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ECO-MATERIALS, PRAXIS AND PERFORMANCE IN THE PERSPECTIVE OF THE SUSTAINABLE URBAN PROJECT APPROACH. CASE OF THE TRANSPOSITION OF THE ENERGY2D TOOL IN THE ASSESSMENT OF THE THERMAL CONDUCTIVITY OF THE DREDGED MUD BRICK

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ABSTRACT

In an eco-responsible approach to environmental protection, the urban project is sustainable and multidisciplinary in nature, both as an innovative approach to eco-design and as an innovative approach to eco-design. It encourages the use of healthy, recyclable and reusable eco-materials in operations designed according to the standards of sustainable development and urban planning. The objective is to raise awareness about building "eco" by reducing the potential environmental impact of buildings. For this reason and in view of the problem of silting up the Bouhanifia dam, and in view of the shortage of inexpensive building materials, we opt for the development of the dredged silt. Empirically, the temperature variations and thermal conductivity of the brick with appropriate insulation are tested according to simulations carried out by digital tools (Energy2D and Ecotect), certifying an efficient thermal behavior.

Keywords: Sustainable Urban Project; Brick; Thermal Conductivity; Ecotect; Energy 2D.

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1. INTRODUCTION

At present, the act of building relies heavily on the excessive use of non-recyclable materials and non-renewable resources. Thus, the construction sector is considered polluting, energy-intensive and contributes to environmental degradation. To cope with this complex urban production and to meet the major challenges of construction or rehabilitation, stakeholders are encouraged to innovate the methods of project management. In order to make a real transition to the urban renewal process, postmodernist theory has conveyed the Urban Project approach as an objective to build and design in an optimal way this "eco" paradigm on the sustainable development platform, which pays particular attention to ecological responsibility. This logic calls for a rethinking of the restructuring operations of the existing fabric, in order to increase thermo-acoustic comfort, to support the responsible and integrated choice of processes and construction materials with high energy performance. It is in this sense that the digital approach is involved, through the application of dynamic simulation tools (case of Ecotect)/Energy2D), and eco-labels for certification and impact assessment throughout the life cycle (LCIA)[1] [1], appropriate to the new urban trend, which favours an innovative design capable of designing an autonomous and viable eco-building, energy efficient, environmentally friendly, and which takes into account the climate challenge[2],, in fact accepted by its users today and in the future.

2. CONSULTATION, PROBLEMATIC AND DEVELOPMENT

This research work is developed according to the systemic approach of the Urban Project, which is collaborative and partnership-based. Thus, its multidisciplinary vision makes it possible to cooperate adequately with tools and methods. Among its fields of intervention, it confirms above all the themes of sustainable urban planning, eco-construction, high energy and environmental performance materials. These topical subjects are developed in synergy in a process of continuous urban improvement. From now on, we no longer think of the construction field in parts, but as a coherent whole, an interactive relational system. In this context, our research is focused on a theoretical corpus explaining the contours of appropriate

[1] Life Cycle Impact Analysis: a technique for quantifying the environmental impact or pressure of a product, building element or building throughout its life cycle, i.e. from cradle to grave

concepts and their interference. Thus, the issue is centred around the role of the digital approach, with its tools (Energy2D and Ecotect), transposed into hybridization to support this triptych (energy performance / urban sustainability / environmental efficiency) in synergy, to successfully carry out a responsible construction or rehabilitation operation using Eco-materials (case of BBV brick + glass wool or sheep wool insulation) in a wide range of materials, thus testing and adapting thermal conductivity in order to improve the building's energy and environmental balance, or even to understand the sustainable building paradigm[3].

3. CONCEPTUAL ANALYSIS AND INTERFERENCE

3.1. Sustainable Urban Project

The urban planner ASCHER François certifies that "The urban project can be defined as a complex operation, for which an operator is in charge of the overall project, and which brings together various projects in a programme, a plan and overall forms. These projects are developed and defined during a process that involves local elected officials, developers and designers and is punctuated by numerous negotiations between all the actors involved in the project[1] [4]. Marcus ZEFT (2004) also defined PU as an innovative process of urban transformation [5, 3]. Otherwise, Patrizia Ingallina (2001) indicates that this notion of urban project is presented as a global and negotiated act in order to create a sustainable environment [6, 7]. However, Sachs, Ignacy testifies that the urban project must contain elements of ecological sustainability that make it possible to identify the use of resources without damaging the environment[2] [8].

At the operational level, this urban project approach has achieved successes in sustainable urban planning and development experiments in various contexts, by involving digital tools for multi-criteria analysis, and for eco-design assistance [9], demonstrated through the table and radar scheme below, established by the RAUD [10], reference frame, which we have tested to analyse and evaluate the performance of certain targets selected appropriately to their environmental themes in the local context. The objective is to encourage the use of materials

[1] ASCHER, François, Professor at the French Institute of Urban Planning and the University of Geneva

[2] Sachs, Ignacy. 1992. Transitions strategies for the 21st centry. In Nature and Ressource. Vol.28.n° 3.p.4-17

with low environmental impact; efficient rehabilitation and the introduction of renewable energies; limit the urban heat island ICU; create conditions of passive comfort; design and build energy positive buildings, thus respecting the health of users in a living environment of high environmental quality. See Table 1 and Figure 1.

(Table.1) : RAUD (analysis of energy and air-climate targets) in a sustainable urban planning and ecological architecture operation

N°	Critère	Évaluation (à remplir) (liste déroulante)	Justification (à remplir)	Possibles mesures d'ajustement ou d'amélioration (à remplir)
	TARGET 2. ENERGY, AIR, CLIMATE			
	Criterion 1. Common denominators			
2.1.1	Analyze energy needs	1		
2.1.2	Encourage the use of materials with low environmental impact	1		
2.1.3	Encourage the development of renewable energies	2		
2.1.4	Respect the health of users	1		
2.1.5	Acquiring good practices	2		
	Criterion 2: Outdoor spaces			
2.2.1	Limiting the urban heat island	Non applicable		
2.2.2	Design and build energy positive public spaces	2		
2.2.3	Adapting public lighting to energy efficiency	1		
	Criterion 3: New construction and rehabilitation			
2.3.1	Seeking energy efficiency	1		
2.3.2	Create the conditions for passive summer and winter comfort	2		
2.3.3	Encourage the use of alternative heating and cooling systems	1		
2.3.4	Define an effective energy rehabilitation strategy	Non applicable		
	Criterion 4. Traveling			
2.4.1	Reduce greenhouse gas emissions by limiting motorized travel in the project	1		
2.4.2	Develop efficient and accessible public transport	3		
2.4.3	Rationalize parking lots	1		

Target 2: Energy, Air, climate

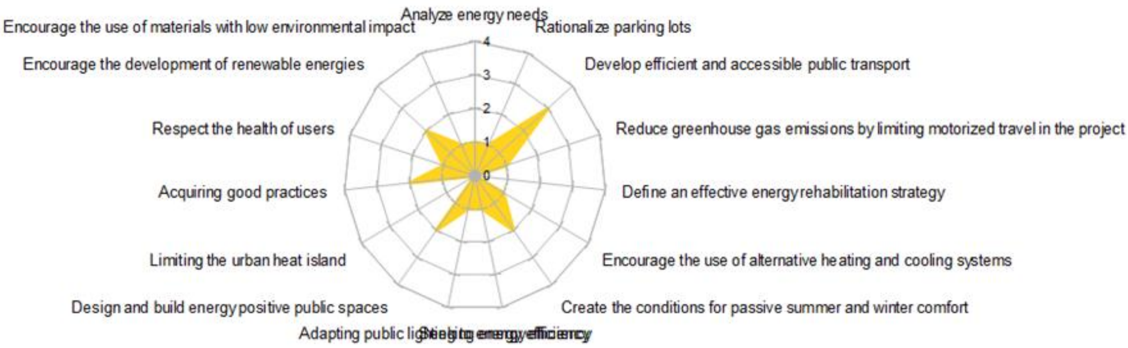

Fig.1. RAUD radar scheme - reference frame for sustainable development and town planning

3.2. Environment

The notion of the environment refers to natural and socio-cultural situations that may impact living organisms and human practices [11]. It should be noted that this term is polysemic, and thus constitutes a focal point between the human and social sciences HSS; hard sciences (HS); earth sciences, urban planning, architecture and construction, and more particularly urban ecology.

In the urban and architectural context, the word is used to describe the area of contact between a built space and the surrounding natural or para-natural environment, in other words the urban landscape offered to the urban dweller within his residential block, the framework of his movements and journeys according to his daily and weekly schedule. According to Victor Bure, the environment is the major concern in urban planning. However, the notion of urban environment refers to a set of components, such as materials, water, soil, soil, energy and air, whose impact on one component will affect the others. Thus, in our research work, the perception of the environment is addressed at the operational level and essentially refers to encouraging the optimal use of eco-materials, in the urban project approach that supports the transition from eco-design to taking into account the management and life cycle of projects, including bioclimatic architecture and sustainable urban planning. Indeed, the environmental dimension is a major concern on a global scale, and conceives the 3rd pillar of the sustainable development logic.

3.3. Eco-Materials

It is now useful to place sustainability within an operational framework of eco-urban planning and ecological architecture, which display environmental concerns, giving priority to aspects related to precise and adequate building materials (clay bricks and insulation), for the implementation of clean technologies and the minimisation of ecological impact, to reduce needs and losses, and to rationalize effective energy consumption, to preserve the health and well-being of the building's occupants. This is supported by the integration of specific requirements for the use of eco-materials in the various assessment and certification systems for sustainable buildings, including eco-labels and environmental declarations. In this context, ADEME[1] certifies that the philosophy of sustainable development applied to architecture focuses on the design and construction of environmentally friendly buildings, through an energy management process.[2] [12]

3.4. Dredged Vase Brick

This ecological material is made of clay [13]. Its characteristics include: thermal conductivity; technical and functional performance; architectural quality, durability, safety, ease of

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[1] Energy Development and Control Agency

[2] Energy control is not a drug that you take in times of crisis or illness, but a lifestyle that helps you stay healthy. Pierre Radanne, former Director of ADEME

maintenance, resistance to fire, heat and humidity, enormous energy savings, low environmental impact, reduced use of natural resources and a reduced ecological footprint of the building throughout its LCA[1] life cycle. The choice of materials in the rehabilitation of old buildings must imperatively integrate environmental, health and energy concerns. To build a healthy and sustainable building, it is necessary to choose materials and processes that do not affect the health of the inhabitants. We can also go further and question the energy consumption necessary for the manufacture of these materials and the management of their waste, with the aim of making the building ecological and a vector of health and well-being, therefore sustainable and acceptable to the occupant [14].

3.5. Ecotect

It is asoftware that performs a wide range of dynamic simulations, analysis and functionalities. This digital tool helps with environmental design and optimal decision-making in the project management mission. It combines a 3D modeler with various analyses, in particular thermal, acoustic and cost analyses, in order to validate the results of the field and try to test the indicators related to the performance of the material used (case of mud-based brick) in a reliable way, to optimize certain choices for a better comfort, thus improving the environmental quality of the living environment. Indeed, Ecotect allows to measure temperature variations through a mud-based cladding as a function of time [15].

3.6. Energy2D

In line with eco-design targets, we used this emerging digital tool "Energy2D"[2], (Physicist Xie-2010-USA), which allows us to design "computer experiments" to test a scientific hypothesis or solve an engineering problem without using complex mathematics. Thus, this visual and interactive multiphysics simulation program models the three modes of heat transfer (conduction, convection and radiation) and their coupling with particle dynamics. Energy2D helps to better understand heat transfer mechanisms, and allows to explain and quickly test heat flow phenomena [16]. In the empirical part of this research, we transposed the "Energy2D" method in order to validate the results of the field and try to test in a reliable way, the indicators related to the performance of the building materials used (brick based on

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[1] LCA: life cycle analysis, a tool for evaluating induced energy. (i.e. from the production phase to the disposal or recycling phase and ultimately reuse).

[2] https://energy.concord.org/energy2d/

dam dredged mud / Glass wool / Mouton Doschawol wool), used in a house, to optimize certain suitable choices and to achieve optimal thermal comfort in the living environment of the inhabitant.

4. EMPIRICAL PART (RESULTS AND DISCUSSIONS)

4.1. Identification

The material used to make the brick comes from the Bouhanifia dam,

Located in the northwest of Algeria, willaya de Mascara. The dam is 53% silted up, after dredging, fifteen settling basins have been built over an area of 200 hectares, in order to recover the extracted silt[17]. The results of the characterization are summarized in Table 2

Table.2. Characterization of the mud from the dredging of the Bouhanifia dam

Characteristics	***Results***
Moisture content (%) w	49,8
Liquidity limit (%) w_l	50
Plasticity limit (%) w_p	28
Plasticity index Ip	22
Specific surface area SSB (cm^2/g)	*2515*
Absolute density (g/cm3) ρ_s	*2.6*
Value of methylene blue VBS	*6.76*
$CaCo_3$ Carbonates (%)	12.59
Organic matter MO (%)	3.01
Cl- Chlorides (%)	*00*
Silica Si02 (%)	*40.13*
Lime Ca0 %	14.39
Magnesia Mg 0 %	1.58
Alumina Al203 %	15.58
Iron oxide Fe2 03 %	6.72
Sulfates S03 %	0.50
Alkalis (Na_2O + K_2O)%	2.29+0.9
Amorphous phase pozzolanic activity (°C)	850
Mechanical strength (Mpa)	21

The vase resulting from the dredging of the dam of Bouhanifia promises to be used as building material in the red brick [18].

Mineralogical analysis reveals an amorphous phase, resulting in pozzolanic activity at a temperature of 850°C. Figure 2 shows us a prismatic brick with dimensions (4*4*16) cm3

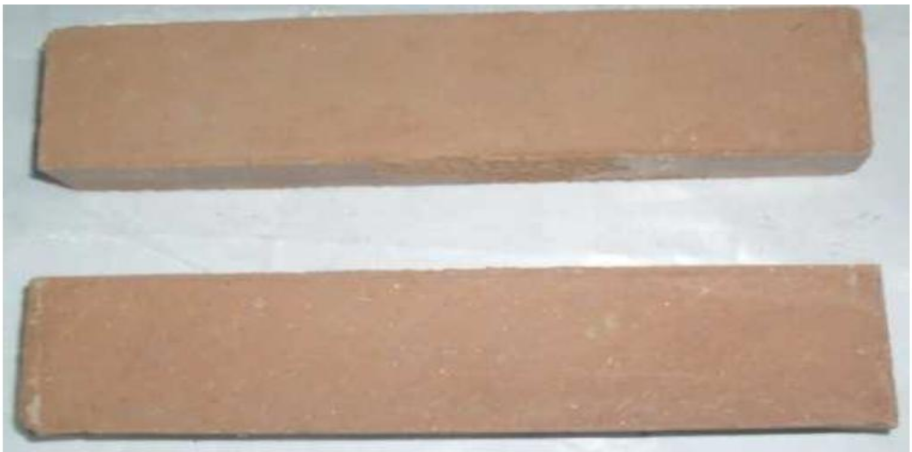

Fig.2 Prismatic brick based on mud from dredging

The result of the compressive strength is 21 Mpa. The values obtained from the resistance to compression are acceptable because they are higher than the limit tolerated by the standards in force which is 100 bars [18, 19].

4.2 . Thermal Identification

Thermal conductivity or thermal conductivity is a physical quantity that characterizes the behavior of materials during conduction thermal transfer. Noted λ (W-m-1-K-1), the measurement of this physical quantity is obtained using a KD2 Pro probe. See figure3

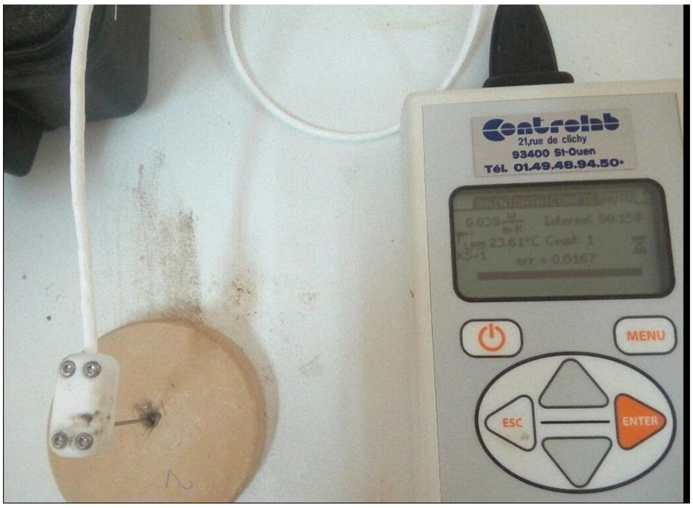

Fig.3 Thermal conductivity measurement

The thermal parameters are summarized in Table 3

Table 3. Thermal parameters

Thermal Parameters	*Thermal conductivity of the mud-based brick λ_1*	*Thermal conductivity of glass wool λ_2*	*Thermal resistance $R = e / \lambda$*	*La Conductance thermique U=1/R*
Wall thickness e= 30cm	**0.039w/m .k**	0.037w/m..k	**7.76 m^2.k/w**	0.128w/ m^2.k

The thermal conductivity value of the mud brick is very encouraging. Heat travels within the material from one particle to another. It is an intrinsic part of each material that characterizes it, so only its insulating performance. The lower λ is, the more resistant the material is to conduction transfer. The value of the thermal resistance is also adequate, the RT 2005 thermal regulation indicates that the thermal resistance must be greater than or equal to a minimum value of 2.2 m2.k/w, our result gave 7.76 m2.k/w.

4.3 Dynamic Simulations (evaluation and verification) by Ecotect

The following diagram (Figure 4) shows the temperature that passes through a 30cm thick double cladding made of mud from the dam with insulation (glass wool) as a function of time.

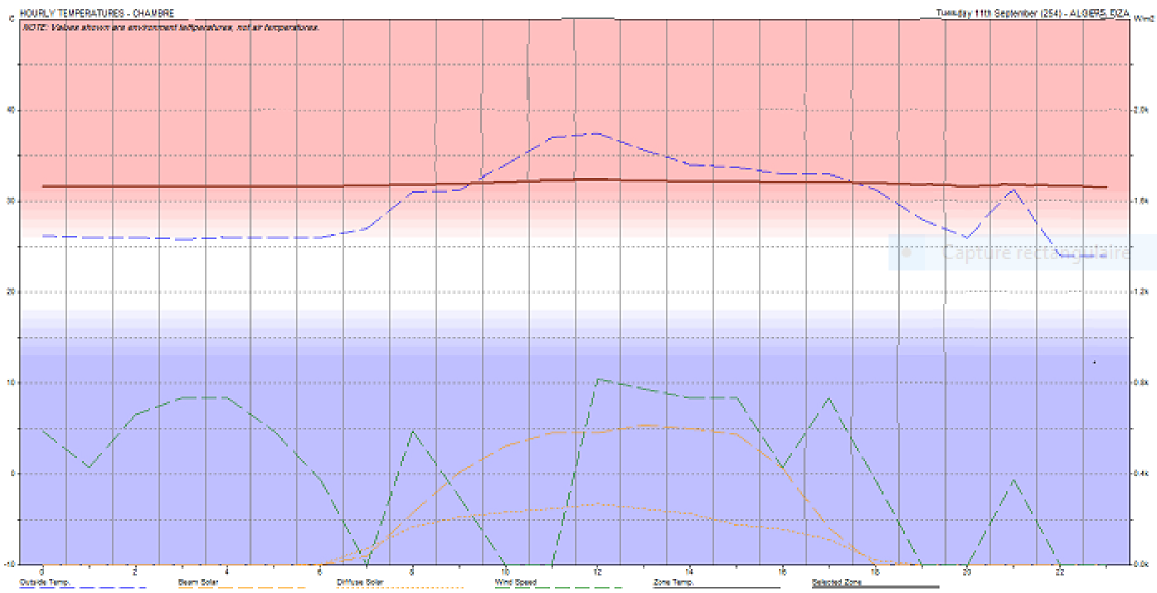

Fig.4. Temperature variation through a mud-based cladding as a function of time using the Ecotect software

A comparison between two media, internal medium in blue color with another external medium in pink color, separated by a red line that indicates the internal ambient temperature. The external temperature path in the discontinuous blue line, varying from a low temperature at midnight (00h), reaches a maximum at midday (12h) and descending to a lower temperature in the evening.

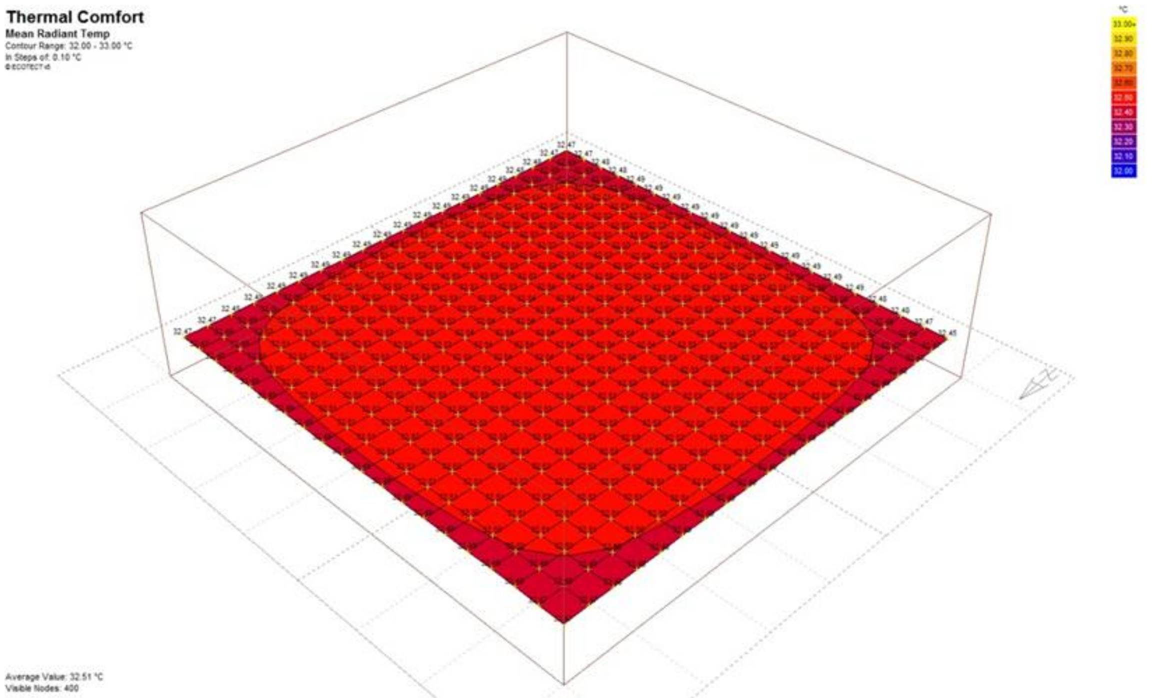

Fig.5. Ambient temperature inside the room partitioned by Ecotect 3D

According to the results, the Thermal behavior of the mud-based brick (BVD) is encouraging. The average ambient temperature inside a brick partitioned part made of dredged silt from the dam (BVD) with glass wool insulation (LV), calculated by Ecotect, is of an equal optimal value (32.47°C). See Figure 4.

4.4. Comparative Analysis and Evaluation of Thermal Performance by Energy2D

4.4.1. Thermal Flow and Phase Shift Time

Phase shifting time: Phase shift is the time between the time when the temperature was highest outside and the time when it was highest inside. Indeed, the purpose of this transposition of the "Energy2D" software is to experiment by verifying the ambient thermal behavior, with respect to the Time parameter, in two similar chambers, the peripheral wall of the first of which is made of double walls, based on clay brick (BTC), compared to the second, made of dredging mud brick (BBV). The use of intermediate insulation (glass wool LV /

sheep wool LM) is experimented with both materials (BBV) and (BTC), illustrated in the figures below, figures 6-7-8 and 9

a)- Wall= BBV+ Glass Wool: We note that the temperature sensors indicate decreasing values (Tp. Outdoor =50°C / Tp. Glass wool insulation = 30°C / Average interior = 16.2°C). This result indicates that increasing the thickness of the inner wall is well recommended to achieve more adequate thermal comfort.

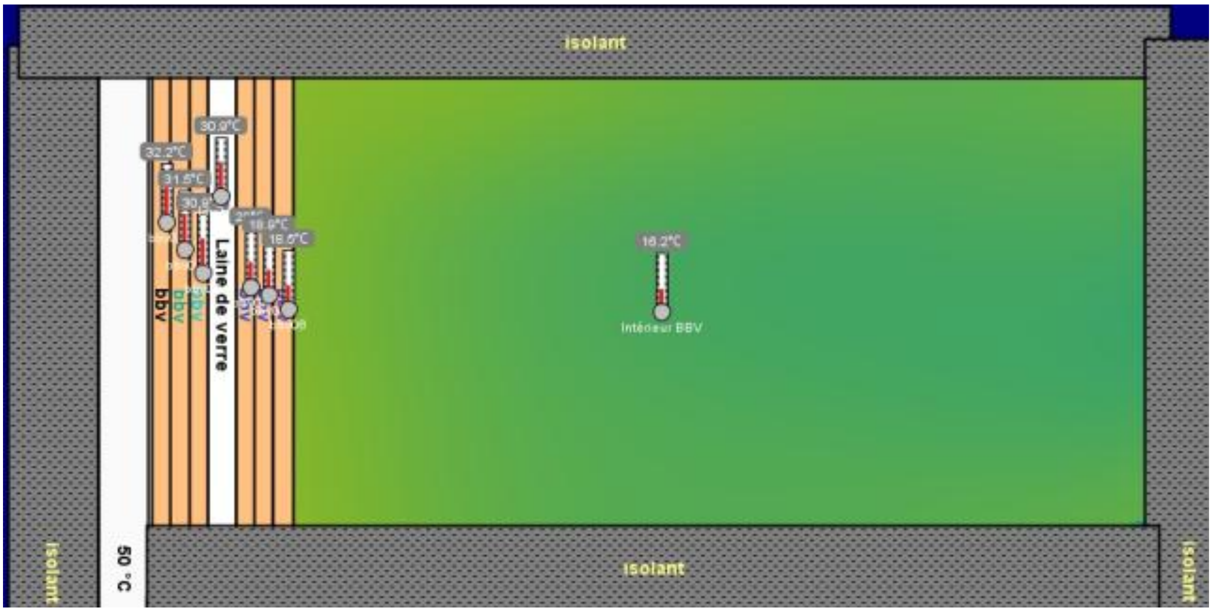

Fig.6. Heat sensors of a BBV brick wall with glass wool insulation

b)- Wall= (BTC)+ Glass Wool : It should be noted that the temperature sensors indicate decreasing values (Tp. Outdoor =50°C / Tp. Glass Wool Insulation= 22.9°C / Average ambient temperature inside the chamber = 17.2°C.

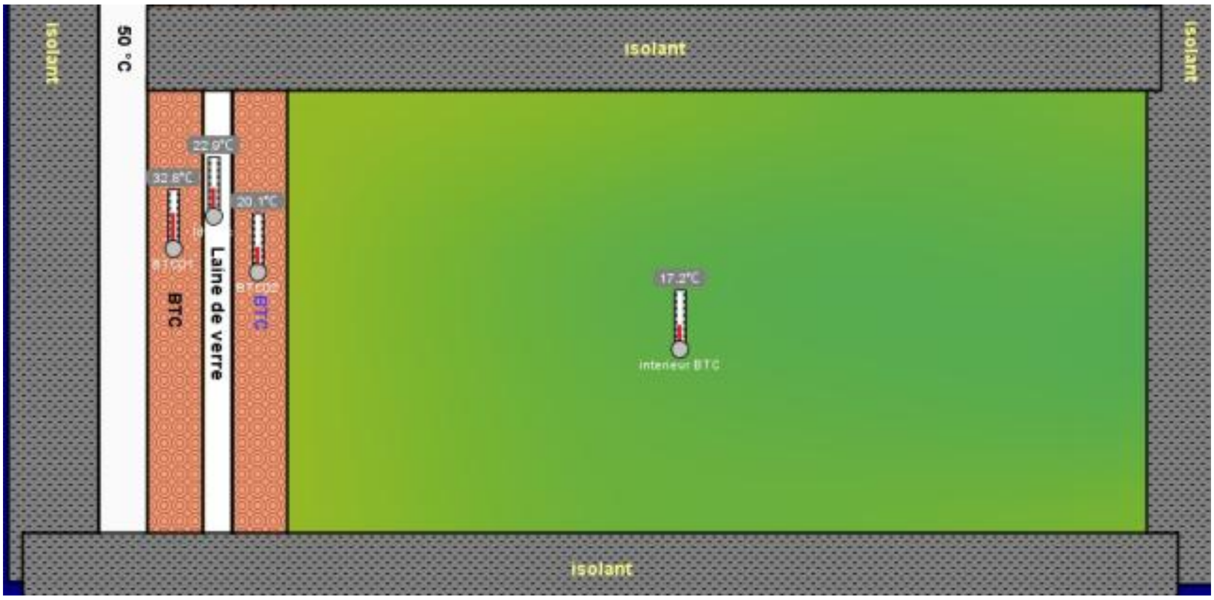

Fig.7. Heat sensors of a wall in (BTC) with Glass Wool insulation

c)- Wall= (BBV)+ (Sheep's Wool): We note that the temperature sensors indicate decreasing values (Tp. Outdoor =50°C / Tp. Sheep's wool insulation = 21.4°C / Average ambient temperature inside the chamber = 14.5°C.

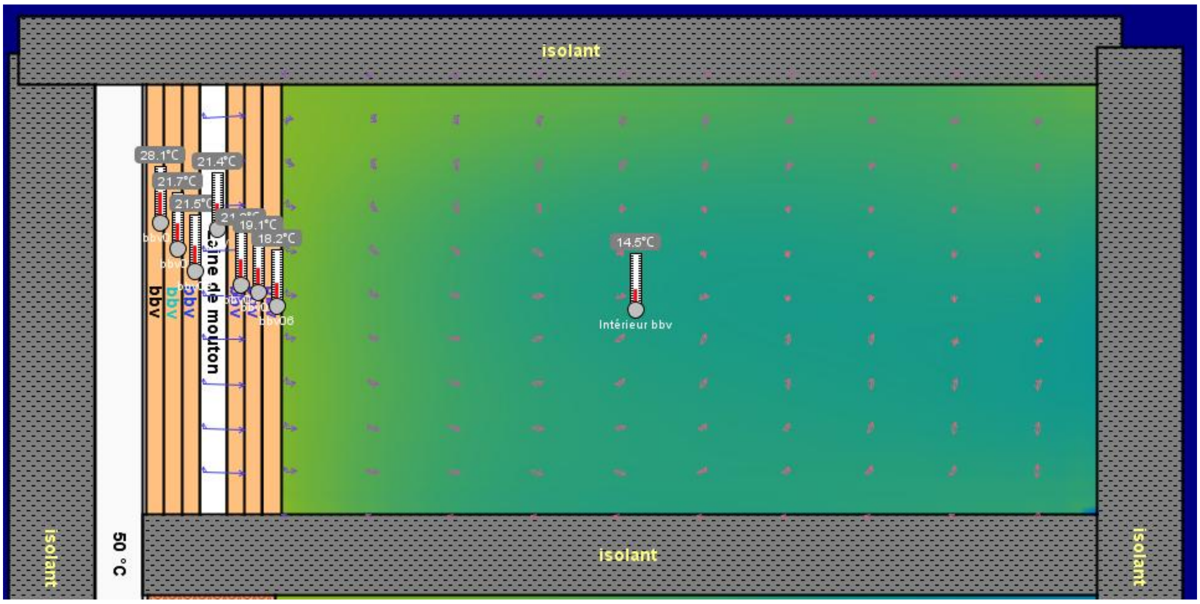

Fig.8. Heat sensors of a wall in (BBV) with Sheep's Wool insulation

d)- Wall= (BTC)+(Sheep's Wool): It is noted that the temperature sensors indicate decreasing values (Tp. Outdoor =50°C / Tp. Sheep's wool insulation = 21,4°C / Average ambient temperature inside the chamber = 15.4°C.

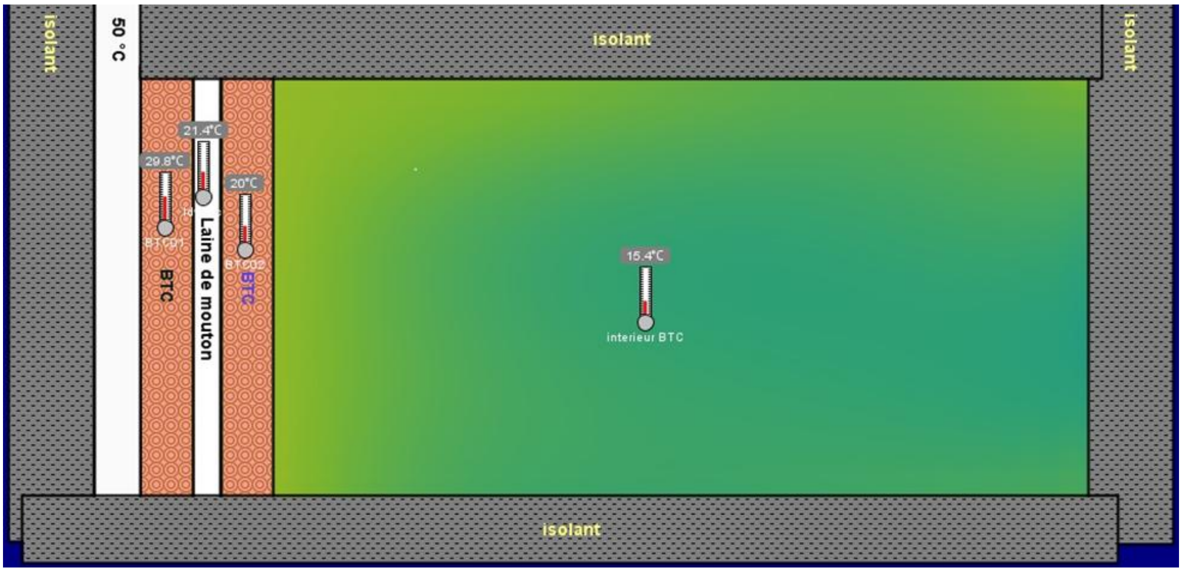

Fig.9. Heat sensors of a wall in (BTC) with sheep's wool insulation

4.4.2. Recap (Tests and Results) See Table 3

Table 3. Different temperatures obtained (inside / outside) of the wall

Test	*BBV*	*GW*	*BBV*	*Result 1*
N°01	*32 ,2°C*	*30,0°C*	*18,0°C*	*16,2°C*
Test	**BTC**	**GW**	**BTC**	**Result 2**
N°02	*32,8°C*	*22,0°C*	*20,1°C*	*17,2°C*
Test	**BBV**	**SW**	**BBV**	**Result 3**
N°03	*28,1°C*	*21,4°C*	*18,2°C*	*14,5°C*
Test	**BTC**	**GW**	**BTC**	**Result 4**
N°04	*29,8°C*	*21,4°C*	*20,0°C*	*15,4°C*

Energy 2D, allowed us to test the thermal conductivity of the BBV brick and make corrections by choosing an appropriate insulator (sheep's wool). Indeed, the results obtained help to adapt properly to the eco-design targets of a high energy-efficient dwelling and to certify environmental efficiency, particularly at the relevant scale of the district. This vision is well managed in the spirit of the urban project approach that now appears unavoidable.

5. CONCLUSION

The urban environment significantly alters the global environment. The sustainable development approach to the built environment is a current trend, with the environmental issue being the vital concern of building professionals. The evolution towards a sustainable approach to eco-design of buildings, which reveals multiple skills, has thus become essential. In line with the results of this multi-criteria analysis, and in order to increase the thermal and acoustic performance of the wall made of eco-materials (mud brick with insulation) with low environmental impact, we recommend increasing the thickness of the wall, particularly in the restoration of the old building of cultural value. As much as replacing the thermal insulation glass wool with a natural and renewable (thermoacoustic) insulation (Doschawol Sheep's Wool), which is more ecological and economical. This innovative material (DSW) is hydrophobic, energy efficient during its life cycle. It is characterised by its better physical, chemical and mechanical characteristics, which are the result of good performance in terms of durability and health. The objective is to contribute to making the building more efficient, to increase energy efficiency and well-being, to limit the urban heat island and the impact of the operation (Eco construction / Eco rehabilitation). This makes it possible to design a healthy indoor and outdoor environment, to create the conditions for passive comfort in summer and winter. Therefore, in a corrective action, the synergy of the two eco-materials reported (BBV and DSW) designs an optimal thermal conductivity in the certified home. So, the idea of an eco-responsible design is to combine thermo-acoustic comfort, quality and bio-specialty atmosphere correlative to the user. Indeed, the right choice of the above-mentioned process, which does not penalize the environment, becomes vital and aims to combine the ecological exemplarity of the building with the improvement of urban amenities. Firmly, environmental responsibility is constantly applied in the logic of the incontrovertible urban project to think urban and human, as much to preserve our planet for future generations in a panoply.

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