

Comparison of Cost – Profit in relation to the hydrothermal characteristics of the outer walls of the building in Córdoba, Argentina

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ABSTRACT: An important transformation in architectural wall construction has been made. The mass has been decreased, new materials have been incorporated, and the use of a single element has been substituted by several layers.

These modifications have an important impact on the hydrothermal conduction of the walls, and therefore on the amount of energy required to maintain a building's comfort level during its lifetime (energetic effectiveness).

An analysis was performed using differently aged schools, houses and buildings in Córdoba, Argentina.

The walls were classified and different categories were established based on whether or not single or multiple layers were used and with what materials.

The hydrothermal behaviour was assessed using software designed to estimate the transmittance and condensation risk according to the current Argentinean norms which establish the minimum and recommended amount. The current cost was calculated, allowing a comparison of cost – profit.

The conclusions indicate a general decrease in the hydrothermal performance of the walls in terms of comfort, increase in energy consumption and a creation of various pathologies which reduce the walls' lifetime.

The transformations are not considered as a general system change, but rather as a performance change. In the professional field there is a lack of knowledge about new types of construction, which leads to the frequent selection of alternatives that are far less efficient but just as costly.

Keywords: enveloping evaluation energy

NOMENCLATURE

K Thermal transmittance [$\text{W/m}^2\text{C}$]

1. INTRODUCTION

The use of energy is strictly related to the development of humanity; as well as lack of control of the planet's deterioration. Thus, in order to make the two terms of this

equation compatible, energy should be generated and used reasonably.

The control of the generation and use of energy does not provide by itself a solution to problems such as Climate Change, but it does contribute to the urgent need to fight against its causes.

We admit that acting on Climate Change or changing the global energy market is something that no society or country can do

by themselves. Therefore, a global change is necessary. Likewise we admit that these problems greatly exceed the technical aspects.

However, we believe in the importance of acting locally.

The Argentine Republic has undertaken international accords in this respect, and it is our responsibility as a public university to make contributions to solve the problem.

We are aware that one of the main topics on the political agenda of our universities is the relationship with the productive system, making production transformations compatible with a sense of social equity and strengthening of the political democratization processes. In this sense Energetic Efficiency is important.

We expect to generate models of strongly effective architectural interventions in our system, for society in general and for the professional field in particular. Whatsmore, we feel that this subject matter may significantly contribute to the debate within our academic field.

2. MATERIALS AND METHODS

For the purpose of investigation, the architecture established in the city of Cordoba, Argentine Republic, has been considered. **It is limited to lateral enveloping.**

Two types of buildings were analyzed: educational buildings and dwellings, classifying them into buildings constructed by state promotion and by private promotion. The study was limited to formal construction, done through state plans or, if private, that which was registered in the relevant entities.

Of the buildings surveyed, the performance of the lateral enveloping was analyzed through a program for the calculation of thermal transmittance (K) and verification of superficial and interstitial condensation, elaborated by CEEMA –

Center of Energy and Environment Studies, IAA, FAU, UNT, Argentina. The climatic parameters of the city of Cordoba were considered. The calculated K is compared to the minimal K, the recommended K and the ecological K, fixed by the IRAM standards (Argentine Institute of Standards). These three levels of hydrothermal comfort are defined by the verification of the superficial condensation taking different internal design temperatures (18°, 20° and 22°) and by the difference between internal design temperature and enclosed superficial temperature (4°, 2,5° and 1°).

Table I: K values set by IRAM 11605 Standard: 1996-12

Cordoba Bioenvironmental zone III	Minimal K	Recommended K	Ecological K
Summer	2,00	1,25	0,50
Winter	1,85	1,00	0,38

2.1 Historical evolution of the problem.

For the selection of educational building cases, examples of periods corresponding to different governments, either provincial or national, whose interventions were significant due to the importance of the intervention and building typology were used. At the same time, private educational buildings were selected, as long as there were some during the period.

For residential buildings, typical examples were taken from the different building operations of state promotion dwellings. They mainly correspond to proposals for middle class and middle-lower class.

2.2 Present time

The records in the Association of Architects were analyzed, corresponding to projects in the city of Cordoba, registered during the period between November 2006 and April 2007. From this data it was detected that 54% of the formal

interventions in the city corresponded to the construction of apartment buildings with more than four floors.

Table II: Works registered in the Association of Architects of Cordoba. Period November 2006 to April 2007.

	Building typology	m ²	%
1	Single-family house up to 100 m ²	5.115	1%
2	Single-family house between 100 to 150 m ²	11.922	3%
3	Single-family house between 150 to 200 m ²	36.058	10%
4	Single-family house between 200 to 300 m ²	34.018	9%
5	Single-family house of more than 300 m ²	37.799	10%
6	Apartments (buildings up to two floors)	30.618	8%
7	Apartments (buildings between 2 to 4 floors)	17.871	5%
8	Apartments (buildings of more than 4 floors)	205.407	54%

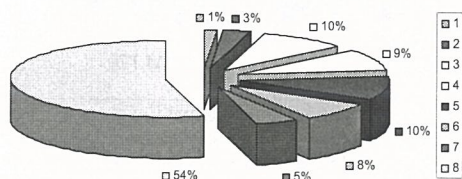


Figure 1: Percentage of the different types of building typologies (corresponding to Table II) registered as Projects with the Architects Association of Cordoba.

According to the localization analysis of these buildings, it was determined that most of them corresponded to a particular area, Nueva Cordoba, where the leading cases were taken.

To make this sampling, all the buildings under construction at the moment on the two most important arteries of said area were surveyed.

For the state promotion buildings, the recent provincial plans for the eradication of informal settlements conducted by the Government of the Province of Cordoba had

been considered, since there are no significant plans for middle-class housing at this time.

2.3 Catalogue of enveloping types

Later on, a catalogue with all the types of external enveloping found was organized, based on whether or not single or multiple layers were used and with what materials. In each case, the transmittance, the risk of superficial and interstitial condensation, as well as the cost, were obtained using constantly updated software.

2.3 Other actions

The work has been completed with:

- External and internal on-site measurements with a temperature and humidity Data Logger.
- Surveys of users on perceptions of comfort levels.

3. RESULTS

For the purpose of this presentation **only non-translucent enveloping** is considered. Only one representative case for each period analyzed is presented.

The cases are organized into educational buildings and housing plans.

For the present period, a case of intervention of the provincial state in a plan for the eradication of informal settlements is compared to the building of one of the highest sale-value sectors in the city.

The historical sequence shows that, in spite of the importance of hydrothermal comfort in educational buildings and/or dwellings, the architectural enveloping has never been constructed to function as a regulator of external conditions.

Similarly, it must be pointed out that, though standard brick was used for wall construction, these walls were close to the current advisable standards.

The above does not imply ignoring the negative implications of different origin that

come with the massive use of standard brick.

Other technologies as, for example, pre-cast concrete panels with an insulating core, are not a solution to the problem either, since they are not entirely developed.

In the case of the panels used by the present provincial government to build 100 schools, 11605 Iram Standard is not observed. 1996, in its point 5.4 Thermal bridges

4. CONCLUSION

Of the different conclusions drawn in this investigation we consider:

4.1. Referring to the concept of hydrothermal comfort in buildings.

The variable of hydrothermal comfort is not really considered in the architectural design. In our area, the paradigm of energy waste prevails, and the criteria for sustainability in buildings construction are not incorporated in the professional responsibility.

Table III: Educational buildings. Historical sequence. Lateral enveloping performance.

Until 1950	1950	1960	Military Gov.	1980	1990	2000	
Sabattini (Provincial Government) 	Peron (National Government) 	Paez Molina (Provincial Government) 		Angeloz (Provincial Government) 	Mestre (Provincial Government) 	De la Sota (Provincial Government) 	
H. Yrigoyen School	Roma School	Rep. Del Perú School		A. Cámara School	IPEM 149	IPEM 129	
External Env: Plastering Standard brick 31,5 cm Plastering	External Env: Plastering Standard brick 29cm Plastering	External Env: Plastering Standard brick 28cm Plastering		External Env: Plastering Non load-bearing ceramic brick 20 cm Plastering	External Env: Standard brick 15 cm Chamber 20cm Hollow ceramic brick 12 cm Plastering	External Enveloping .Precast concrete panel with core in polystyrene and concrete frame.	
						Panel	Frame
Summer K 1,94	Summer K 1,94	Summer K 1,99		Summer K 1,64	Summer K 1,07	Summer K 0,73	Summer K 4,10
Winter K 1,82	Winter K 1,94	Winter K 1,99		Winter K 2,28	Winter K 1,07	Winter K 0,73	Winter K 4,10
Minimal K Yes	Minimal K No	Minimal K No		Minimal K No	Minimal K Yes	Minimal K Yes	Minimal K No
Recomm K No	Recomm K No	Recomm K No		Recomm K No	Recomm K No	Recomm K Yes	Recomm K No
Ecological K No	Ecological K No	Ecological K No		Ecological K No	Ecological K No	Ecological K No	Ecolog K No
Superf. Condens: No	Superf. Condens: No	Superf. Conden: Yes		Superf. Condens: No	Superf. Condens: No	Superficial Condensation No	
Condens. Interst.: No	Interst Condens.: No	Interst Condens.: No		Interst Condens.: No	Interst Conden: Yes	Interstitial Condensation : Yes	

Table IV: Housing Plans. Historical sequence. Lateral enveloping performance.

Until 1950	1950	1960	1970	1980	1990
	Eva Peron Plan	VEA, May 25 and October 17.		FONAVI – FOVICOR Operations.	
					
Barrio Obrero	Residencial Olivos	Consortio Universitas	Conj. Ejército Argentino		
External enveloping Plastering Standard brick 32cm Plastering	External enveloping: Plastering Standard brick 30cm Plastering	External enveloping: Plastering Standard brick 28cm Plastering	External enveloping: Plastering Hollow ceramic block 20 cm Plastering		
Summer K: 1,92	Summer K: 2,03	Summer K: 1,99	Summer K: 1,55		
Winter K: 1,92	Winter K: 2,03	Winter K: 1,99	Winter K: 1,55		
Minimal K: Yes	Minimal K: No	Minimal K: : No	Minimal K: Yes		
Recom K : No	Recom K : No	Recom K : No	Recom K : No		
Ecologic K : No	Ecologic K : No	Ecologic K : No	Ecologic K : No		
Superficial Cond: no	Superficial Cond: no	Superficial Cond: : No	Superficial Condensation: no		
Interstitial Cond: no	Interstitial Cond: no	Interstitial Cond: no	Interstitial Condensation : no		

It is ironic that two present dwellings, one in Ciudad Evita and the other in Nueva Cordoba, turn out to have a similar K, in spite of the excessive difference in the cost per square meter of the building.

In the case of the eradication of informal settlements, the state's irresponsibility is obvious in giving a totally inefficient dwelling to a sector of the population without resources by which to obtain comfort by mechanical means.

In the case of the dwelling in Nueva Cordoba, it is the disproportion of the relation between sale value and comfort offered. In both cases, it is the level of social impact made by both dwellings, due to the energy necessary to make them habitable and the probable useful life of both buildings.

4.2. Referring to the changes produced in the construction of the enveloping and its relation with its performance.

Historically, the enveloping has solved the problem of energy interchange with the external environment through two means,

basically: the mass that allows the inertia and the geometry that helps the runoffs.

From the conceptual revolution that the

Table V: Present dwellings.

	
Dwelling in Ciudad Evita Year of Construction: 2004	Dwelling in Nueva Cordoba Year of Construction: 2007
Provincial state promotion of social welfare dwellings	Private promotion dwellings, Sale US\$ 950/m ²
Cementitious block	Plastering Hollow ceramic brick 12 cm Plastering
Summer K: 2,12	Summer K: 2,02
Winter K: 2,12	Winter K: 2,02
Minimal K: No	Minimal K: No
Recommended K: No	Recomm.K: No
Ecological K: No	Ecological K: No
Cond. Superf.: Yes	Cond. Superf.: Yes
Interstitial Condit.: No	Interstitial Condit.: No

Modern Movement brought forth in architectural production, and its dialectic relation with the appearance and development of new technologies, a reduction in the thickness of enveloping was produced, as well as the replacement of the single-layer enveloping by a sequence of layers of materials with specific functions.

4.3. Referring to the professional ignorance on the functioning of the enveloping system.

Even today, this multi-layer enveloping is not totally interpreted by construction professionals, generating incompatibilities within the construction system itself, in spite of the use of high performance materials, if compared historically.

This ignorance is manifest in the maintenance of fallacies in the construction field ("the vapor barrier is not important") or in bad choices regarding alternatives in relation to cost.

4.4. Referring to the appearance of new pathologies.

The new ways of producing the enveloping in terms of thickness and/or the use of thermal insulation, is presenting new pathologies, such as: superficial and interstitial condensation and the movements related to the different components of the system.

These pathologies reduce the useful life of the buildings considerably.

4.5. Referring to costs.

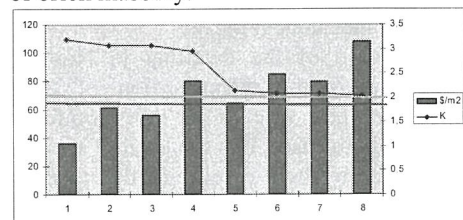
In the building's conception only the construction cost is evaluated, without considering what it will take for the building to be put into operation.

Even considering only the primary cost of the enveloping, the former does not grow in proportion to the latter's performance, as shown in the chart below, in terms of characteristics of masonries in standard brick, different thicknesses and finishes.

Table VI: Masonry of Standard brick. Performance according to thickness and combination with plastering (internal and external)

	Type	Thickness [cm]	Weight p/m ²	\$/m ²	K	Tot vapor access resist.	Minimal K	Superf. Cond.	Instersit. Cond
1	Brick	12,5	234,0	36,29	3,19	1,63	NO	Yes	Yes
	External plastering								
2	Brick	14,0	262,5	61,19	3,07	1,97	NO	Yes	Yes
	Brick								
3	Internal plastering	14,0	262,5	56,27	3,07	1,97	NO	Yes	Yes
	External plastering								
	Brick								
4	Internal plastering	15,5	291,0	80,17	2,95	2,31	NO	Yes	Yes
5	Brick	27,0	486,0	64,57	2,14	3,38	NO	Yes	NO
	External plastering								
6	Brick	28,5	514,5	84,77	2,08	3,72	NO	Yes	NO
	Brick								
7	Internal plastering	28,5	514,5	79,85	2,08	3,72	NO	Yes	NO
	External plastering								
	Brick								
8	Internal plastering	30,0	543,0	107,80	2,03	4,06	NO	Yes	NO

Figure 2: Cost – performance comparison of brick masonry.



REFERENCES

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