PARAMETERISED DATABASE CREATION FOR CONSTRUCTION ELEMENTS OF MONUMENTS

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Abstract: This article presents an innovative method for digital content creation and for digital restoration of destroyed ancient monuments using a database of parameterised construction elements. The case study was conducted on a Dacian watch tower, which was destroyed during the wars with the Romans. The archaeologists during the excavations found only a few rows of blocks of the foundation of the tower. Since the archaeological information available about the tower is very little, the reconstruction can be done with many different designs, and the reconstruction using the database offers a very high level of detail, which can be useful in the validation process of the virtual reconstruction.

Keywords: CAD software, virtual reconstruction, parameterised database, ancient construction elements, digital archaeology.

1. Introduction

As technology progresses, different technologies become better and cheaper to be used in different fields of science like virtual archaeology, which was invented in the 90's[1] and nowadays uses the latest technologies in data acquisition and data processing for virtual reconstructions of artefacts and monuments.

Digitization and reconstruction of monuments are strongly encouraged by the European Commission through various projects like: Europeana[2] or Carare Project[3]. *Europeana* is an internet portal that acts as an interface to millions of digitized items from all around Europe. The *Digital Libraries Initiative* has the goal to make all Europe's cultural resources and scientific records accessible to all, and preserve them for future generations. The initiative focuses on two areas: cultural heritage and scientific information.

The *Carare Project* aimed to make over two million items for Europe's unique archaeological monuments, historic buildings and heritage places to Europeana including three-dimensional models, text and images.

In the 2011 report "Comité des Sages" – "The New Renaissance" specifies that "the public sector has the primary responsibility for making our cultural heritage accessible online and to preserve it for future generations". One of the studies cited in the report mentioned above states that it will take about 100 billion to digitize Europe's cultural heritage. In Table 1 are shown some

[1] REILLY 1990, 133–139.
[2] Accessible on www.europeana.eu.
[3] Accessible on www.carare.eu.

statistical numbers of the digitized items which can be found trough the Europeana portal. In Table 1 are shown some statistical numbers of the digitized items which can be found trough the Europeana portal. The number of such items introduced in the portal is continuously increasing.

Table 1 The number of digitized objects in Europeana on 7th May 2014.

Type	Amount	Objects
Images	20,118,640	paintings, drawings, maps, photos, pictures
Texts	12,217,485	books, newspapers, letters, diaries, archival papers
Sounds	497,302	music and spoken word from cylinders, tapes, discs, radio
Videos	230,802	films, newsreels, TV broadcasts
3D objects	**15,013**	three-dimensional digital models
Total	33,079,242	

As can be seen in the table above the number of three-dimensional objects is lower compared to the rest of the objects included in the database. Apart from being easier to interpret than two-dimensional drawings, these models facilitate data necessary for reconstruction projects, preservation or rehabilitation of the architectural or archaeological heritage[4].

Within this context, any action of digitization and virtual reconstruction of monuments to enrich the database with three-dimensional models and the cultural heritage is welcome.

Since the monuments are preserved in different conditions a), the monument is still present or parts of the monument are still present and historical information is available b) only small parts of the monument are present and historical information is poor[5]. The authors propose a CAD and 3D software suit for the second case. Taylor used SolidWorks for the virtual reconstruction of the Baths of Caracalla[6], others used CATIA V5 for the virtual reconstruction of Dacian fortifications and artefacts[7].

This paper also presents a virtual reconstruction of a destroyed ancient watch tower with user-based CAD software, CATIA V5[8], but with the help of a database which contains parameterised construction elements.

2. Historical Background

Blidaru Fortress (near Orăştioara de Sus village, Hunedoara County, Romania) is part of the Dacian fortification system from Orăştie Mountains included on the UNESCO heritage list.

From archaeological sources it appears that, in the mid first century BC, the Dacian people built the first fortification walls of limestone blocks, according to Hellenistic influence techniques.

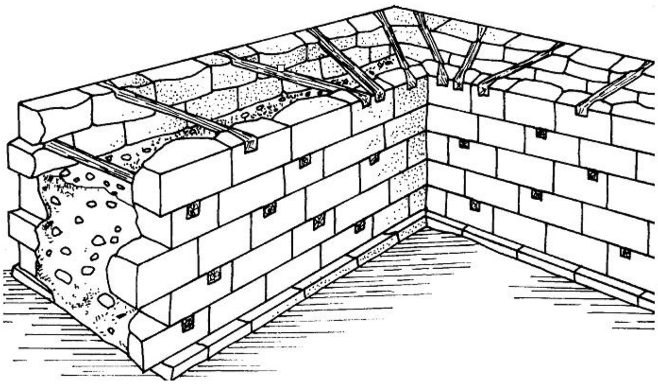

Figure 1. Illustration of a Hellenistic type of wall.

In the second part of the first century AD, probably shortly before the war with the Romans, the fortress was expanded to the shape and size that can be seen on the field today[9].

One of the characteristics of the Blidaru fortress is the network of towers built around it. Archaeologists have identified not less than 18 such towers, placed at various distances from the main fortification[10]. Their role was varied: some were meant to oversee the main access routes to the fortress, other protected the water sources and others, located on dominant positions, acted as excellent lookouts of the area up to a distance of 10–15 kilometres.

One example is the *Poiana lui Mihu* watch tower, located on a higher area with the altitude of 712 meters, which gave a very good visibility to the Mureş Valley, one of the main ways of communication in the ancient Dacia.

Figure 2. Position of the watch tower seen from inside of Blidaru Fortress.

Archaeological research has shown that this is a quadrilateral tower, which has medium dimensions compared to the other towers within Orăştie Mountains. Its outer side measures 11.75 meters, its inner side 6.15 meters and its wall thickness it's about 2.8 meters.

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[4] ANDRÉS/POZUELO/MARIMÓN/GISBERT 2012, 103–106.
[5] THEODOROPOULOS/MOULLOU/MAVROMATI/LIAPAKIS/BALIS 2009, 473–480.
[6] TAYLOR, 2014.
[7] NEAMŢU/POPESCU/MATEESCU 2011, 79–88; NEAMŢU/BADIU/PUPEZĂ/GHINEA 2012, 509–512; NEAMŢU/BUNA/MATEESCU/POPIŞTER/MORAR 2012, 513–524.
[8] More information available on http://www.3ds.com/products-services/catia/welcome/.

[9] GLODARIU 1983; DAICOVICIU/FERENCZI/GLODARIU 1989.
[10] DAICOVICIU/FERENCZI 1951; PESCARU 2004.

Figure 3. Ruins of the Dacian watch tower.

The lower part of the tower consists of strings of limestone blocks (four rows in most of the segments, three rows of blocks on some portions of the wall), but the upper part, which consists of a structure made of wood and very compacted clay, was affected by the passing of time. During the archaeological excavations were found several fragments of tiles, fallen especially outside of the tower's walls[11].

Figure 4. Excavation of the exterior wall of the Dacian watch tower (2011 campaign).

In the campaigns between 2007 and 2011, the investigations of this tower provided a new set of data, related to the wall building techniques or to the very well preserved *emplecton* (the mentioned tower is among very few cases of Dacia, where has been certified the archaeological presence of longitudinal beams, along with the cross ones).

A more comprehensive documentation regarding the above mentioned watch tower has been presented by other researchers in[12]

3. **The creation of the database**

In this section will be discussed the creation of a parameterised limestone block for the database. The first step is the creation of a base model, which contains all the possible features that can have a construction element. These features can be: gutters, cut-outs, holes and rounding. In this case a basic cuboid with the average dimensions of a limestone block (Figure 5a) is created, then the horizontal cut-out (Figure 5b) is created, in which the connection beams are inserted for consolidation of the wall. The corners of the model are rounded (Figure 5c), then the vertical cut-outs (Figure 5d) and rounding (Figure 5e) are created on one side, and after on the other side (Figure 5f). It's important to keep the operations in this order, because otherwise errors can occur during the model generation process, especially if there are missing edges for rounding operations.

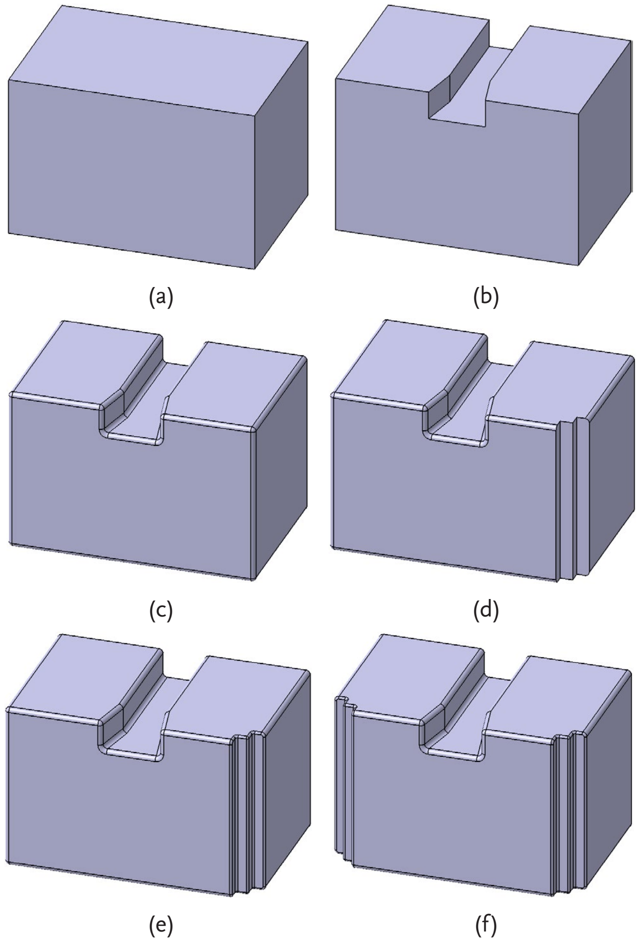

Figure 5. Creation of the geometry of the 3D model**.**

The next step is the preparation of important items for parameterisation. In this step all the important dimensions, angles and features will get a name (e.g. Height, Width, etc.) and an implicitly given standard value from their creation, which can be modified later when the construction element is generated from the database. In Figure 6 can be seen two elements parameterised, the distance from the centre of the gutter from one of the sides and the angle between the gutter and the side. Naming dimensions and features makes them easier to find later in the parameterisation process.

Before parameterisation the 3D model can be textured, to have o more realistic representation of the components.

The parameterisation of features is done when they are introduced in the database using a *PowerCopy*, which is a special feature available in CATIA V5 used for database creation. In Figure 7 can be seen the parameterisation of the gutter of

[11] FLOREA 2012.
[12] PESCARU/FLOREA/MATEESCU/PUPEZĂ/CRISTESCU/BODÓ/PESCARU 2014, 3–28.

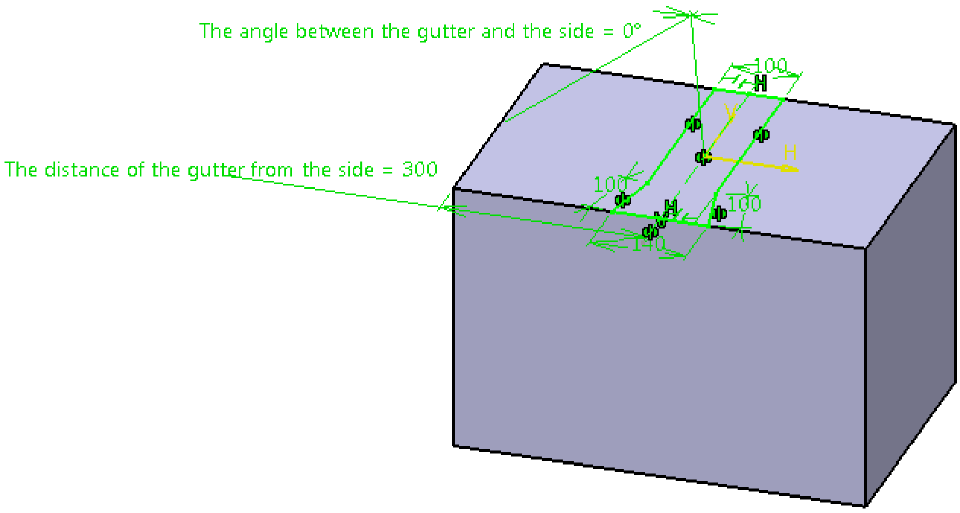

Figure 6. Naming the important dimensions and angles of the gutter.

the limestone block, where can be observed that initially the gutter will appear in the generated model (due to the "true" value of the Boolean operator from the *Activity* parameter), with 0 degrees angle between the gutter and the side and 300 mm distance from the side of the block. These initial values can be changed in this step. Also these values will be changed by the end-users of the database, but using a more user-friendly graphic user interface.

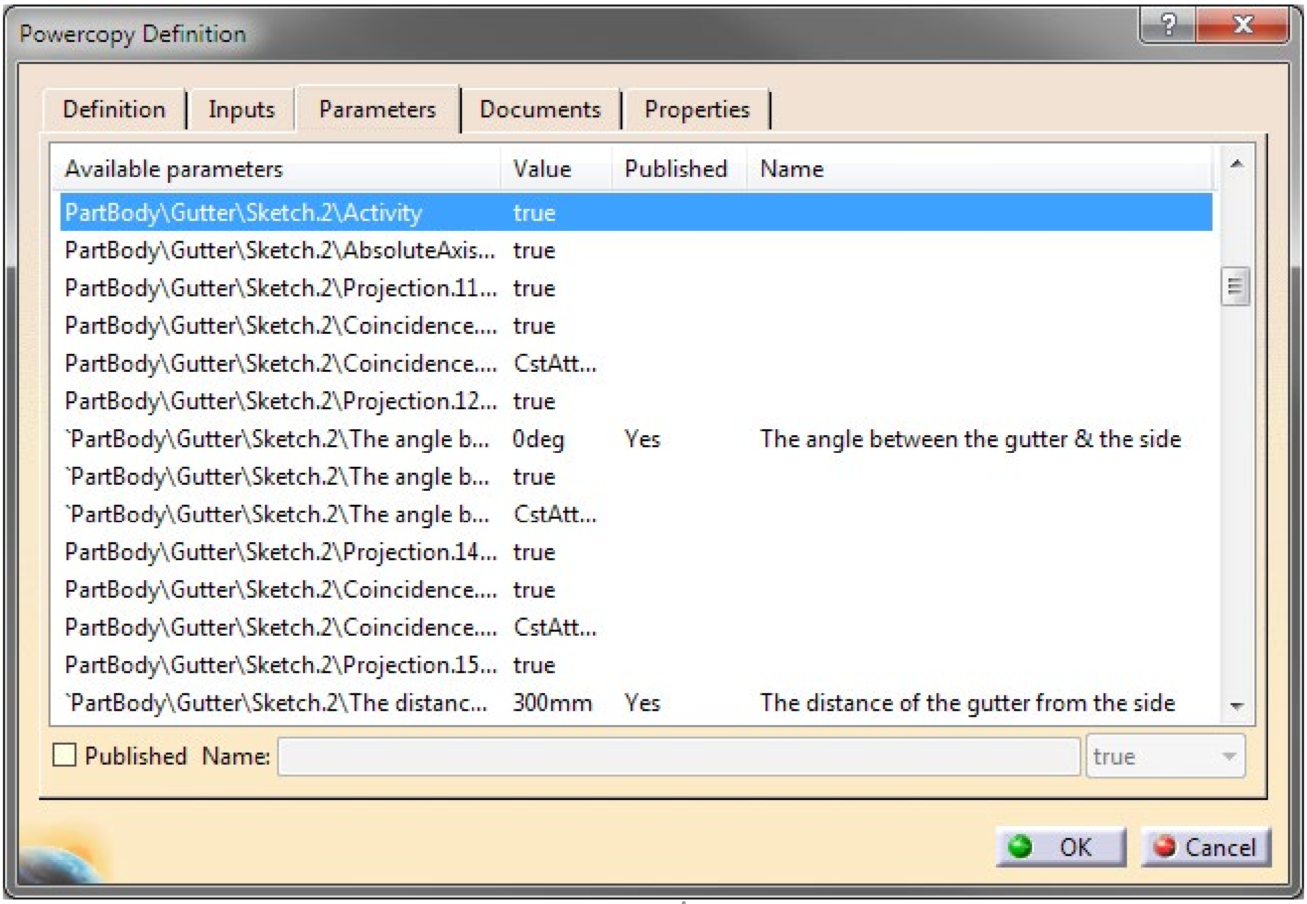

Figure 7. The PowerCopy and the parameterisation.

After all the dimensions, angles and features are parameterised the PowerCopy is saved in a Catalogue, which is opened for future use of the database by the end-user. In the same Catalogue can be inserted other similar parameterised elements such as different types of beams, tiles and other construction elements.

4. Using the database

This database works the same way as the integrated databases of standardised elements (screws, nuts, etc.) in the CAD software. The interface of the Catalogue Browser can be seen in Figure 8, where different types of construction elements can be selected for 3D model generation.

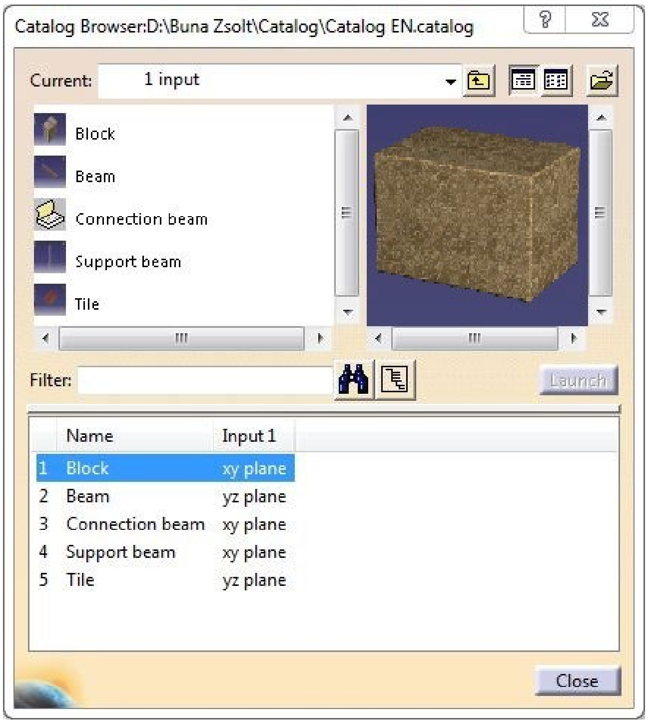

Figure 8. The Catalogue.

In Figure 9 can be seen the *Parameters* window for the limestone blocks generation.

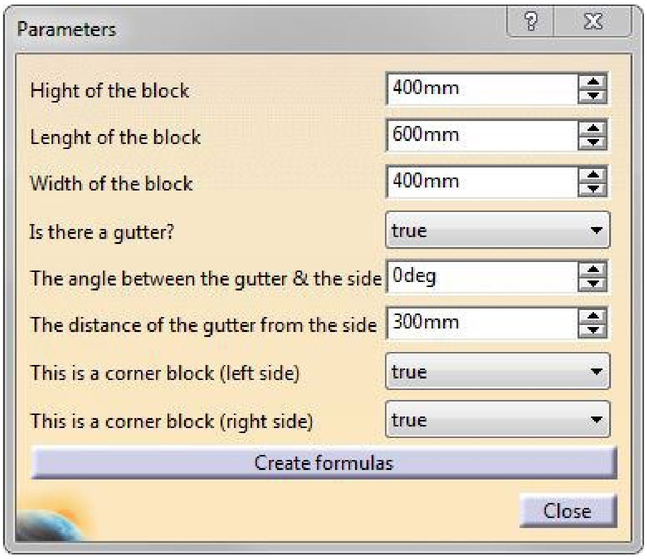

Figure 9. Parameters for limestone blocks.

Using the *Parameters* window can be created a high variety of 3D models of limestone blocks, which differ not only from the dimensions point of view, but differ in shape and features that they contain.

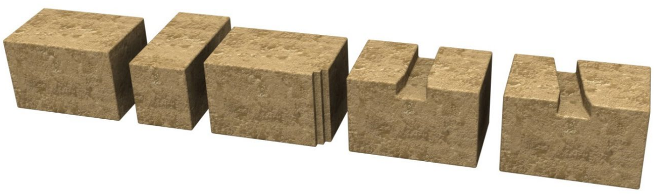

Figure 10. Generated limestone blocks from the database.

Once a 3D model is generated it can be saved as a standalone part, which can be inserted in as many assemblies as the user wants. The generated 3D models can be separately edited if the user wants to make some changes – without generating new 3D models since there is no link between the generated 3D models.

Using the database, portions of the tower can be recreated, from the Hellenistic type of wall (see Figure 11) to the roof structure (see Figure 12) where higher level of detail is intended to be achieved. These database-generated models can be combined with other 3D models (created with the use of the database or by 3D modelling) in an assembly to create the whole reconstruction.

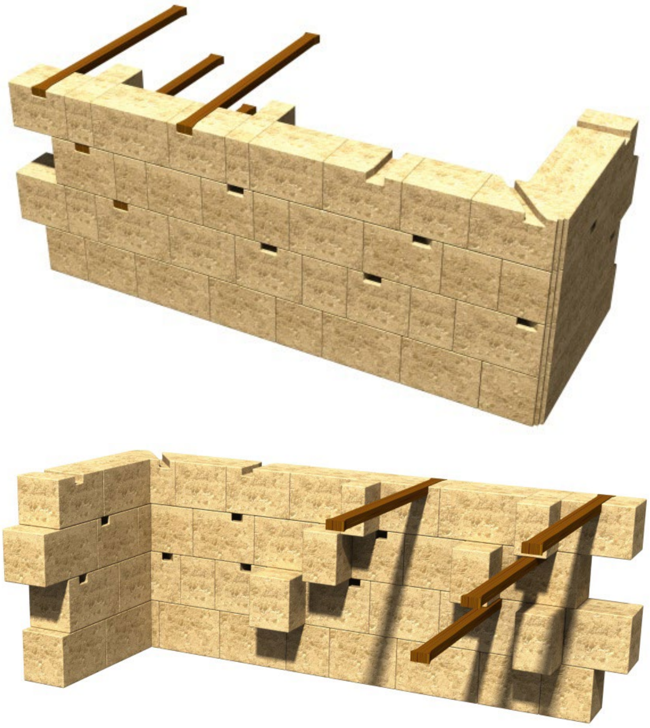

Figure 11. Virtual reconstruction of a portion of the tower's wall, using the database

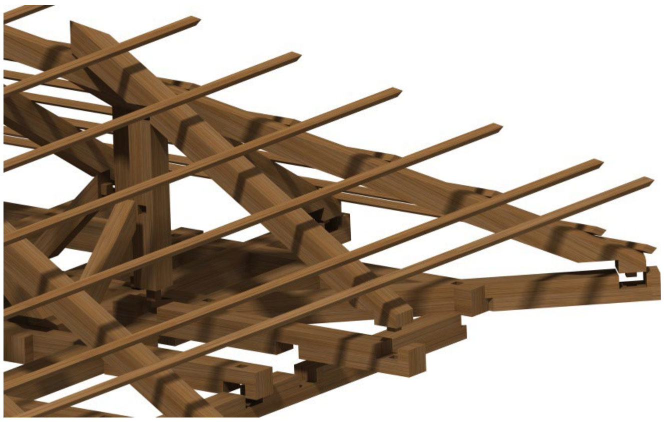

Figure 12 Virtual reconstruction of the towers roof, using the database (exploded view).

The virtual reconstruction of the *Poiana lui Mihu* watch tower can be seen in Figure 13.

Figure 13. The virtual reconstruction of *Poiana lui Mihu* tower.

5. Conclusions

The creation of a database of parameterised construction elements to create digital content and to create virtual reconstructions of destroyed monuments which have very little archaeological information available is a viable solution that can be successfully used. The database facilitates the generation of such 3D models that are similar to each other, differing in dimensions or special features, and which must be created in a large number, making the individual modelling of these items very time consuming. The database also helps to achieve a very high level of detail of the virtually reconstructed monument. Items generated through the database are saved separately, and can be used in the same assembly several times if needed, and can be used together with other 3D modelled items. Unfortunately this database is usable only in CATIA V5, which is a very expensive CAD software.

6. Acknowledgement

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