0.641,3.735,7.118 -0.490,3.510,7.118 -0.265,3.359,7.118 0.0,3.307,7.118 0.265,3.359,7.118 0.490,3.510,7.118 0.641,3.735,7.118
range name b_9 x -0.708 0.708 y 3.292 4.708 z 6.421 7.118

;behind_10

poly prism a 0.694,4.000,7.118 0.641,4.265,7.118 0.490,4.490,7.118 0.265,4.641,7.118 0.0,4.694,7.118 -0.265,4.641,7.118 -0.490,4.490,7.118 -0.641,4.265,7.118 -0.694,4.000,7.118 -0.641,3.735,7.118 -0.448,3.552,7.118 -0.265,3.359,7.118 0.0,3.307,7.118 0.265,3.359,7.118 0.490,3.510,7.118 0.641,3.735,7.118 &

b 0.612,4.000,7.748 0.621,4.257,7.748 0.475,4.475,7.748 0.257,4.621,7.748 0.0,4.672,7.748 -0.257,4.621,7.748 -0.475,4.475,7.748 -0.621,4.257,7.748 -0.672,4.000,7.748 -0.621,3.743,7.748 -0.475,3.525,7.748 -0.257,3.379,7.748 0.0,3.328,7.748 0.257,3.379,7.748 0.475,3.525,7.748 0.621,3.743,7.748

range name b_10 x -0.6935 0.6935 y 3.307 4.694 z 7.118 7.748

;behind_11

poly prism a 0.652,4.000,7.748 0.621,4.257,7.748 0.475,4.475,7.748 0.257,4.621,7.748 0.0,4.672,7.748 -0.257,4.621,7.748 -0.475,4.475,7.748 -0.621,4.257,7.748 -0.672,4.000,7.748 -0.621,3.743,7.748 -0.475,3.525,7.748 -0.257,3.379,7.748 0.0,3.328,7.748 0.257,3.379,7.748 0.475,3.525,7.748 0.621,3.743,7.748 &

b 0.608,4.000,8.589 0.599,4.248,8.589 0.458,4.458,8.589 0.229,4.580,8.589 0.0,4.648,8.589 -0.248,4.599,8.589 -0.458,4.458,8.589 -0.599,4.248,8.589 -0.648,4.000,8.589 -0.599,3.752,8.589 -0.458,3.542,8.589 -0.248,3.401,8.589 0.0,3.352,8.589 0.248,3.401,8.589 0.458,3.542,8.589 0.599,3.752,8.589

range name b_11 x -0.672 0.672 y 3.328 4.672 z 7.538 8.589

;behind_12

poly prism a 0.608,4.000,8.589 0.599,4.248,8.589 0.458,4.458,8.589 0.248,4.599,8.589 0.0,4.648,8.589 -0.248,4.599,8.589 -0.458,4.458,8.589 -0.599,4.248,8.589 -0.618,4.000,8.589 -0.599,3.752,8.589 -0.458,3.542,8.589 -0.248,3.401,8.589 0.0,3.352,8.589 0.248,3.401,8.589 0.458,3.542,8.589 0.599,3.752,8.589 &

b 0.639,4.000,9.382 0.590,4.244,9.382 0.451,4.451,9.382 0.244,4.590,9.382 0.0,4.639,9.382 -0.244,4.590,9.382 -0.451,4.451,9.382 -0.590,4.244,9.382 -0.639,4.000,9.382 -0.590,3.756,9.382 -0.451,3.549,9.382 -0.244,3.410,9.382 0.0,3.362,9.382 0.244,3.410,9.382 0.394,3.606,9.382 0.590,3.756,9.382

range name b_12 x -0.648 0.648 y 3.352 4.648 z 8.589 9.382

;behind_y

poly prism a 0.639,4.000,9.382 0.590,4.244,9.382 0.451,4.451,9.382 0.244,4.590,9.382 0.0,4.639,9.382 -0.244,4.590,9.382 -0.451,4.451,9.382 -0.590,4.244,9.382 -0.639,4.000,9.382 -0.590,3.756,9.382 -0.451,3.549,9.382 -0.244,3.410,9.382 0.0,3.362,9.382 0.244,3.410,9.382 0.451,3.549,9.382 0.590,3.756,9.382 &

b 0.513,4.000,9.527 0.599,4.248,9.527 0.458,4.458,9.527 0.248,4.599,9.527 0.0,4.648,9.527 -0.248,4.599,9.527 -0.458,4.458,9.527 -0.599,4.248,9.527 -0.648,4.000,9.527 -0.599,3.752,9.527 -0.458,3.542,9.527 -0.248,3.401,9.527 0.0,3.352,9.527 0.248,3.401,9.527 0.458,3.542,9.527 0.599,3.752,9.527

range name b_y x -0.648 0.648 y 3.352 4.648 z 9.382 9.527

join_contact on range x -0.852 0.852 y 3.148 4.852 z 9.793 10.081

;behind_k1

poly prism a 0.648,4.000,9.527 0.599,4.248,9.527 0.458,4.458,9.527 0.248,4.599,9.527 0.0,4.648,9.527 -0.248,4.599,9.527 -0.458,4.458,9.527 -0.599,4.248,9.527 -0.648,4.000,9.527 -0.599,3.752,9.527 -0.458,3.542,9.527 -0.248,3.401,9.527 0.0,3.352,9.527 0.248,3.401,9.527 0.458,3.542,9.527 0.599,3.752,9.527 &

b 0.672,4.000,9.576 0.621,4.257,9.576 0.475,4.475,9.576 0.257,4.621,9.576 0.0,4.672,9.576 -0.257,4.621,9.576 -0.475,4.475,9.576 -0.621,4.257,9.576 -0.672,4.000,9.576 -0.621,3.743,9.576 -

0.475,3.525,9.576 -0.257,3.379,9.576 0.0,3.428,9.576 0.257,3.379,9.576 0.475,3.525,9.576 0.621,3.743,9.576
range name b_k1 x -0.672 0.672 y 3.328 4.672 z 9.527 9.576
join_contact on range x -0.852 0.852 y 3.148 4.852 z 9.793 10.081

;behind_k2

poly prism a 0.672,4.000,9.576 0.621,4.257,9.576 0.475,4.475,9.576 0.257,4.621,9.576 0.0,4.672,9.576 -0.257,4.621,9.576 -0.475,4.475,9.576 -0.621,4.257,9.576 -0.672,4.000,9.576 -0.621,3.743,9.576 -0.475,3.525,9.576 -0.257,3.379,9.576 0.0,3.418,9.576 0.257,3.379,9.576 0.475,3.525,9.576 0.621,3.743,9.576 &
b 0.690,4.000,9.793 0.776,4.321,9.793 0.594,4.594,9.793 0.321,4.776,9.793 0.0,4.840,9.793 -0.321,4.776,9.793 -0.594,4.594,9.793 -0.776,4.321,9.793 -0.840,4.000,9.793 -0.776,3.679,9.793 -0.594,3.406,9.793 -0.321,3.224,9.793 0.0,3.160,9.793 0.321,3.224,9.793 0.594,3.406,9.793 0.776,3.679,9.793
range name b_k2 x -0.840 0.840 y 3.160 4.840 z 9.576 9.793
join_contact on range x -0.852 0.852 y 3.148 4.852 z 9.793 10.081

;behind_k3

poly prism a -0.852,3.148,9.793 0.652,3.148,9.793 0.852,3.298,9.793 0.852,4.852,9.793 -0.852,4.852,9.793 &
b -0.852,3.148,10.081 0.652,3.148,10.081 0.852,3.298,10.081 0.852,4.852,10.081 -0.852,4.852,10.081
range name b_k3 x -0.852 0.852 y 3.148 4.852 z 9.793 10.081
join_contact on range x -0.852 0.852 y 3.148 4.852 z 9.793 10.081

## *GEOMETRY OF THE EPISTYLES MODELS*

### *Epistyles in a line arrangement*

;epistyles

;left_epi

;1_
poly prism a -4.000,-0.680,10.081 -4.000,-0.254,10.081 0.0,-0.254,10.081 0.0,-0.680,10.081 &
b -4.000,-0.680,11.431 -4.000,-0.254,11.431 0.0,-0.254,11.431 0.0,-0.680,11.431
range name l_r1 x -4.000 0.0 y -0.680 -0.254 z 10.081 11.431
;2_
poly prism a -4.000,-0.254,10.081 -4.000,0.237,10.081 0.0,0.237,10.081 0.0,-0.254,10.081 &
b -4.000,-0.254,11.431 -4.000,0.237,11.431 0.0,0.237,11.431 0.0,-0.254,11.431
range name l_r2 x -4.000 0.0 y -0.254 0.237 z 10.081 11.431
;3_
poly prism a -4.000,0.237,10.081 -4.000,0.680,10.081 0.0,0.680,10.081 0.0,0.237,10.081 &
b -4.000,0.237,11.431 -4.000,0.680,11.431 0.0,0.680,11.431 0.0,0.237,11.431

range name l_r3 x -4.000 0.0 y 0.237 0.680 z 10.081 11.431

;right_epi

;1_
poly prism a 0.0,-0.680,10.081 0.0,-0.254,10.081 4.000,-0.254,10.081 4.000,-0.680,10.081 &
b 0.0,-0.680,11.431 0.0,-0.254,11.431 4.000,-0.254,11.431 4.000,-0.680,11.431
range name r_r1 x 0.0 4.000 y -0.680 -0.254 z 10.081 11.431
;2_
poly prism a 0.0,-0.254,10.081 0.0,0.237,10.081 4.000,0.237,10.081 4.000,-0.254,10.081 &
b 0.0,-0.254,11.431 0.0,0.237,11.431 4.000,0.237,11.431 4.000,-0.254,11.431
range name r_r2 x 0.0 4.000 y -0.254 0.237 z 10.081 11.431
;3_
poly prism a 0.0,0.237,10.081 0.0,0.680,10.081 4.000,0.680,10.081 4.000,0.237,10.081 &
b 0.0,0.237,11.431 0.0,0.680,11.431 4.000,0.680,11.431 4.000,0.237,11.431
range name r_r3 x 0.0 4.000 y 0.237 0.680 z 10.081 11.431

## *Epistyles in a corner arrangement*

;epistyles_corn

;r_epi

;1_
poly prism a 0.0,-0.680,10.081 0.0,-0.254,10.081 4.000,-0.254,10.081 4.000,-0.680,10.081 &
b 0.0,-0.680,11.431 0.0,-0.254,11.431 4.000,-0.254,11.431 4.000,-0.680,11.431
range name r_r1 x 0.0 4.000 y -0.680 -0.254 z 10.081 11.431
;2_
poly prism a -0.254,-0.254,10.081 -0.254,0.237,10.081 4.000,0.237,10.081 4.000,-0.254,10.081 &
b -0.254,-0.254,11.431 -0.254,0.237,11.431 4.000,0.237,11.431 4.000,-0.254,11.431
range name r_r2 x -0.254 4.000 y -0.254 0.237 z 10.081 11.431
;3_
poly prism a 0.237,0.237,10.081 0.680,0.680,10.081 4.000,0.680,10.081 4.000,0.237,10.081 &
b 0.237,0.237,11.431 0.680,0.680,11.431 4.000,0.680,11.431 4.000,0.237,11.431
range name r_r3 x 0.237 4.000 y 0.237 0.680 z 10.081 11.431

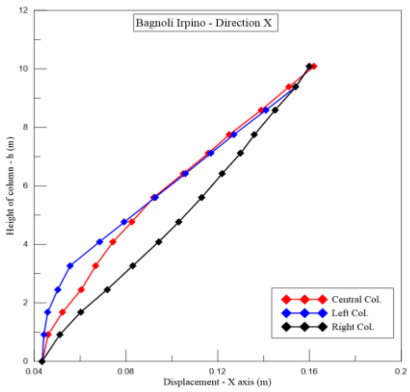
;b_epi
;1_
poly prism a 0.0,-0.680,10.081 -0.680,-0.680,10.081 -0.680,4.000,10.081 -0.254,4.000,10.081 -0.254,-0.254,10.081 0.0,-0.254,10.081 &
b 0.0,-0.680,11.431 -0.680,-0.680,11.431 -0.680,4.000,11.431 -0.254,4.000,11.431 -0.254,-0.254,11.431 0.0,-0.254,11.431
range name b_r1 x -0.680 0.0 y -0.680 4.000 z 10.081 11.431
;2_
poly prism a -0.254,0.237,10.081 0.237,0.237,10.081 0.237,4.000,10.081 -0.254,4.000,10.081 &
b -0.254,0.237,11.431 0.237,0.237,11.431 0.237,4.000,11.431 -0.254,4.000,11.431
range name b_r2 x -0.254 0.237 y 0.237 4.000 z 10.081 11.431
;3_
poly prism a 0.237,0.237,10.081 0.680,0.680,10.081 0.680,4.000,10.081 0.237,4.000,10.081 &
b 0.237,0.237,11.431 0.680,0.680,11.431 0.680,4.000,11.431 0.237,4.000,11.431
range name b_r3 x 0.237 0.680 y 0.237 4.000 z 10.081 11.431

# APPENDIX 2

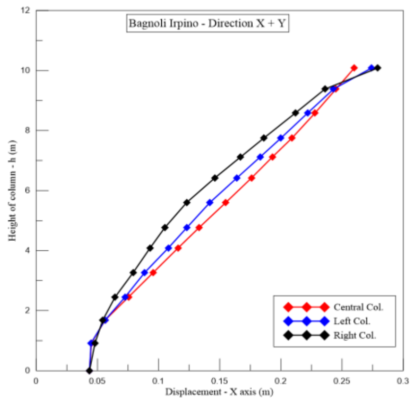
## INDICATIVE DIAGRAMS OF MAXIMUM ABSOLUTE DISPLACEMENTS (in m) OF THE DAMAGED MODELS OF COLONNADES FOR ALL 3 COLUMNS IN X, Y, Z

*COLONNADE IN A LINE ARRANGEMENT*

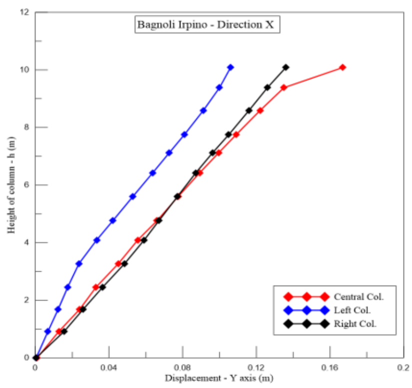
*3rd record*



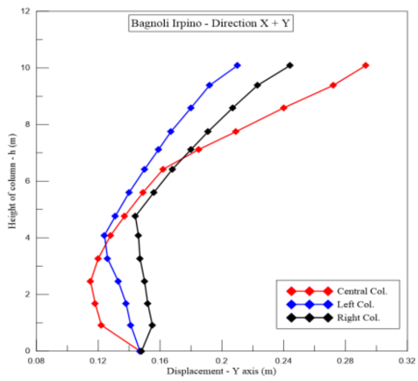

(a)



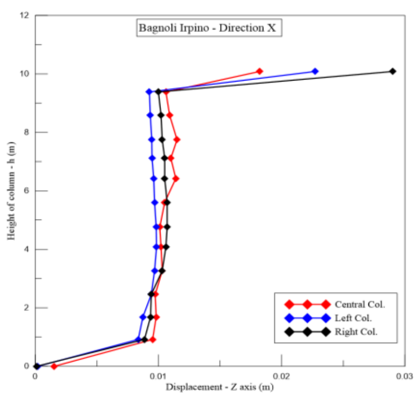

(b)



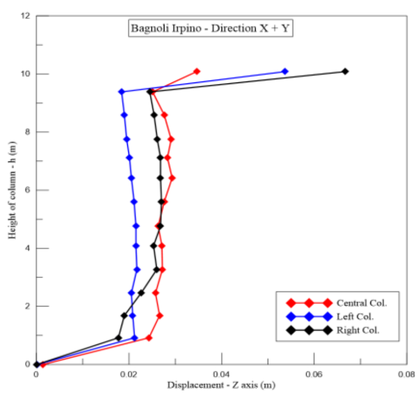

(c)




(d)

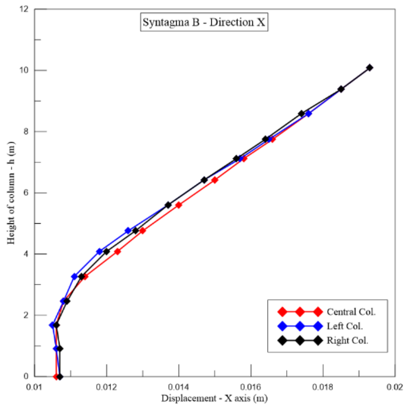



(e)

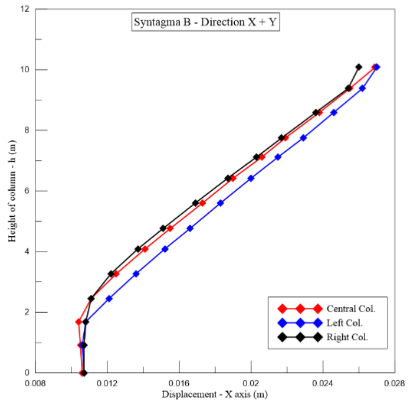



(f)

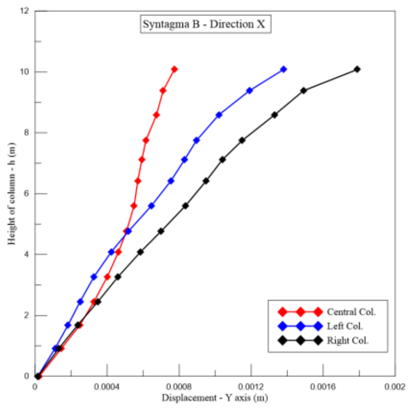
*9th record*



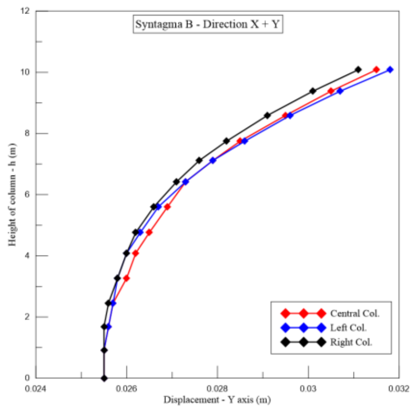

(a)



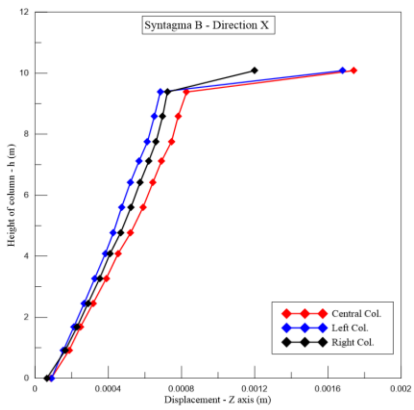

(b)



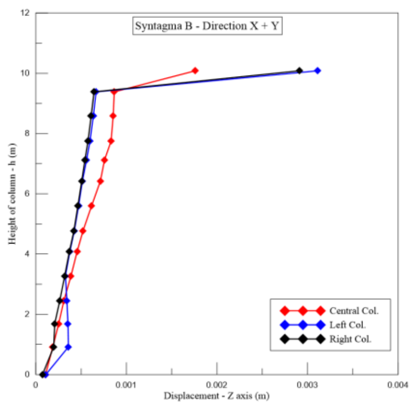

(c)




(d)



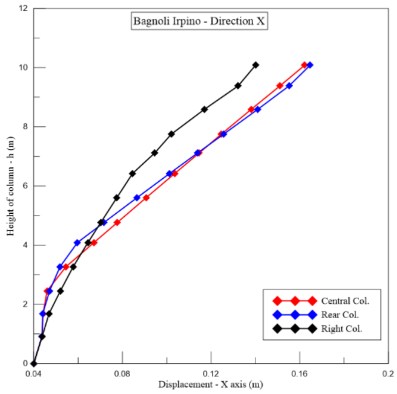

(e)



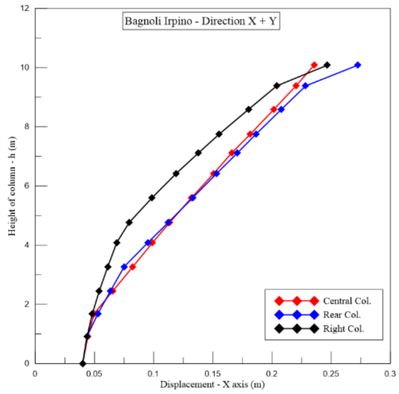

(f)

*COLONNADE IN A CORNER ARRANGEMENT*

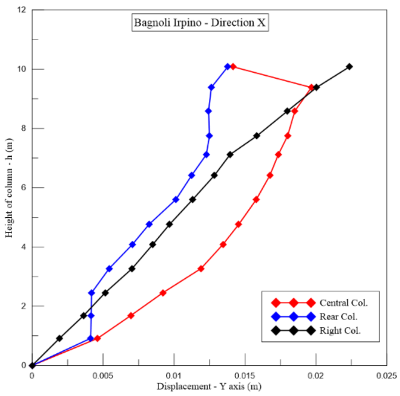
*3rd record*



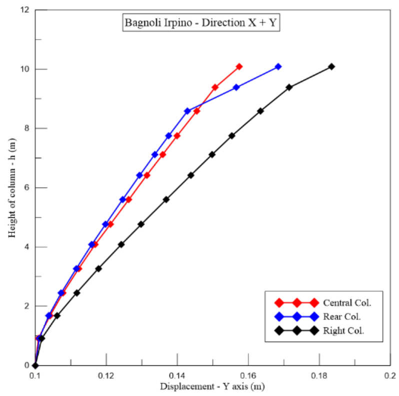

(a)



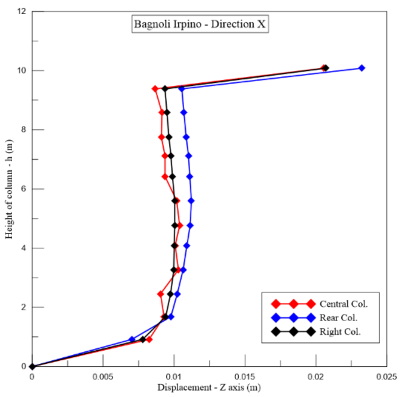

(b)



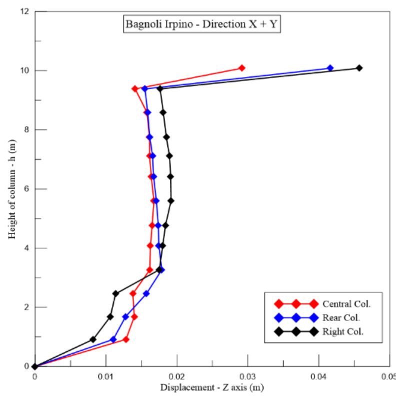

(c)




(d)

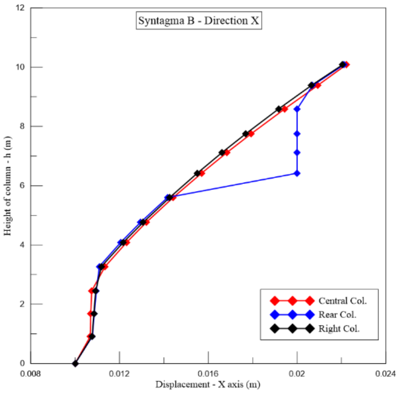



(e)

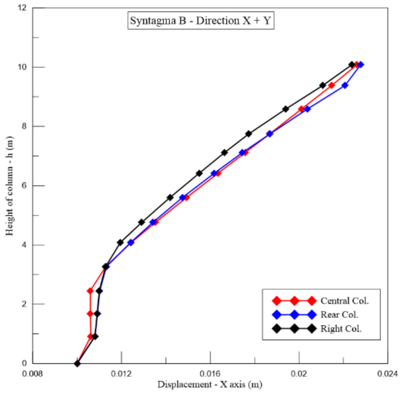



(f)

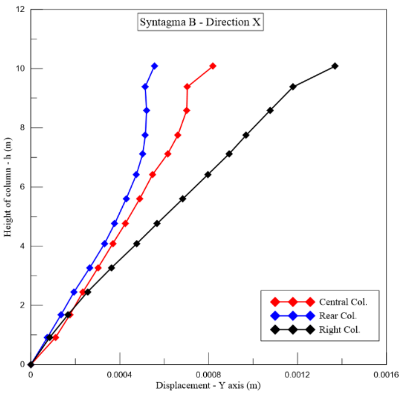
*9th record*



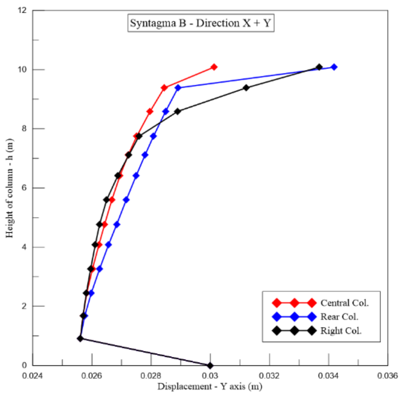

(a)



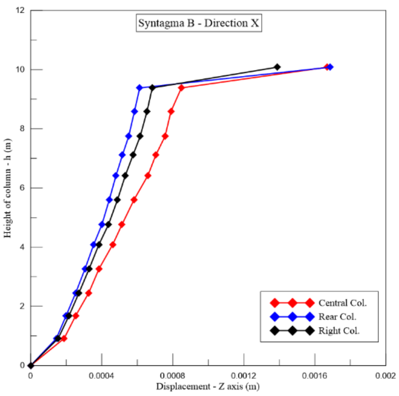

(b)



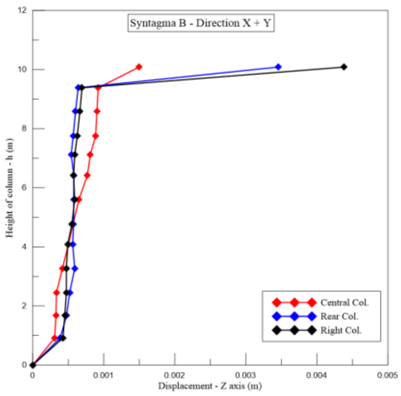

(c)




(d)




(e)




(f)