Monumentality by numbers

Sebastian Hageneuer & Sophie C. Schmidt

Introduction

Monumentality can be defined in different ways: it involves a combination of great technical ingenuity, high levels of skill, the devotion of vast amounts of time to building, the type and range of the resources, and the sheer size of the task (Brunke et al. 2016: 250). As one can see in this volume, the range of objects and tasks associated with monumental endeavors is broad and manifold (Cousin or Pacheco in this volume). In this article, we do not want to (re)start a discussion about what monumentality is or is not (see Introduction to this volume), but to put forward a method of quantification. Our thesis is that if monumental buildings were common at some point in time, not all of them were truly special; or in other words, some buildings seem to be more monumental than others. It also seems that by way of calculation and statistics, we can put forward our own opinion on the title of this volume, as it appears that at least in our case, size did not matter.

If one traveled through ancient Mesopotamia in the 21st century BCE, one would feel immediately at home in all major cities, because all of them had a standardized ziggurat as their central element.[1] A recent article by Hagen Brunke has shown that building a ziggurat in the 21st century BCE, an endeavor that was executed by the king, probably did not even really impact on the economy of the state (Brunke et al. 2016: 284; Brunke 2018). The real purpose of these monumental programs could have been to keep the people – who were workers and farmers – occupied during non-harvest times, as an ancient form of a job creation scheme. The question is, if it was not a problem to create these monuments, why do we think of them as special? If we could find a way to quantify monumentality, maybe we would be able to differentiate between various kinds of monuments, and see which of them stand out and why.

1 Personal comment of Ricardo Eichmann during the workshop 'Size matters' (9–11 October 2017, Berlin).

In this article we use the virtual reconstructions[2] of nine tripartite houses and a quantification of the effort needed to create these buildings to find a 'normal' baseline for the correlation of size and effort to see whether, and if so how, certain monuments deviate from this norm. We intentionally include one outlier from the beginning, the so-called Stone-Cone Building. As is explained below, the structure is built with special and expensive materials and therefore deviates from the set norm. Our aim here is not to point to the obvious (expensive buildings are out of the norm), but rather to show the extent to which the deviation occurs and, as a result, argue about the meaning of the terms 'monument' and 'monumentality'.

Architectural Energetics of Uruk

The basis of this research is provided by the results of the reconstructions of monumental architecture of Uruk (modern Warka in Iraq), which were undertaken partly through the 'Uruk Visualization Project' of the German Archaeological Institute and partly through work in the research group B-2-3 'Big Buildings – Big Architecture?'[3] of the Excellence Cluster TOPOI.[4] This work took place in 2008–2013 (Uruk Visualization Project) and 2013–2017 (TOPOI) and comprised 15 different buildings from the Late Uruk Period (4th millennium BCE). All these buildings – except one from Habuba Kabira in Syria, which we included for comparison – are considered out-of-the-norm compared to others and therefore labeled as monumental or special. The aim of the TOPOI research group was not the simple reconstruction of monumental architecture, but to research the cultural significance of so-called monumental buildings (Brunke et al. 2016).

One part of the project was to reconstruct these buildings scientifically (Bator et al. 2013; Hageneuer 2014; 2016), but also to quantify the necessary building materials in order to establish the basis for a *chaîne opératoire*.[5] The results of this work were tables full of values of the materials for each building reconstructed, based on the proposed version of reconstruction (for a simplified version, cf. Table 1). As

2 The terms *(Virtual) Reconstruction* or *(Digital) Visualization* are used throughout this article. We define these terms for the purpose of this article as the digital recreation of an ancient building based on its primary and secondary sources to the best of our knowledge. For further information about the method used, please refer to Bator et al. 2013; Hageneuer 2014; 2016; Hageneuer/Levenson 2018.

3 Topoi.org. (2019). [online] Available at: https://www.topoi.org/project/b-2-3/ Last accessed 8 January 2019.

4 We are very thankful for the support and collaboration through the Excellence Cluster and with the research group B-2-3 of TOPOI itself, which was always open to new ideas and helpful in countless meetings and discussions.

5 Publication with all the calculated results is in preparation.

these values are based upon virtual reconstructions and are therefore themselves virtual numbers, the question of the usefulness of the calculations arises, especially if we consider that the period these architectures are coming from, the Late Uruk Period (4th millennium BCE), has only scarce remains, sometimes only preserved up to a couple of centimeters. We know little about these buildings and their purpose. All reconstructions, although scientifically researched as much as currently possible, are highly hypothetical.

Table 1: List of the calculated materials for each examined reconstruction in cubic meters

	Mud bricks	Clay	Tempered Clay	Cast wall	Timber	Reed	Asphalt	Clay Cones	Stone Cones	Bottle Cones	Lime-stone
Building B	751.80	205.94	0.00	0.00	25.53	14.47	0.00	0.00	0.00	0.00	0.00
Building C	4420.61	840.68	420.76	0.00	64.54	33.00	0.00	0.84	0.00	0.00	0.00
Pillared Hall	334.40	0.00	167.55	0.00	11.74	6.26	0.00	12.27	0.00	0.00	0.00
Building F	859.71	246.06	0.00	0.00	16.75	9.54	0.00	0.00	0.00	0.00	0.00
Building G	1907.05	596.37	0.00	0.00	27.00	15.03	0.00	0.00	0.00	0.00	0.00
Building H	807.74	255.50	0.00	0.00	17.00	9.14	0.00	0.00	0.00	0.00	0.00
House H (Habuba Kabira)	149.25	89.46	0.00	0.00	7.65	3.78	0.00	0.00	0.00	0.00	0.00
White Temple	1284.82	301.40	174.85	0.00	31.44	10.32	0.00	0.00	0.00	15.49	0.00
Stone-Cone Building	58.77	2550.44	0.00	1396.88	102.82	50.10	49.31	0.00	40.48	0.00	1272.46

Nevertheless, we think that the calculation of the building materials has importance. As we focused on a special building type (tripartite houses) we could apply a certain reconstruction methodology, assuring all reconstructions underwent the same reconstruction procedure. We are therefore confident in saying that even if the reconstructions are hypothetical and thus the calculated values are as virtual as the visualizations themselves, the resulting numbers are comparable to each other and can give us some insights into the relative architectural energetics of tripartite houses in the Late Uruk Period of ancient Mesopotamia.

For the purpose of this article, we first want to take a closer look at nine of the reconstructed and processed buildings: Building B, C, F, G, H, the Pillared Hall, the White Temple, and the Stone-Cone Building of Uruk, and as a comparison House H of Habuba Kabira, all of which date to the Late Uruk Period and are of the tripartite house type. This type is defined by a central middle-hall and at least one row of rooms on either of its long sides. On one short side, the head of the building, another room served as a second hall perpendicular to the main hall. Sometimes, this room was even a secondary tripartite house, with its own side rooms (for example cf. Figure 1; Heinrich 1982: 7–13). These buildings were common in Mesopotamia from the 5th millennium BCE for private as well as for official purposes. Unfortunately, we cannot provide a detailed description of each building itself or the respective reconstruction process,[6] as space here is limited. We will provide citations to the corresponding publications and offer a condensed description of the buildings with only the information we need for the purpose of this analysis.

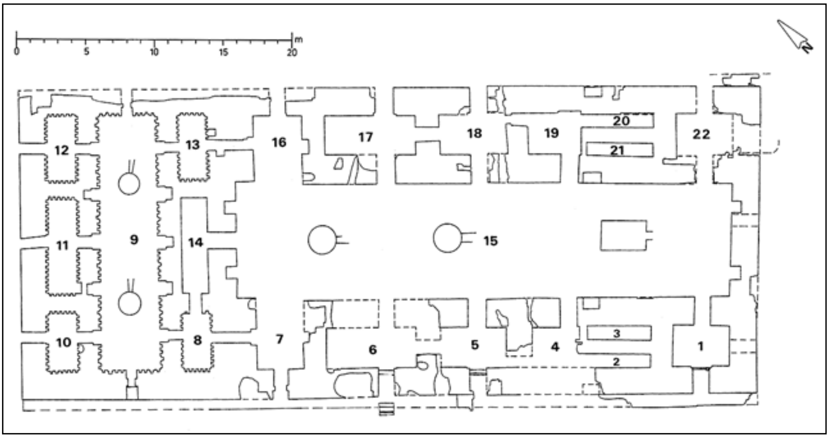
Buildings B, F, and H (Eichmann 2007: 250–254, 137–143, 152–159) are the simplest ones and very similar to one another as they consist of a central middle-hall with three adjoining rooms on each side and a perpendicular positioned room as the head of the building into which one could step directly from the middle hall or the adjoining side rooms. Their areas differ between 382.50 m² and 434.46 m². Building G (Eichmann 2007: 147–152) is a little bit more complex as it features two *alae* at the end of the central hall in connection to the head room, which enlarges the central space of this tripartite building. So, in addition to the three adjoining rooms on each side of the central hall, Building G had two open spaces from which you could step into the head room and occupied an area of 701.68 m². Building C (Eichmann 2007: 236–245) featured these *alae* too and also offered four adjoining rooms on each side (Figure 1). In addition, it had not only one perpendicular room as the head of the building, but rather a whole tripartite house itself with three adjoining rooms on each side. So, to enter the head room you had to pass through the side rooms of the head of the building first. With its size of 1222.88 m², it was one of the biggest buildings in Uruk and is the largest in this analysis.

All these monuments had a very simple building structure in common: mudbrick walls with clay plaster. Only Building C featured some minor decorations and possibly some painting. Also, the plastering of this building was executed with whitewashed clay (Eichmann 2007: 242–243) instead of naturally colored clay.

The Pillared Hall (Eichmann 2007: 159–172) is strictly speaking not a building of the tripartite type, as it consists only of a hall. Its size is also the smallest of the so-called monumental buildings with an area of only 210.34 m². It is considered some kind of gate building to a proposed secluded space in the center of Uruk, as well as a meeting space (Eichmann 2007: 168). We included this building regardless, because we can still utilize the same reconstruction techniques as we did with the tripartite houses before, as the Pillared Hall is simple in its architectural design. Interestingly, this building is heavily decorated with colored clay cones

6 Publication with the reconstruction process of the buildings described here is in preparation.

Figure 1: Plan of Building C in Uruk, 4th millennium BCE (© Deutsches Archäologisches Institut)



which offer a unique design on every panel on the pillars (Eichmann 2007: 166–167). Also, the plastering of the walls where no decoration was applied was carried out with an egg-yolk-yellow washed clay (Eichmann 2007: 167).

The White Temple (Eichmann 2007: 491–503; Hageneuer 2016) is part of a much larger complex as it is situated upon a multi-phased ziggurat. As our calculations focused on the tripartite building on top of this ziggurat, we can omit a description of the terrace itself. The White Temple is a building of the tripartite type with four adjoining rooms on each side, but without a head room. The walls were plastered with whitewashed clay and the building had some minor decorations in the form of bottle-shaped clay cones that were positioned in two bands on the upper outer part. Interestingly, the reconstruction of this building is based upon a model representation found within the foundations of the building itself. The dimensions of the White Temple were 387.63 m².

The Stone-Cone Building (Eichmann 2007: 364–378; Hageneuer/Levenson 2018) is the only building described here that was not constructed with mud bricks, but with some form of ancient concrete that was probably poured into a preconstructed boarding frame. Besides the unusual material for the walls, the building was heavily decorated with stone cones of different colors (Figure 2). In addition to these materials we can also add a massive foundation of mud bricks and limestone slabs to the equation as the weight of the building materials used here demanded a well-constructed base, something that was not necessary for the other buildings in this study. In contrast, Buildings B, C, and the White Temple had smaller mud-brick foundations above the ground that served to level the building layer. The visible part of the building covered an area of approx. 560 m². It consists of a middle-hall with three adjoining rooms at each side. At the head of the building, there is a recess in the center and a gateway room on one side entering into the head room. This room is special, as it is shaped like an 'L' and featured a waterproof basin of unknown function. The Stone-Cone Building is therefore expected to be an outlier and the quantification and statistics below prove this hypothesis. Nevertheless, our aim is to show how much of an outlier this building is and to suggest an interpretation of its importance.

Figure 2: Proposed reconstruction of the Stone-Cone Building in Uruk, 2012 (© artefacts-berlin.de; material: Deutsches Archäologisches Institut)

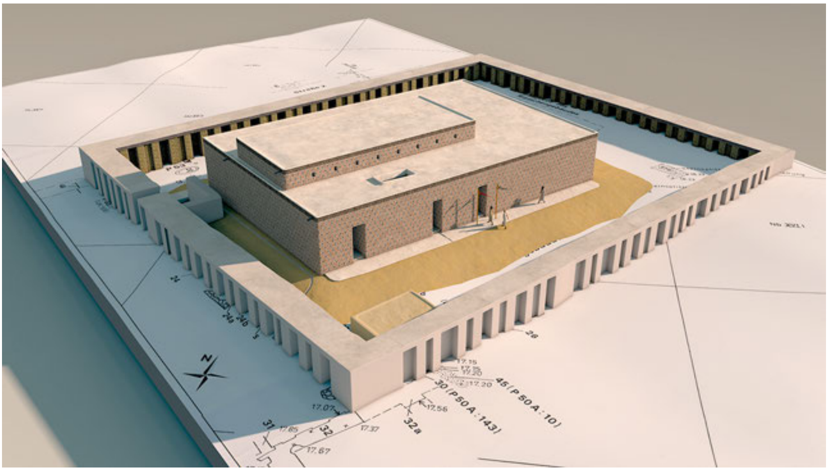
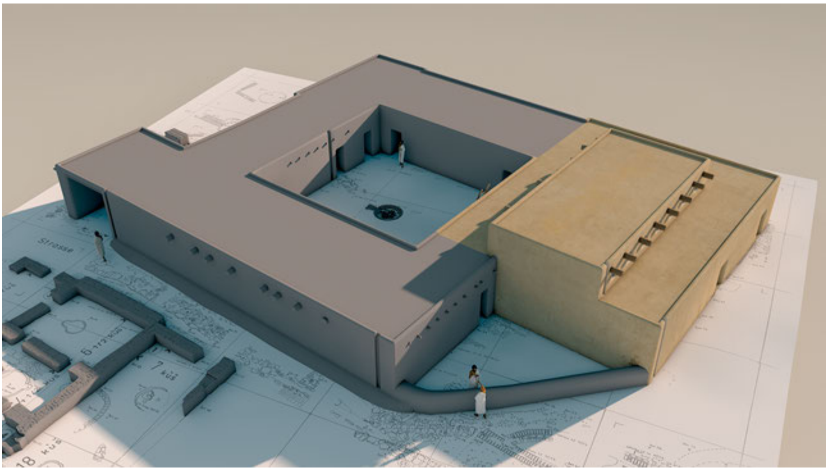


Figure 3: Proposed reconstruction of House H in Habuba Kabira, 2014 (© artefacts-berlin.de; material: Kay Kohlmeyer)



House H of Habuba Kabira (Heinrich et al. 1973; Strommenger 1980) is of interest because of the comparison of monumental architecture in Uruk with ordinary private architecture. We choose Habuba Kabira because in the Late Uruk Period no traces of urban architecture were found in Uruk itself. One example is found at a distance of 1300 km in Habuba Kabira. It was constructed with mud bricks and had no decorations. House H was a bigger complex, but its eastern part consisted of a complete tripartite building with three side rooms to the west and two to the east (Figure 3). The head of the building was divided into a smaller and a bigger room to the north. The area of that part was approx. 130 m² and therefore the smallest tripartite building in this study.

All these buildings (except House H of Habuba Kabira) are termed monumental due to their size, decoration, or proposed public function. Certainly, these buildings are bigger or more decorated than private houses and in the case of the Stone-Cone Building, the decoration was of great importance.

Effort estimation

In the previous section, we presented the reconstructions in question and the respective calculated volumes of different building materials (Table 1). In this section, we analyze the relative effort for each building in order to see in what capacity different building materials and volumes are connected to a possible effort or energy used in constructing the buildings. This involves moving beyond the volumes of building materials to find a comparable value for the effort of creating this monumental architecture. Normally, we would achieve this through a complete *chaîne opératoire*, in which we track every expenditure related to the building process – from getting the resources to finalizing the building (see Buccellati in this volume). For the purpose of this article, we decided to simplify the process of calculation as we do not seek exact figures for expenditures,[7] but rather comparable values between the buildings examined. We want to propose this simplified method in order to offer a quick and accessible way to compare expenditure calculations. As mentioned above, these calculations do not claim to be exact or even true, but to offer a method of comparison. We created a list of factors of effort for each step in the building process to multiply with the calculated volumes of different building materials. Again, this is not to be understood as an exact result for the expenditure of human labor but more as an estimate to put the different building steps in relation to each other (Table 2).

7 This work is currently part of an ongoing PhD by Felix Levenson.

Table 2: List of factors, representing the relative effort of each building step

Process	Factor
Clay for plastering and flooring	1
Reed for roofing or flooring	1
Tempered Clay for plastering (white and egg-yolk yellow)	2
Creation of sun dried mud-bricks (Riemchen, see Eichmann 2007: 16 ff.)	4
Clay & bottle cones	4
Timber for roofing and some staircases	7
Stone-cones of different colour	8
Other materials like limestone or asphalt	12
Cast walls of the Stone-Cone Building	16

Clay and reed are resources that are available in abundance in the Mesopotamian plains (Coockson 2009: 12; Levey 1959: 149). This is the reason why nearly all the architecture was built from these two materials from the 8th millennium BCE (Coockson 2009: 11). The knowledge of processing clay was common and therefore the simplest task in our list (factor 1). Clay was used for plastering the mud-brick walls and roofs in order to keep the occasional rain from damaging the building. Reeds, on the other hand, were used to cover the roofs before a thick package of clay was applied to seal the surface (van Beek 2008: 293–294). Occasionally, reed was also used as a basis for mud-brick walls, as we can see with the Stone-Cone Building (Eichmann 2007: 371).

For some buildings (Pillared Hall, Building C, and the White Temple) tempered clay was used to plaster the building in order to give it a different color. For the Pillared Hall, an egg-yolk-yellowish color was detected (Eichmann 2007: 167–168). It is not yet clear what temper caused the coloring of the clay in this manner, only that it did not preserve very well. The White Temple and Building C, however, were covered with a whitened clay plaster that was made of chalk, which turns white during the calcination of limestone. As the tempering of the clay would have taken more effort than the simple processing of natural clay, we decided to assign a factor of 2 to this step.

The creation of sun-dried mud bricks was a bit more complex, because the collected clay had to be tempered (Coockson 2009: 31), put in forms to give them the desired size, and left to dry on wide empty fields (Hageneuer/Levenson 2018: 113) that were probably not located on site. The transport of the sun-dried mud bricks is therefore also part of this factor. Hagan Brunke completed such calculations for the mud-brick construction of a ziggurat in the 21st century BCE. Not only did he include the creation of the mud bricks, but also their transportation onto the site, the payment of the workers involved, and the masonry work (2018: 30–34). Taking these numbers into consideration, we feel quite confident in assigning a factor of 4 to the production of mud bricks and the creation of the walls of our buildings.

Clay and Bottle Cones as they appear in Building C, the Pillared Hall, and on the White Temple are made from normal clay but need additional firing, for which one would have needed fuel in the form of dung and wood. The process of creating these items was not complicated, but the additional steps of firing and processing these decorations led us to assign the factor 4.

Various sources tell us that the roofing in ancient Mesopotamia was carried out as a combination of timber, reed, and clay packages (Cookson 2009: 64–68; Heinrich 1935: 21; Heinrich/Seidl 1968: 7; Miglus 1999: 237; Pfälzner 2001: 126). It is known that timber was a rare resource and would have been utilized sparingly. To construct a roof, one needs at least two kinds of timber: thick beams that span over the width of the bigger rooms to support the roof and smaller beams to lay on top or to cover smaller rooms. The relation between both types is approximately two to three times more smaller beams than bigger ones. The bigger beams could reach a length of 7 m and probably more (Eichmann 2007: 244) and are therefore costlier in terms of energy than smaller beams, which could be found and transported much more easily. The transportation costs of these bigger beams were very high, as they had to be imported from far away, probably Lebanon, Turkey, or Iran (Kuniholm 1997: 347). The smaller ones are of local origin and compensate for the high energetic value of the transportation of the bigger beams. As an estimate, we decided on an averaged factor of 7 that includes mainly the transportation of the timber from distant sources, but also the smaller beams as well as the timber-work necessary for construction.

One of the last items on the list are the stone cones, which were only used for the Stone-Cone Building. These were made from limestone of different colors. They had to be cut, processed, and transported to the site, where the cones most probably were smoothed before they were put into the still-wet cast wall of the Stone-Cone Building. The shaping of the cones was done very roughly and would not been particularly time-consuming. We do not know the exact origin of these stones, but as we do not know of any limestone sources in the vicinity of Uruk itself, we can only suggest that the transport was of long range. Therefore, we decided to apply the factor 8 to this production step. As the cones were small and easily transported, we assigned a lower value than for the limestone blocks, which essentially had the same source but were much harder to transport.

Some other materials were more difficult to process. Asphalt or bitumen was available at the surface in some areas of the Ancient Near East (Connan 1999: 34, Figure 1). For the Late Uruk period, the sole source of bitumen, based on analysis of bitumen remains in nearby Tell el-Oueili, seems to have been Hit-Abu Jir, an area located to the west of Baghdad, over 400 km away (Connan 1999: 41) but reachable via the river Euphrates. Although a trade route for the common use of bitumen was established, this resource had to be transported over a great distance. We therefore assigned a factor of 12 to the energy effort of obtaining the bitumen and processing it. We also included the limestone that was used in the foundation of the Stone-Cone Building in this 'others' category, as the source and transport would have been the same as for the cast stone material (see below) and therefore relied heavily on transportation.

The main building material of the Stone-Cone Building was made from carbonate rock which had to be transported from the closest source, which was at least 50 km away and only reachable by land (Boehmer 1984: 147). The production stages for creating the cast wall material were complex and involved a lot of different steps (Hageneuer/Levenson 2018: 113–115). As a result of studying the production process, we agree with an estimated triple to quadruple effort in creating this building material in comparison to traditional mud bricks (Hageneuer/Levenson 2018: 115). Hence, we decided to assign the highest factor of 16 to this material.

After exploring several possibilities for using the assigned factors in our calculations, we realized that the results differed very little if the individual factors were increased or decreased, but rather more if the order was changed. As we are looking at factors describing effort in creating different building materials, this makes sense, as these factors are proportionally defined by their relation to each other. It is twice as costly to create clay cones as colored clay, whether these factors are 4 and 2 or 19 and 10 does not matter in terms of our analysis, which aims to compare different buildings made from the same materials.

Therefore, we conclude that for this analysis the exact factors are not of as much importance as the assignation of a well-established rank system. For this reason, we are confident that these factors represent a good evaluation of effort in regard to the respective building steps and can serve as a tool of analysis until the complete *chaîne opératoire* is established.

Quantitative Analysis

In the following analysis,[8] we look at several points to identify out-of-the-norm monuments within a group of out-of-the-norm buildings. Two steps are necessary here:

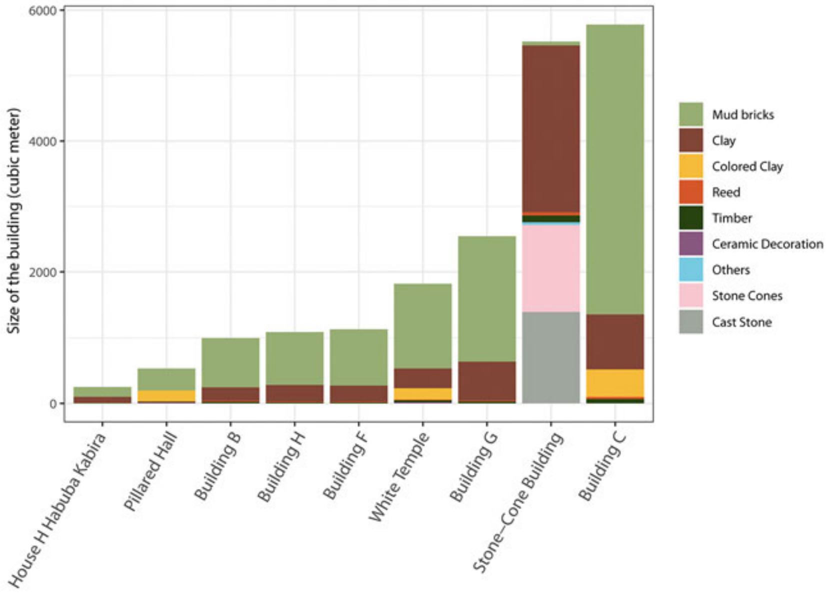
8 All calculations discussed in this chapter were realized with R 3.3.4 (R Core Team 2017). Code and data are available under the DOI 10.17605/OSF.IO/3AJ7V.

1. A quantitative analysis of the building materials in order to see which production steps demand the greatest effort;
2. A regression analysis to see if there is a relationship between volume and effort and, if so, how predictable it may be.

The first step is comparing the different amounts of materials used for the different buildings. They are listed in Table 1 and visualized in the stacked bar plot (Figure 4).

It is no surprise to see that mud bricks are the most important building material in almost all tripartite buildings. Clay used as plaster was needed just as often, but of course the volume required was smaller. Also, all buildings included reed and wood in their construction, as described above.

Figure 4: Stacked bar plot showing mass of different materials used in the building process of the different buildings



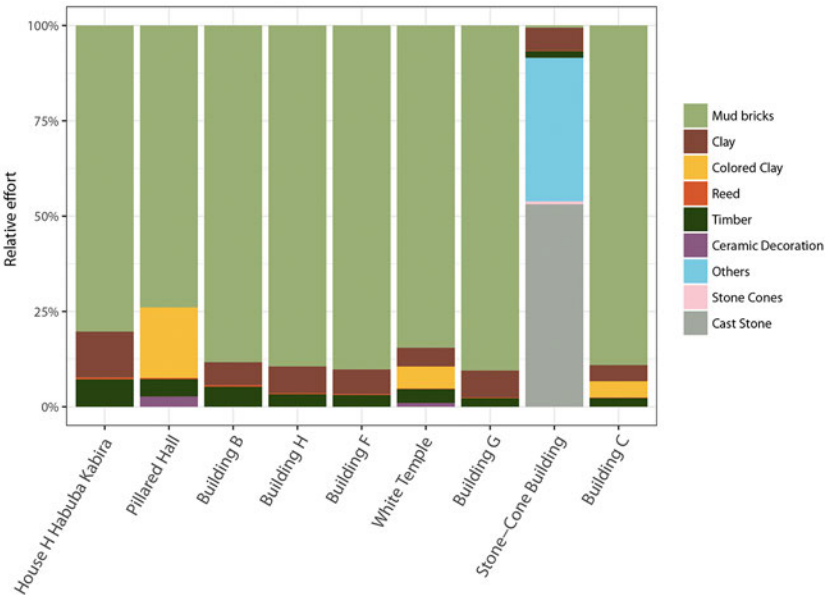
Interesting here are two monuments that do not conform to the others. When building the Pillared Hall, people did not use normal clay at all but rather a tempered clay, mud bricks, and clay cones ornamentation. This shows a creative way of aiming at singularity without changing much in the construction process in comparison to the buildings B, H, F, G, and House H of Habuba Kabira, which are very similar in their material.

The Stone-Cone Building, in contrast, shows distinct features in its material composition. Almost no mud bricks were used but much more clay and rare materials (cast stone, asphalt, and limestone), as well as the stone cones it was named for. Here we can observe a vastly different building process from that of the other monuments.

Concerning size, an impressive range can be observed. The virtual reconstructions of the two smallest tripartite buildings (Habuba Kabira House H and the Pillared Hall) are only 225 and 485 m³, whereas the reconstructions of the two largest tripartite buildings (the Stone-Cone Building and Building C) are 10–20 times as big (5521.26 m³ and 5780.43 m³ respectively).

As has been argued above, the effort involved in constructing the buildings depended on the materials used. We therefore created a graph comparing the effort involved in using the different materials scaled to 100 % for each building (Figure 5). This enables the viewer to easily compare the composition of efforts in relation to the different materials used in the building processes, independent of the absolute effort that went into erecting the monument.

Figure 5: Stacked bar plot (scaled to 100 per cent) showing effort needed for different materials by building



The largest part of constructing the tripartite buildings was always the processing of mud bricks – except for the Stone-Cone Building. We see that the large amount of bricks used insured their great impact on the effort involved in constructing the building. Clay and tempered clay also have a recognizable impact, but as they were much easier to produce it is relatively small. It is noticeable that the effort involved in building with timber was quite low, and with reed the effort was almost negligible.

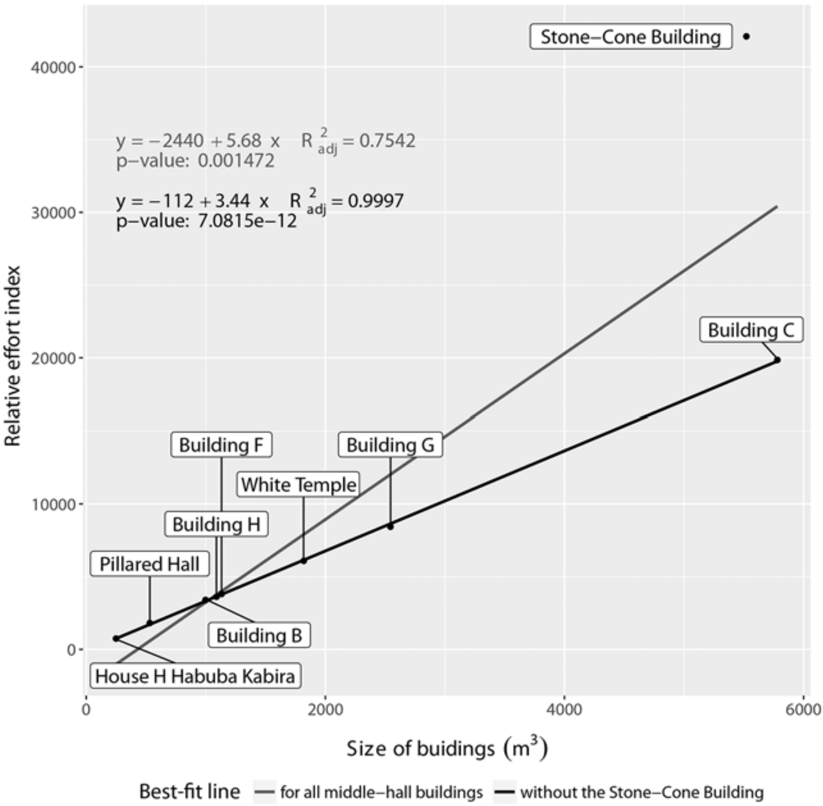
The Stone-Cone Building, the White Temple, and the Pillared Hall are buildings on which decoration was recorded. Though this ornamentation has an impact on the effort involved in construction, it is easy to see that this impact is small. This may not be surprising for the ceramic decorations because they are easy to produce (clay and bottles cones: effort factor 4), but the stone cones built into the Stone-Cone Building also show very little impact, less than might have been expected considering that the effort factor assigned to them was double that of the ceramic decoration (stone cones: effort factor 8). This shows that although decoration may be a highly visible aspect of a monumental building, due to the small amounts needed in comparison to the masonry work, decorations had no significant impact on the overall effort calculation of the building process. In light of these findings, it is interesting to note that so few buildings were decorated. It seems effort might have been more important than appearance.

As in the analysis before, the Stone-Cone Building is a special case as there are two categories of material built into it which were not recorded in the other buildings. The categories 'other materials' (consisting of asphalt and limestone) and 'cast stone' have a huge impact on the effort of the construction. As there were also large amounts of material used in the building (see Figure 6 and Table 1) this is not surprising *per se*, but the high amount – 38 per cent for 'other materials' and 53 per cent for cast stone – (together more than 90 per cent of all the effort in building this monument) is quite impressive. It raises the question as to why these materials were chosen and why this amount of effort was put into the construction of the Stone-Cone Building (Hageneuer/Levenson 2018). This building also exemplifies how low the effort for clay production was, which was the largest class of material used in the building process for the Stone-Cone Building (46 per cent) but nonetheless has so little impact on the effort (only 6 per cent).

We may conclude that the effort involved in constructing a monument lies in erecting the walls and less in roofing, plaster, decoration, or similar constructions.

Lastly, the relation between effort and the size of the tripartite buildings is investigated. First, we plotted the relative effort index against the size of the buildings in cubic meters (cf. Figure 6). There is a correlation between the size of a building and the effort involved in its creation, except for the Stone-Cone building, which is the second largest (after Building C) but has by far the highest cost in effort. To analyze this further, a linear regression was calculated between the two variables. The linear regression creates a "best-fit straight line" (Drennan 2009: 205), which describes the general trend between these two variables. The R^2-value then evaluates how good this fit is. R^2 describes the proportion of the variance in the dependent variable that is predictable from the independent variable. It is calculated using the residuals, which are the difference between a value that is predicted by the regression line and the actual measured value. R^2 is the sum of the squares of the residuals divided by the variance of the predicted values. It can take values between 0 and 1, where 1 is the best fit possible and the trend has little or no variance (Drennan 2009: 209–210; Baxter 2015: 63–79). Next to this evaluation of the strength of the correlation between the two variables, a p-value was calculated to describe the statistical significance of the findings. We chose a linear regression as a starting point, because it fits to the hypothesis that the effort involved in creating a monument should directly and linearly correlate to its size.

Figure 6: Comparison of two linear regression models fitted to the variables effort and size



The results of our analysis are visualized in Figure 6. There are two main observations we want to point out in this figure. Firstly, if all tripartite buildings are evaluated together and a linear regression is calculated, only buildings B, F, and H are near the best-fit line and the Stone-Cone Building is an obvious outlier in effort. An R^2-value of 0.75 might be considered a fair fit of the trend line to the data, but just by looking at the plot it becomes obvious that a better fit might be found, either with a non-linear regression or if the Stone-Cone Building is removed from the calculation. To try a non-linear regression, we used the 'loess' (Local Polynomial Regression Fitting) method, which is a smoothing algorithm that downweighs outliers (Baxter 2015: 80–82) and a generalized additive model (GAM). Using these non-parametric regression methods did not improve the R^2-value (R^2 of 0.72) and the resulting best-fit line could not be reasonably explained. Therefore, we returned to the linear regression and removed the Stone-Cone Building. As explained above, the structure had been built with special building materials and therefore was an expected outlier. We had included it in our earlier analysis to test this expectation. To take it out of the calculation proved to be the best way to achieve a near perfect best-fit line: the second linear regression that was calculated without the Stone-Cone Building created an extraordinarily good fit ($R^2 = 0.9997$).

Residual analysis of the first linear regression confirmed that the Stone-Cone Building is responsible for almost all the variance if included in the regression. P-values for both linear regression lines are highly significant. Therefore, we conclude that the Stone-Cone Building is a special case, where the effort required to build it does not correspond linearly to its size.

On the other hand, we can see that the building costs of all the other tripartite buildings do correspond almost perfectly with their size (see the linear model without the Stone-Cone Building in Figure 6). Costs increase with size by a factor of 3.44. This is, of course, dependent on the way effort is calculated.[9]

Not perfectly aligned are the Pillared Hall, Building B, and Building C, which are slightly costlier than the linear model suggests, and the Building G, which is slightly cheaper in effort. Looking back at the materials used for building, it is easy to see that the slight increase in effort for the Pillared Hall is a result of the decoration and colored clay used on the building. In Building B a little bit more timber was utilized even though it is small in size, and in Building C colored clay replaced the natural clay. Building G is the third largest building but composed of mud bricks and a relatively large amount of clay, which is very cheap, therefore the effort in construction was a little less than might have been expected.

To conclude this analysis, we state the following: a linear relationship between size and effort of construction can be found for most tripartite buildings except for the Stone-Cone Building. The effort, the material type, and the amount of building materials used for this construction are unusual, which we could illustrate using a quantitative approach and linear regression modeling.

9 If one takes a closer look at the formula which describes the linear relationship for the buildings without the Stone-Cone Building one notices the Y intercept (value of Y where the regression line crosses the X-axis) of -112, meaning that to 'build a building of size 0 cubic meters' a value of -112 is estimated on the effort-scale. Considering we are dealing with values for effort of more than 40,000 this is quite near the realistic value of 0.

Monumentality vs. Monuments

Our analysis shows that in a comparison of size versus effort, most of the buildings seem to follow an estimated line. It seems only natural to assume that similar buildings show a linear relationship if their sizes are compared to their building efforts, as the more these buildings grow, the more resources, transportation, and workers are needed. However, the interesting cases of this statistical analysis are not the items that comply with this estimation, but the ones that do not, like the case of the Pillared Hall, which is of very small size but is extensively decorated.

In this concluding section, we want to draw attention to two buildings. The first one is the private house H in Habuba Kabira, which we find in the lowest section of our graph (Figure 6). Although the tripartite house of this building is only part of a bigger structure, the relationship between size and effort holds true. We can see here that a normal private house does not differ much from a monumental tripartite building like Building C of Uruk regarding material used and effort compared to size. Of course, the resources and human labor needed for Building C were much higher and therefore we speak of a monument, but we can also assume that the authority responsible for Building C had greater resources available than the private person in Habuba Kabira. Interpreting the regression model of our graph as normal or expected, we can therefore suggest that bigger buildings do not necessarily mean greater noteworthiness in relation to the respective owner. It can be expected that a king would construct a bigger building than a private person. Now, if we define monumentality not by size or cost, but by singularity and exceptionality, 'something that stood out' to people, we must look at buildings that do not follow the estimated line. This brings us to the Stone-Cone Building.

As we have already seen, the Stone-Cone Building is special in many respects, but our quantitative analysis confirms that it stands out from the other examples of our study due to the special building materials used instead of mud bricks. We may define monumental architecture by certain categories or factors (see the Introduction to this volume), but they might not have been of importance in antiquity. In this analysis we propose that the factor of size might not have played a role. In our opinion, we clearly need to distinguish between usual monuments and out-of-the-norm monuments and therefore true monumentality as we term it today with all its connotations.

The Stone-Cone Building's construction effort deviates from the best-fit line of the other monuments by a factor of more than two. It was therefore more than twice as expensive as expected regarding its size. This shows clearly that the construction of the Stone-Cone Building was an act of exceptional effort and importance, which is a sign of true monumentality.

To summarize we want to recall that we are still talking about monuments with an extraordinary function and symbolic value. Nonetheless, we believe that there is a difference in monuments and monumentality such that within the realm of extraordinary buildings, we still find monuments of exceptional value. These could represent a form of monumentality that might be of higher importance than others, though perhaps not as visible on first sight. To use George Orwell's well-known adage: all monuments are monumental, but some are more monumental than others.[10]

Bibliography

Bator, S./van Ess, M./Hageneuer, S. (2013): "Visualisierung der Architektur von Uruk." In: N. Crüsemann/M. van Ess/M. Hilgert/B. Salje (eds.), Uruk. 5000 Jahre Megacity, Petersberg: Michael Imhof, pp. 365–371.

Baxter, M. (2015): "Notes on Quantitative Archaeology and R." https://www.academia.edu/12545743/Notes_on_Quantitative_Archaeology_and_R (last accessed March 31, 2018).

van Beek, G. W. (2008): Glorious mud! Ancient and Contemporary Earthen Design and Construction in North Africa, Western Europe, the Near East, and Southwest Asia, Washington D. C.: Smithsonian Institution Scholarly Press.

Boehmer, R. M. (1984): "Kalkstein für das urukzeitliche Uruk." In: Baghdader Mitteilungen 15, pp. 141–147.

Brunke, H./Bukowiecki, E./Cancik-Kirschbaum, E./Eichmann, R./van Ess, M./Gass, A./Gussone, M./Hageneuer, S./Hansen, S./Kogge, W./May, J./Parzinger, H./Pedersén, O./Sack, D./Schopper, F./Wulf-Rheidt, U./Ziemssen, H. (2016): "Thinking Big. Research in Monumental Constructions in Antiquity." In: G. Graßhoff/M. Meyer (eds.), Space and Knowledge. Topoi Research Group Articles, eTopoi. Journal for Ancient Studies, Special Volume 6, Berlin: Edition Topoi, pp. 250–305.

Brunke, H. (2018): "Großbaustellen in Sumer – Aufwand und Kosten." In: K. Rheidt/W. Lorenz (eds.), Groß Bauen – Großbaustellen als kulturgeschichtliches Phänomen, Kulturelle und technische Werte historischer Bauten, Basel: Birkhäuser, pp. 27–36.

Connan, J. (1999): "Use and trade of bitumen in antiquity and prehistory: molecular archaeology reveals secrets of past civilizations." In: Philosophical Transactions of the Royal Society of London B: Biological Sciences 354, 1379, pp. 33–50.

Coockson, B. C. (2009): Living in Mud, Istanbul: Ege Yayinlari.

Drennan, R. D. (2009): Statistics for Archaeologists. A Common Sense Approach. Second edition, Heidelberg et al.: Springer. DOI 10.1007/978-1-4419-0413-3

Eichmann, R. (2007): Uruk – Architektur I. Von den Anfängen bis zur frühdynastischen Zeit, AUWE 14, Rahden/Westf.: Marie Leidorf.

10 Orwell 1945: "All animals are equal, but some are more equal than others."

Hageneuer, S. (2014): "The visualisation of Uruk – First impressions of the first metropolis in the world." In: W. Börner/S. Uhlirz (eds.), Proceedings of the 18th International Conference on Cultural Heritage and New Technologies 2013, CHNT 18, 2013, Wien: Museen der Stadt Wien – Stadtarchäologie, pp. 1–12.

Hageneuer, S. (2016): "Le Temple blanc d'Uruk sur sa haute terrasse." In: P. Quenet (ed.), Ana ziqquratim. Sur la piste de Babel, Strasbourg: Presses Universitaires de Strasbourg, pp. 112–113.

Hageneuer, S./Levenson, F. (2018): "Das Steinstiftgebäude in Uruk – ein gescheitertes Experiment?" In: K. Rheidt/W. Lorenz (eds.), Groß Bauen – Großbaustellen als kulturgeschichtliches Phänomen, Kulturelle und technische Werte historischer Bauten, Basel: Birkhäuser, pp. 109–21.

Heinrich, E. (1935): Sechster vorläufiger Bericht über die von der Deutschen Forschungsgemeinschaft in Uruk-Warka unternommenen Ausgrabungen (= UVB VI), Berlin.

Heinrich, E. (1982): Die Tempel und Heiligtümer im alten Mesopotamien, Textteil, Berlin: de Gruyter.

Heinrich, E./Seidl, U. (1968): "Maß und Übermaß in der Dimensionierung von Bauwerken im alten Zweistromland." In: Mitteilungen der Deutschen Orient-Gesellschaft 99, pp. 5–54.

Heinrich, E. et al. (1973): Vierter vorläufiger Bericht über die von der Deutschen Orient-Gesellschaft mit Mitteln der Stiftung Volkswagenwerk in Ḥabuba Kabira (Ḥububa Kabira, Herbstkampagnen 1971 und 1972 sowie Testgrabung Frühjahr 1973) und in Mumbaqat (Tall Munbaqa, Herbstkampagne 1971) unternommenen archäologischen Untersuchungen, erstattet von Mitgliedern der Mission, Mitteilungen der Deutschen Orient-Gesellschaft 105, pp. 5–68.

Kuniholm, P. I. (1997): "Wood." In: E. M. Meyers (ed.), The Oxford Encyclopedia of Archaeology in the Near East, Volume 5, Oxford: Oxford University Press, pp. 347–349.

Levey, M. (1959): "Clay and its technology in Ancient Mesopotamia." In: Centaurus 6/2, pp. 149–156.

Miglus, P. A. (1999): "Städtische Wohnarchitektur in Babylonien und Assyrien." In: Baghdader Forschungen 22, Mainz.

Orwell, G. (1945): Animal Farm, http://www.gutenberg.net.au/ebooks01/0100011h.html (last accessed June 6, 2018).

Pfälzner, P. (2001): Haus und Haushalt. Wohnformen des dritten Jahrtausends vor Christus in Nordmesopotamien, Damaszener Forschungen 9, Mainz.

R Core Team (2017): "R: A language and environment for statistical computing. R Foundation for Statistical Computing." https://www.R-project.org/ (last accessed June 11, 2018).

Strommenger, E. (1980): Habuba Kabira. Eine Stadt vor 5000 Jahren, Mainz: Philipp von Zabern.