Conception of a Tool for the Restoration of the Roman Imperial Baths

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Abstract: ***This paper presents an approach to the development of a tool for the restoration of the Roman imperial baths. This tool is obtained from an architecturological analysis of the Roman imperial baths of North Africa. We propose that it allows generating analog models considered as hypothesis for the restoration of Roman imperial baths from their remains. These can be refined and supplemented by specialists in the field of archeology.***

Keyword: Tool for restitution, Roman Imperial Baths, Architectural analysis, Analog model.

1. Introduction

The purpose of this paper is to present an approach to the development of a tool for the restoration of the Roman imperial baths. It is developing a digital platform (an expert system) to generate one or more restoration hypotheses of Roman imperial baths from their remains. These assumptions can be refined and supplemented by specialists in the field of archeology. This paper proposes a multidisciplinary and cognitive method which will be translated into a virtual and interactive digital platform that we call "Thermae"1. To do this, we proceed by architectural analyzing of imperial Roman baths to extract the genetic model of this type of buildings.

2. Imperial Roman Baths in North Africa

Roman imperial baths are monumental buildings that differ in their architecture and their symmetrical circuitry of other baths. They are intended not only to host all kinds of baths, but also to cultivate the mind and body. These monuments Obey in their conformation to a rational composition and universal thermal model distributed and reproduced throughout the Empire. We choose to study the Roman imperial baths of North Africa.They are twenty-three baths.

Table 1: Romans imperial baths of Noth Africa[13]

Roman Baths		*Datingfrom*	*Area m²*
Tunisia			
T 1	Al Khnissia	Unknown	1600
T 2	Great Baths of Antoninus	145 (or rather157)-161	18000
T 3	Mactaris : Great Baths	199	4500
T 4*	SiccaVeneria : Great Baths	Unknown	Unknown
T 5	Thelepte : Great Baths	Unknown	>3000
T 6	Thugga : Baths of AinDoura	End II sc. Second beginning sc.	> 3300
T7	Thugga : Baths of Caracalla	211-217	1700
T8*	Uthina : Great Baths	Last years of the Second sc.	> 3200
T9	Uthica : Great Baths	Unknown	5990
T10*	Bulla Regia : Great Southern Baths	Unknown	3300
T11*	Membressa	Unknown	> 1350
Algeria			
T12	Thamugadi: Great Baths - North	Unknown	4400
T13	Lambaesis: Great Baths	Last years of the Second sc.	>5000
T14	Lambaesis: baths Camp	Hardian?	2700
T15	Caesarea: Great Baths - West	Unknown	5500
T16	Tubusuptu: Great Baths	SeveranEra	3000
T17	Cuicul: GrandsThermes Sud	183-184	3000
T18	Cuicul: Capitolebaths	First half of the second sc.	1200-1300
T19	Hippo Reguis: Great Southern Baths	198	1500-2000
T20	Calama	II sc.	>3000
T21*	Tiddis	Unknown	Unknown
Libya			
T22	Leptis Magna : Great Southern Baths of Hadrian	Hadrian : 126-127	>13000
T23	Sabaratha : Baths of the sea	I-II sc.	1900

(*) These terms are not studied because of insufficient data to their studies.

3. Architecturological Analysis of Roman Imperial Baths in North Africa

The architecturological analysis is performed using the matrix organization. This matrix is a systemic model of the architectural complex that articulates two distinct and complementary matrices, a structural matrix and a generative one.

"The organization matrix is a dynamic model of the architectural complex as hierarchical, autonomic, dynamic and quasi-decomposable system, able to describe the stable states of the system architecture but also its process of formation and transformation of development evolution, and articulating the analysis to synthesis,

[1]Thermae means the baths in ancient Rome (from the Greek "thermos").

understanding the design."(Dhouib, 2004)

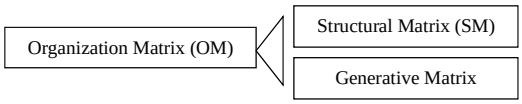

Figure 1: Organization matrix [12]

3.1 Classification According to the Surface

Y.THEBERT ranked the imperial baths in medium and great baths. We conducted another classification respecting the one done by Y.THEBERT to facilitate analysis.

Table 2: Classification of baths

Category		Baths	
Cat.1	The area is more than 1000m ² and less than 2000m ²	T1, T7, T8T19, T11	Mediums
Cat.2	The area is more than 2000m ² and less than 3000m ²	T14, T16, T17, T23	
Cat.3	The area is more than 3000m ² and less than 4000m ²	T5, T6, T8, T10	Greats
Cat.4	The area is more than 4000m ² and less than 5000m ²	T3, T12	
Cat.5	The area is more than 5000m ² and less than 6000m ²	T9, T13, T15	
Cat.6	The area is more than 6000m ²	T2, T22	

3.2 Frequency Spaces

We note the presence or absence of basic components in the baths according to the previous typological classification refined. This allows us to identify the program in each category:

Table 3: Program of baths

	Programme
Cat.1	-Warmed Sector: I: Input Tepidarium II: Destrictarium, III: Laconicum, IV: Caldarium, V: Output Tepidarium, VI: Praefurnium.
	-Cold Sector:E: Entrance, A: Apodyterium, F: Frigidarium, H: Hall distribution.
	-InfrequentSpaces[2]: P: Palestra, Ap: AppendixPalestra, Ex: Exedra, G: Gymnasium.
Cat.2	-Warm Sector: I: Input Tepidarium II: Destrictarium, III: Laconicum, IV: Caldarium, V: Output Tepidarium, VI: Praefurnium.
	- Cold Sector: E: Entrance, A: Apodyterium (swimmers and athletes), F: Frigidarium, P: Palestra, G: Gymnasium, N: Natatio, H: distribution Hall.
	-InfrequentSpaces: Ap: AppendixPalestra.
Cat.3	-Warm Sector: I: Input Tepidarium II: Destrictarium, III: Laconicum, IV: Caldarium, V: Output Tepidarium, VI: Praefurnium.
	- Cold Sector: E: Entrance, A: Apodyterium, F: Frigidarium, G: Gymnasium, N: Natatio, H: distribution Hall.
	-InfrequentSpaces: P: Palestra, N: Natatio.
Cat.4	-Warm Sector: I: Input Tepidarium II: Destrictarium, III: Laconicum, IV: Caldarium, V: Output Tepidarium, VI: Praefurnium.
	- Cold Sector: E: Entrance, A: Apodyterium, F: Frigidarium, P: Palestra, N: Natatio, H: distribution Hall, Ex: Exedra, Ap: Appendix Palestra
Cat.5	-Warm Sector: I: Input Tepidarium II: Destrictarium, III: Laconicum, IV: Caldarium, V: Output Tepidarium, VI: Praefurnium.
	- Cold Sector: E: Entrance, A: Apodyterium, F: Frigidarium, P: Palestra, H: distribution Hall, Ex: Exedra, Ap: Appendix Palestra
	-InfrequentSpaces: N: Natatio
Cat.6	-Warm Sector: I: Input Tepidarium II: Destrictarium, III: Laconicum, IV: Caldarium, V: Output Tepidarium, VI: Praefurnium.
	- Cold Sector: E: Entrance, A: Apodyterium, F: Frigidarium, P: Palestra, G: Gymnasium, H: distribution Hall, Ex: Exedra, Ap: Appendix Palestra, An: Appendix Natatio
	Infrequent Spaces: VII : Warm Pool

3.3 Structural Matrix

This is the result of crossing structural hierarchies and functional ones.

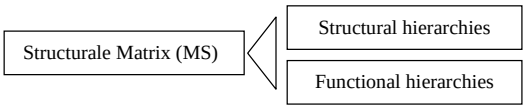

Figure2: Structural Matrix [12]

At this level, we performed several types of analysis to set of geometric-physical rules of this architectural system:

3.4 Geometric Level of Scheduling (dimensions - proportions - Orientations)

We study the geometric level of each category in order to identify thermal dimensional rules governing the architecture of the baths. At this level, we also analyze the relationship between the length and width of the components and the building as a whole.

Table4: Example of analysis of length / width ratio of the components of the warmed sector

	Cat.1	*Cat.2*	*Cat.3*	*Cat.4*	*Cat.5*	*Cat.6*
I	1,40	1,31	1,27	2,03	1,32	1,84
II	1,29	1,54	1,63	1,16	1,54	1,01
III	1,47	1,33	1,96	1,10	1,27	1
IV	1,58	1,27	1,16	1,07	1,17	1
V	1,98	1,67	2,34	1,38	1,54	1,09
VII	-	-	-	-	-	1,24

3.5 Geometric Level of Surfaces

We study the relationship between the two surfaces of warm and cold sectors and between components of the same sector in order to identify the principle of equilibrium. At this level, we analyze the relationship between the surface area (of work) components and their respective heights.

[2]These areas are identified once.

Table 5: Example of analysis of area ratio of two sectors compared to the total area of baths

	Total warm sector area (%)	*Total cold sector area (%)*
Cat.1	43,2337	56,7662
Cat.2	61,9542	38,0457
Cat.3	28,9868	71,0131
Cat.4	30,7031	69,2968
Cat.5	27,3267	69,2968
Cat.6	28,857	71,143

3.6 Physical Level of Materiality

We study at this level the relationship between the useful area and the physical envelope of each space for each sector in order to extract information about the thickness of the walls, the amount of material ... and to define the principle of balance between matter and lived space.

Table 6: Example of analysis of the ratio between the useful surfaces and respective quantities of materials

	Total useful area (%)	*Quantity of the material (%)*
Cat.1	75	25
Cat.2	71,5039	28,4960
Cat.3	63,8197	36,1802
Cat.4	69,0765	30,9234
Cat.5	79,5773	20,4226
Cat.6	66,455	33,545

Table 7: Example of analysis of the quantities of material for two sectors (warmed and cold)

	Qty of the material_ Warm sector (%)	*Qty of the material _Cold sector (%)*
Cat.1	51,8804	48,1195
Cat.2	61,6292	38,3707
Cat.3	35,5679	64,4320
Cat.4	34,2511	65,7488
Cat.5	41,3576	58,6423
Cat.6	42,237	57,763

For the development of our digital platform:

- We collected dimensional data in a table with the smallest and largest values recorded in our analysis as well as the average between the two.
- We analyzed in more detail the significant spaces in bathing establishments that are caldarium (the hot room) and Frigidarium (the cold room). These two spaces are located on the axis of symmetry called “fire axis”. This line has great symbol in Roman ideology.

3.7 Sample of Analysis for the Frigidarium

Table 8: Example of analysis of length / width ratio of the circulation and basins

	Circulation Area_Frigidarium	*Basinof Frigidarium*
Cat.1	2,10	1,2981
Cat.2	2,8995	1,099
Cat.3	1,8325	1,2795
Cat.4	1,8845	1,5505
Cat.5	1,4986	1,3
Cat.6	2,2	1,78

Table 9: Example of analysis of the circulation area and basinsarea

	Circulation Area_ Frigidarium (%)	*Basin of Frigidarium (%)*
Cat.1	86,0024	13,9975
Cat.2	68,7876	31,2123
Cat.3	80,8208	19,1791
Cat.4	84,4339	15,5660
Cat.5	86,84	13,1599
Cat.6	82,8048	17,1951

4. Results and Discussion

For the moment, we have succeeded to describe, with a scientific way, the geometry and morphology of the Roman imperial baths of North Africa. This description stops at the two-dimensional description because of the absence of data about the heights. We intend to use hypothesis for the restoration to complete our study. Our platform is dynamic and it accepts the changes throughout the process of re-design and restitution.

In addition to the constitution of the genetic grammar, this study allowed us to identify a set of ascertainment.

- In relation to the classification of thermal buildings: in our analysis, we noticed a disruption at the results of categories1 and 2 from other categories. The baths that belong to these two categories have an area between 2000m ² and 4000m ². We call-disruption-transition zone because they are in the range of passage from mediumto large baths. This led us to consolidate the classification of Y. THEBERT. It ranked in the baths:
  - Means that the bath area is less than 3000m².
  - And large bath area exceeding 3000m².
- In relation to the Roman architectural expertise: in our analysis, we found some equilibrium whatever the size of the baths. The most significant is at Frigidarium except in the disturbance-transition zone. We noticed

that the area of circulation in the Frigidarium occupied about ¾ of the entire area whatever the size of the baths is.

5. Conception of the tool for the Restoration

The results obtained will allow the development of a platform which generates two-dimensional sketches restorations only.This platform will facilitate the virtual modeling of this architectural system and its return even if we have only fragments. This platform will accept the entry of new data what-so-ever at the building and at the decor and serve as a support of experimentation of results, memory and data collection.

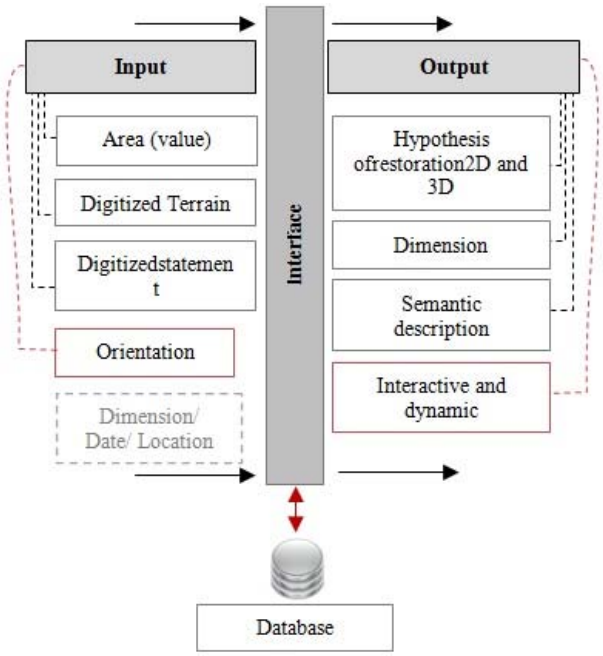

Figure 3: Functional diagram of the tool

It can be used as a support of interaction between the different fields of research within the discipline of architecture (morphology, ambience, heritage building ...) or with other disciplines such as archeology, history, medicine, engineering ... etc.

6. Conclusion

In this paper, we proposed an approach for the development of a tool for the restoration of imperial baths. This tool is cooperative, cognitive, dynamic and multidisciplinary. It restores the baths even if we have only fragments. This work should be completed in a cooperative and multidisciplinary environment. From our part, architects researchers, we study the process of design and re-design and we try to model but this task must be carried out within a multidisciplinary framework to be really more useful and functional.

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