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THE IMPORTANCE OF DURABILITY AND QUALITY CONTROL IN SOCIAL DWELLINGS IN A HIGH SEISMIC RISK REGION WITH COMPOSED WOODEN MATERIALS

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ABSTRACT :

The aim of this paper is to evaluate the performance of no traditional wooden materials, for social dwellings in the highest seismic risk zone of the Argentine Republic. The mix of materials is a new challenge in the evaluation of service life because the thermal bridges generate new problems in the durability of seismic-resistant structures. The used methodology is based on a theoretical study of conditions of habitability, laboratory tests on natural scale specimens to evaluate mechanical characteristics and the construction of prototype to validate durability. A valuable alternative to solve the deficit of dwellings is considered but it must include quality control of constructive processes and criteria of maintenance during service life must be established.

KEYWORDS: service life, social dwellings, habitability, durability, wooden materials

1. INTRODUCTION

The housing shortage at local, national and Latin American levels is estimated by CEPAL (Economical Council for Latin America) about 42 millions of units, and as much as 50 millions by ONGs. The problem of dwellings deficit is minimized when it is necessary to build 4 millions per year during a generation to solve it. But only 1.5 million per year are built. Latin America presents the highest growing population rate worldwide which meant to triple the whole population in only 40 years. The distinctive feature of this geographic area is that the unconventional building surpasses in great manner the conventional construction. More than three fifths of dwellings are built by unconventional workmanship. Another aspect that characterizes the state of Latin American social dwellings is 211 millions of paupers, or the 44% of its population economic insolvency can not access to a dwelling of their own house. Owing the complex political and economic situation of Latin America new formulae must be looked for based on local raw materials and sustainable aboriginal technologies which are not only economical, but also improve growing population conditions (Boccalandro Montoro, 2006).

The proper dwellings are estimated in about 35% of the whole value of urbanization. The technological factor plays a fundamental role in the solution of dwelling deficit due to massive demand and the requirement of great volumes of materials owing to the necessity of using appropriate practices and technologies with local materials and potential or ordinary productivity. However, the 98% of dwellings built in Latin America employs technologies with poor effectiveness and long time of construction. The traditional systems use more than 100 hour-workmanship/m2. The most common materials are masonry, blocks, wood and concrete.

Other technologies are also used in social dwellings and consolidation of suburbs (40%) based in raw materials or materials without industrial process such as clay, timber, bamboo and others. These technologies also use discarded materials and unconventional industry residues in outer suburbs. Less than 1% of dwellings in Latin America use products from industrial technologies although it is known that only these industrial products allow production volumes of which meet quality controls.

In the Argentine Republic, the deficit of dwellings is about 1.7 millions of units (INDEC, 2007), including the population who lacks dwellings and the population which lives in crowded units. The world estimation for minimum unit dwelling has 50 m2 and national codes establish about 56 m2 due necessities of minimum areas, sun light and ventilation. This situation implies the construction of 85 millions of m2 and the estimation of cost is about 320 dollars per m2. For 2007, the Government Federal Plan II would build 59000 units which cover only 2.87 % of dwelling deficit. With this rate of construction, 18 years will be required to satisfy the lack of social units.

1.1. Local Research Program

The National Technological University has in its research programs about social dwellings, innovative systems of structures, high performance materials and local near source earthquakes especially located in Regional Mendoza Faculty. The project of social housing has developed an innovative modular prefabrication system for seismic emergencies called Modulus for Seismic Emergency (MSE) (Pizarro et al, 2006). This proposal is unique and though ameliorable, it is sustainable because it meets the standards in force referred to design, construction, habitability and includes minimum size of premises, ventilation, lighting, capacity to support vertical and horizontal loads and the requirements about comfort: transmission of temperature, condensation of moisture, consumption of power and service life.

In this paper we present the analysis of panels made by wooden residues (oriented strand board, OSB) or with local production wood (called “Alamo criollo” or populus nigra with low density).

2. REGULATIONS FOR SOCIAL DWELLINGS

The Law Nº 18 (National Secretary of Housing, 2000) establishes the minimum requirements for social dwellings due the problems of poor quality of dwellings and the federal government must repair or replace them. The requirements are related to: 1) localization, 2) urban design, 3) total design, and 4) dwelling units.

The requirements about points 1, 2 and 3 depend on social housing politics and the jurisdiction. There are few problems in these area, but the social magnitude of impact is very important due to the relation with urban planning (for e. lack of transport or accesses), with availability of infrastructure (for e. drainage, water pressure), with location (for e. cheap soils without residue treatment).

The requirements in relation to dwellings are: 1) flexibility and expansion 2) safety 3) habitability and 4) durability. The aspects about flexibility and expansion of the unit must present proved criteria, with optimization of areas and to support minimum conditions of habitability preferably without demolition. The analysis of social unit growing has not succeeded because it has produced crowded units.

The main requirements about safety in social dwellings are: to give adequate resistant structures, especially in seismic zones, to avoid failures in installations, to adjust the design and the technology for prevention standards for accidents and to avoid intruders trespasses and to produce quick evacuation of the unit in case of fire.

The requirements of habitability in social dwellings are: to achieve minimum comfort conditions in winter as in summer; to avoid the superficial and interstitial condensation in walls and roofs; to assure minimum conditions of lighting, ventilation and sunlight to avoid the entrance of outer moisture through walls, roofs and openings and to obtain acceptable acoustic conditions between dwellings and common spaces.

The requirements of durability in social dwellings are: to secure a minimum service life according to the credit loan and to diminish to a minimum the risk of main damages as well as the requirements for maintenance and conservation

With the use of new materials or recycled materials, it is necessary to know or to anticipate the performance in time. There are studies in Argentina and Brazil which show that the controls must be done during the construction rather than in projects as it happens in developed countries (CYTED, 2005). The question is what happens in social dwellings in presence of problems of durability and damages generated by natural phenomena such as earthquakes in relation with the specification of service life with no traditional materials.

Although the standards about habitability produce models of performance in the presence of different combinations of environments; its inclusion generates important issues related to technology and structure, due to thermal bridges, condensations, joints, and so on, which mean an impact in the service life of new materials. The approach to design must be holistic and it must include interdisciplinary analysis. All the steps on the process of construction must be considered and it must be include the use of an appropiate inspection, control and maintenance in order to obtain service life of the unit.

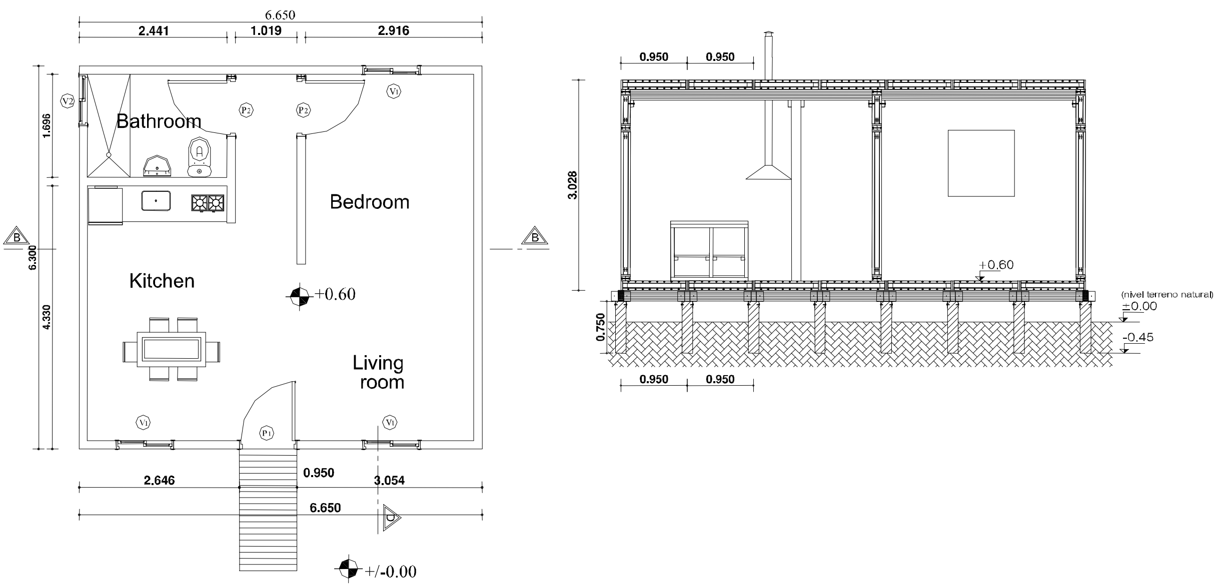
3. USED METODOLOGY

The project of social dwellings has had several stages. The first study was the pathology of social dwellings built with traditional materials during 1999-2004 (Maldonado et al, 2001). The impact of social problem is reflected in the results of surveys in relation to habitability and comfort (Pizarro et al, 2003).

Different types of masonry panels are experimentally evaluated in 1:1 scale (Maldonado et al, 1998) and wooden panels (Rotella, 1992).

These studies generated the design of Modulus for Seismic Emergency with the possibility of growing of the unit for no traditional materials (Pizarro et al, 2006). Figure 1 shows the drawings of MSE.

Aspects of safety, habitability and durability are evaluated in social dwellings panels built with local wood or wooden residues in a polymeric matrix. The mechanical properties of walls are evaluated by standardized tests. To evaluate the durability of dwellings, prototypes are being built at natural scale.



Plant Section

Figure 1: Drawings of MSE

4. RESULTS AND DISCUSSION

4.1. Results of Structural Safety

The result is the media of five tests. The dimensions of specimens correspond to the natural scale of panel (about 1.2 m x 2.4 m) and the thickness is variable according to backfill. In both panels the framed structure, the upper beam and the lateral supports are made in “Alamo criollo” or populus nigra wood, the backfills are variable in thickness and material (polyurethane foam, extruded polystyrene, gypsum board, dovetail).

The mechanical results confirm that wooden panels verify the requirements of Code of Seismic Resistant of Mendoza (1987) Article 7.4.1. for Group 3: Very soft wood with density less than 0.45 and resistance level II . Although it is a low density wood, populus nigra wood has important stability under environment conditions because of the climate which is mid-dry. The tests confirmed the appropiate distribution of fasteners, nails, staples and screws depending on the conection.

For mitigation of fire risk, the panels would be recovered with gypsum board. They would also require protection for termites and sun-exposure (IRC, 2003).

Figure 2 presents lab tests of Table 1 for oriented strand board panels which are presented more flexibility than populus nigra wood panels and a higher thoughness.

Table 1: Results of characteristics mechanical of panels

Evaluation	Unit	National standard	Populus nigra panel	OSB panel
Compressive resistance	MPa	IRAM 11588	7.2	0.82
Flexural resistance	MPa		7.8	4.0
Elasticity modulus	GPa		72	
Excentric load Hard impact Soft impact		IRAM 11596 IRAM 11595 IRAM 11585	With unimportant damage	Without damage
Termal transmitance	Kcal/h.m2K	IRAM 11564	0.964	0.405
Acoustic Transmitance	Dba	IRAM 4044	---	35.3
Density	g/cm3		0.420	0.600
Toughness			Few toughness	Higher toughness

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Figure 2: Laboratory tests on OSB Panel

4.2. Results of Habitability

The classification of bio-environmental due Standard IRAM 11603 sets four different zones in Mendoza, from Zone IIIa (moderate climate with great thermal range), Zone IV a and b (cold moderate climate with thermal range), Zone V (cold) to Zone VI (very cold). Thus, the design drawings for social dwellings are unique and the environment condition is not taken into consideration.

The condensation evaluation is a complex phenomenon, variable in time and depending of the position in the housing unit. The studied constructive solutions only achieve at minimum level of standard (level C) because they guarantee the minimum conditions of healthfulness and sanitation. They do not consider the concurrent effects of other simultaneous variables: water filtration by splitting or joints, moisture by capillarity, residue moisture of building site, thermal bridges, and interstitial condensation due to lack or insufficiency of steam barriers.

Table 2 presents the minimum conditions of habitability for the level of comfort of the highest seismic risk (Great Mendoza, Argentina, INPRES, 1989) under standard IRAM 11603, thermal coefficient by standard IRAM 11601 and superficial condensation and interstitial condensation by standard IRAM 11625, obtained by theoretical models of standards.

The interstitial condensation reduces the isolation capacity of enclosures therefore the same materials situated en different positions can be opposite results. In seismic zone some thermal bridges are unavoidable because different materials are combined and for this it is necessary to create details of quit water, protection of different materials and to vent (Maldonado et al, 2005).

The acoustic condition is a difficult-to-measure quality but one that has a significant effect on the occupants. The lab tests at natural scale confirm the necessity of improve this condition with additional gypsum board panels.

Table 2: Values of parameters of habitability by IRAM standards for studied panels (Zone IIIa).

Item	Thickness (m)		K (kcal/h.m2.K) (IRAM 11601)		Superficial condensation (IRAM 11625)		Interstitial condensation (IRAM 11625)	
	pps. nigra	OSB	pps. nigra	OSB	pps. nigra	OSB	pps. nigra	OSB
Wall panel	0.135	0.07	0.964	0.4005	Verified C	Verified B	Verified	Verified
Floor panel	0.147	0.07	0.889	0.3932	Verified C	Verified B	Verified	Verified
Roof panel	0.155	0.07	0.807	0.4062	Verified C	Verified B	Verified	Verified

4.3. Results of Durability

Generally, the evaluation of durability is related to other mechanical parameters which are easy to measure such as compressive resistance. The mechanism of aging materials and its correlation with compressive resistance, environment, use conditions and maintenance will be only understood if a prototype is built, and it is maintained a year under the same performance conditions (Law 18, 2000).

Figure 3 shows the prototype built for this study with strand board oriented panels. During the year, the environment conditions were evaluated and details of performance were considered to search solutions for the optimization of thermal bridges. This prototype allows to evaluate the time of erection. Modular panel sections shorten the erection time.

Figure 3: Prototype built for studying performance durability

5. CONCLUSIONS

- The standards in force for traditional materials are adequate but not sufficient to ensure a compatible service life with use and maintenance because they only include structural design.
- The inclusion of durability concept is considered promissory as another action in the design of new material panels.
- The standards in relation to environment are essential to valuate the performance of structure with composed materials.
- The saving of materials cost affects durability in social dwellings because the owners do not make the appropriate maintenance.
- It is essential to include the concepts of habitability, environment, power equilibrium and sustainability in the formation of degree, especially when the users have no sufficient funds for repairing or replacing dwellings.
- It is important to evaluate the performance of new materials under vertical and horizontal loads in order to solve the problem joints. The studied panels show strenght and energy efficiency.

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