

REHABILITATION OF A SINGLE-FAMILY HOUSING IN BUENOS AIRES, ARGENTINA, USING MATERIALS MADE OUT OF RECYCLED WASTE

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ABSTRACT

The purpose of this research is to contribute to the utilization of construction and demolition waste (CDW), while reducing the use of cement and the environmental impact produced by the traditional manufacturing of blocks, bricks and cladding, making construction materials out of elements usually discarded in landfill such as the paper bags of cement, lime, adhesives and additives plus expanded polystyrene from discarded packaging and recycled wood that will be used for molds.

It points to the manufacture of durable, affordable, lightweight and with good thermal insulation construction materials.

These materials will be applied to the rehabilitation of a single-family housing in the city of Buenos Aires, Argentina, through criteria of sustainable design, as part of the case study within the research project named *Mixtures with low proportion of cement or other binders applicable to materials and construction techniques using recycled paper and natural fibers in its composition*, which is directed by the authors.

The building to rehabilitate dates from 1920 with constructive type of bearing walls in common bricks. Its architectural typology is called "Casa Chorizo".

Through expansion carried out in 1957 it was added a second floor with independent concrete structure and common bricks enclosing walls. Due to the expansion of a neighboring house, problems of reduction in solar lighting and moisture filtrations took place. The building presents ceilings and walls with humidities plus fissures, and damaged interior and exterior plasters.

It is planned the making of ceiling tiles, walls cladding, furnishing and green wall modules made out of papercrete and natural fibers. It is expected that the use of papercrete in ceilings and walls contribute to regulate rooms moisture, improving their acoustic and thermal insulation properties.

Materials and molds will be manufactured in situ, made to measure, without causing either garbage or surpluses, this will allow to avoid also the expenses in charters, fuel and emissions due to the transportation of finished materials. The rehabilitation site is intended to be a factory and a school simultaneously, qualifying the workers in a technology that is simple, replicable and environmentally friendly at the same time.

Keywords: waste, rehabilitation, papercrete, polystyrene, natural fibres.

1.- The Problem of waste in the city of Buenos Aires and its reduction

The Autonomous City of Buenos Aires (CABA) buries every day more than 6,000 tons of garbage in landfills that are located in suburban Buenos Aires and processes the waste produced by its nearly three million permanent residents and three million visitors per day [1].

The Law N ° 1854 of zero waste, sanctioned on 24/11/2005, sets a timetable for the progressive reduction of the burial of waste of 75% for 2017, taking as a basis the levels sent to the public company which carries out disposal in landfills, CEAMSE (Society of the State for Ecological Coordination of Metropolitan Area) during 2004. This law prohibits completely the burial of usable and recyclable residues for the year 2020 and among its specific objectives are the following ones:

- To promote the use of the urban solid residues, provided that no combustion is used.
- To diminish the negative effects that the urban solid residues could produce to the environment, by means of the incorporation of new processes and clean technologies.
- To promote industry and market inputs or products obtained from recycling.
- To encourage the use of objects or products in whose manufacture is used recycled material or that allows the recycling or reuse [2].

Both the Zero Garbage Law and the Law on Minimum Standards for Environmental Protection in Residential Waste No. 25,916, require the recovery of waste and decreasing sent to landfills. Reduction targets have not yet been reached but according to an article on the website of Greenpeace dated July 24, 2014, the downward trend of garbage began in 2012 with a warm percentage grew during 2013 and continued during the first trimester of 2014 [3].

1.1.- Waste paper from CDW and MSW

Waste from construction and demolition (CDW) such as paper bags of cement, lime, adhesives, additives, paperboard from boxes of cladding and faucets are dumped daily in the landfills along with remnants of paints, varnishes, cans, plastic containers, wood, set material, etc., the latter are also separated and disposed of as MSW. There are also wastes of cups and cardboards made of coated paperboard as well as paper labels discarded by bottlers which are not recycled in the CABA and are usable as components of concrete mixtures. According to the Association of Portland Cement Manufacturers (AFCP) in 2013 199.044 Tn (3.980.880 bags of 50 kg) were delivered in the CABA [6]. Each bag weighs 200 grams, totaling 796.176 kg a year. According to own survey to a local hypermarket of construction, cement represents only 16.55% of total sales of bagged products.

1.2.- Specific problems of CDW waste paper and the recycling of paper in Buenos Aires, Argentina

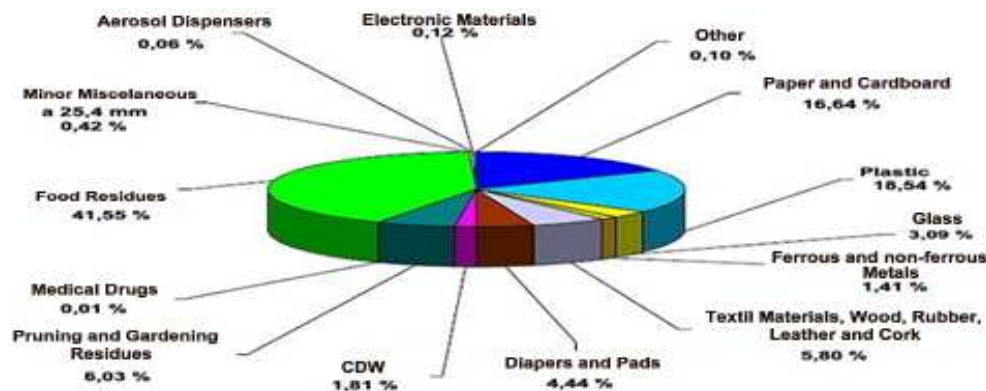
Through a telephone consultation made to the Government of the city on final disposal of waste paper and cardboard from construction sites, we were informed that they are separated and disposed as Municipal Solid Waste (MSW).

According to the Argentina Chamber of Paper and Allied "Almost any type of paper can be recycled, although some are more difficult to treat than others, eg. covered with plastic or aluminum, these wastes are not recycled due to the high cost of the processes involved. "... "Reality in Argentina: In our country is not still developed this branch of industrial activity. There are some isolated initiatives in quality recycled paper fibers, but still not available in the local market. Some private companies and institutions of different industries have taken advantage of this global trend for their corporate communications or policies of corporate Social Responsibility "[4].

Components	TOTAL COMPOSITION
Papers and Cardboards	16,64%
Newspapers and Magazines	4,58%
Office Paper (High Quality)	0,39%
Mixed Papers	7,60%
Cardboard	3,60%
Tetrabrick Packages	0,46%

Table 1 “Entire physical composition of the CABA - 2010/2011. Paper and Paperboard”. Source: Study of Quality of Solid Waste Metropolitan Area [5].

According to the Study of Quality of Solid Waste of Greater Buenos Aires [5] the amount of paper waste collected daily in the CABA is 519, 50 tons, being a 16,64% of the total amount. (Table 1 and Graphic). In this research we take into account also a telephone consultation to the Government of the City about disposal of paper and cardboard waste from construction work, confirming that these are separated and disposed of as solid waste (MSW). We assume that such wastes are discriminated as Mixed Paper (Table 1).



Graphic 1 “Average Physical Composition of MSW CABA - Year 2011”. Source: Study of Quality of Solid Waste in Metropolitan Area [5]

1.2.3.- Quantification of paper and paperboard profitable for making materials

We start from the assumption about Mixed Paper mentioned in point 1.2. So, if on the 519,50 Tn of paper and paperboard waste harvested daily (16.64% of the Total) (Table 1 and Chart 1) [5], we apply the 7.60%, corresponding to Mixed Paper, it turns out to be 39,48 Tn. "Of the total waste generated that is collected by the urban hygiene services, it is estimated that 19,8% would be potentially recyclable material, representing approximately 523 tons per day" [5]. Discounting of the estimated 39.48 Tn that 19.8 %, we can see that 31.63 Tn would be discarded. If we were recycling only 50 % of 31,66 Tn, it would prove that 15.830 kg per day or 5.777.950 kg a year could be exploited in the CABA for the manufacture of materials of thermal and acoustic insulation, cladding or housing construction (Table 2).

Non-recyclable paper and cardboard	Paper per brick	Bricks for a house of 50 m2	Paper for a plate of 25 cm x 50 cm	Plates of 25 cm x 50 cm for a house of 50 m2	Bricks to be made	Plates to be made	Houses of 50m2 to build
	kg	u	kg	u	u	u	u
5.777.950	0,28	7.800	0,56	800	20.635.535	10.317.767	2.645

Table 2 “Possibility of manufacturing materials and building houses on the CABA per year by mixing cement with paper and paperboard waste”. Source: the authors

2.- Papercrete, concept, state of the situation

Concrete is the material of construction most frequently used throughout the world due to its excellent characteristics. However, the manufacture of cement involves large costs to the environment. Something similar happens with bricks because of the use of large amounts of energy for cooking, adding in the case of the common bricks the destruction of the fertile layer of the ground used as raw material. At the same time numerous unemployed people and social cooperatives members attend to the CEP led by arch. Carlos Levinton, in search for advice to build their houses or support to create micro-enterprises. During the training they learn how to manufacture new products that comply with the paradigm of sustainability, including those products created within the Project SI TRP 18 which is being carried out from March 2013 and that aims to develop different formulas using recycled paper and natural fibers mixed with a small proportion of binders such as cement, lime or clay. The use of papercrete as a construction material aims to reduce the amount of cement used in the construction industry, using an abundant residue at the urban level, and contributing to the creation of materials that are at once economic, lightweight and with properties of thermal and acoustic insulation. "At the end of the 60s, was carried out in other countries a systematic evaluation of the engineering properties of natural fibers and the compounds formed by these fibers with the cement. The results of the research indicate that the fibers can be used with success to make construction materials. It was subsequently developed manufacturing processes suitable for commercial production in several countries of Central America, Africa and Asia. Products made with portland cement and not processed natural fibers as sisal, coconut, sugar cane, bamboo, jute, wood etc., have been tested to determine their engineering properties and its possible use in the construction in at least 40 different countries." [7]

2.1.- International background

In the United States, in the Department of Civil and Environmental Engineering from the Arizona State University, J. Santamaria, B. Fuller and A. Fafitis, carried out various tests on papercrete and evaluated several constructions made in that country over the past few years. The results of this study indicate that it is a safe and convenient material for residential construction of up to two floors, while show that the main problem of the material is the lack of systematic research about the same [8]. Different research on the use of paper and natural fibers associated with lime or cement as components of construction materials have been developed in the world in recent years. Some of them have given rise to successful commercial ventures, having been applied materials made from paper or natural fibers both in the construction of load-bearing walls as in the form of thermal and acoustic insulation and mixtures for interior walls cladding tiles [9a].

2.2 .- Background in Argentina

- The Architect Horacio Berretta and his colleagues at the center of the Affordable Housing (CEVE), Córdoba, developed around year 2003 a technology of bricks, blocks and plates using raw materials such as shell of peanuts or paper [10].
- Since 2003 within the program of the Museum of the Recycling, of which she was a founding member, the director of this project began to experiment with bricks and pieces for cladding made with papercrete.
- In 2013 Federico N. Andres, Loreley B. Beltramini, Anabela G. Guilarducci, Melissa S. Romano and Nestor O. Ulibarrie, belonging to the National Technological University (UTN), Santa Fe, presented a paper which analyzes

density and resistance to compression of the waste generated by a plant that produces recycled cellulose pulp, for the study of the homogeneity of the obtained material, also examining their feasibility to manufacture panels [11].

- In 2014 the industrial engineers of the UTN San Nicolás, Alvaro Montaldo and Nazareno Tontarelli, unveiled the project of a material formed in a 85 per cent by recycled newspapers with the addition of salts of borax, which would allow to substitute imports in cellulose insulators [12].

3. - Analysis of the case study in healthy and sustainable rehabilitation

3.1 - General objectives

Contribute to:

- The burial reduction of MSW and CDW.
- Promote the use of MSW and RCD for the generation of new products.
- The reduction of environmental impact caused by the use of virgin raw materials in the manufacture of ceilings plates, wall coverings, blocks and bricks, while reducing the use of cement.
- The decrease in the cost of fuel used in transportation of raw materials and finished products to construction site.
- The active participation of Architecture students of all levels in the design of new products and their production processes.

3.2.- Specific objectives

- Fabricate plates for ceilings and interior walls paneling inside the Case Study, feasible to be placed quickly and manually, using mixtures that include paper residues that are usually discarded in landfill and using expanded polystyrene packaging and phenolic or wood waste from MSW or CDW., to build the molds.
- Develop products that do not require cutting processes or that release pollutants or harmful substances in their stages of manufacture and assembly, using healthy materials criteria [13a].
- Manufacture plates with no specialized manpower to verify feasibility of the subsequent transfer of the model to cooperatives with the creation of green jobs and a low-cost investment.

3.3- Methodology

- Previous work: analysis of the case of study, its description, background, surveys and definition of criteria for selection of materials, study of products on the market.
- Selection of the most suitable mixture of all the investigated
- Design of plates for the ceiling of the Entrance Hall including boreholes and determination of support and fixing elements.
- Training of student interns at FADU UBA in the manufacture of moulds and plates.
- Processing of recycled materials and acquisition of virgin materials.
- Manufacturing of plates, drying, control of dimensions and weights.
- Transferring of plates and installation in their final location.
- Preparation of a manual on the experience to transmit to students, cooperatives and microentrepreneurs.
- Controlling the performance of the already placed plates over time relating to: bending, loose materials, dimensional changes, color changes, loss or deterioration of the laquer coating.

3.4.- Description of the case study

The building is geographically located in a central area of the city, with a wide range of trade and transport. There are no floods because the street has good runoff and the House is 20 cm high. It is located in bioclimatic zone IIIB which is humid and warm, according to IRAM 11603. With a total area of 136 m², it is an original construction without proper maintenance, whose ground floor dates back to the 1920s and the first floor of the years '50, including refurbishment of the ground floor. The original construction system, as stated in the introduction, corresponds to the typology of bearing walls of common bricks without insulation in foundation, and generous heights allowing the inclusion of ceilings and revetments.

3.5.- Background of the study for the implementation of healthy materials

In 2012, the ground floor of this property was measured and analyzed in depth, as a thesis for the seminar "The selection of materials in the times of sustainability", dictated by the arch. Susana Mühlmann in the Faculty of Architecture of the University of Buenos Aires, with the name of "Survey of a site and the planning of its remediation with healthy or with environmental low toxicity materials applying sustainability criteria" [13b]. Includes a detailed survey all rooms, analyzing them particularly and classifying them according to the same state, taking into account different variables and considering each venue as Good, Regular or Bad, as appropriate. These evaluated variables were: a) moisture; (b) mold, fungus and greasiness; c) cracks and others; (d) lighting, ventilation and comfort. (e) equipment; (f) general. The room taken as a first case study for remediation is the entrance Hall to the Studio, with a surface of 1 m x 2.35m, and two steps in transverse direction, height of three meters. According to the classification referred to above, it can be seen that the limestone mosaic floors and plumbing were in good condition, regular State timber doors, and walls and ceilings (plaster and painting) in bad state. With regard to the first variable, the Hall was considered in bad state due to moisture on the ceiling and walls, with detachments of plaster, due to moisture from a neighboring house. Mold, fungi or grease were not detected (good condition) nor cracks (good), ventilation, comfort were also good. The Lighting equipment was considered in Regular state featuring only one incandescent lamp. It was proposed to change that lamp for a LED. After the analysis it was developed a comprehensive proposal of remediation and replacing materials of the sector under study. At the time of the thesis presentation by the year 2012, the proposal for the Hall consisted of covering walls with Superboard (plates of fibrous cement without asbestos) on metallic structure, leaving a ventilated space between ceiling and plates. Additionally, the neighbour was asked to repair the humidity in the divider wall.

3.6.- Evaluation criteria for the selection of materials

It was agreed for the present case the following criteria on the materials:

- That they do not emit pollutants or harmful substances in their stages of manufacture, assembly and use in accordance with healthy materials criteria [13c].
- That MSW and/or CDW can be used for their fabrication.
- That there be no need to generate cuts of pieces.
- That the maximum weight per unit does not exceed 4 kilos (because the placement of the plates will be made by autoconstruction and a sector of the Entrance Hall is 3 meters height).
- That the plates are pierced to filter the light from the ceiling
- That ventilation can be generated between ceiling and slab.

- That may be of low reverberation, with good acoustic and thermal properties, fire resistant, and with ability to regulate the rooms humidity.
- That can be customized to user preferences, since the housing is also an artistic, architecture and photography office.
- That the cost does not exceed 30% than similar materials in the market.

Intern students of the Center fabricated the ceiling plates as part of the Project Workshop. The plates were moved from the Faculty to the construction site making use of trips needed for other uses by the owner of the housing object of this Case Study, who is simultaneously a volunteer for the application of the badges in her domicile and codirector of the Project.

3.7.- Comparative tables of similar materials

Brand and Model	Material	Recycled Material	Surpluses	Plates Measures in mm			Volume per plate m ³	Specific weight in kg/m ³	Quantity of plates in units	Total weight of plates in kg
				Width	Length	Thickness				
				A	B	C	D: (A)*(B)* *(C) in mm	E	F	G: (D)*(E)* (F)
Knauf Fine	Wood Fiber	NO	YES	600	1200	25	0,018000	496	3,19	28,52
Durlock Clásica	Gypsum	NO	YES	606	1212	6,4	0,004701	890	3,13	13,10
Isover Andina Isocustic	Fiberglass	NO	YES	610	1220	20	0,014884	50	3,09	2,30
Standard Superboard	Concrete	NO	YES	1200	2400	8	0,023040	955	0,80	17,57
CEP Plate	Papercrete	YES	NO	265	500	12	0,001590	684	16,00	17,40

Table 3 “Comparison of indicators of volume, weight and surpluses of plates for an Entrance Hall of 2,30 m²”. Source: the authors

Brand and Model	Material	Number of plates required for Hall: 1m * 2.3m	Surpluses in m ²	Production site	Transfer Distance from Factory in Km	Distance from the nearest distributor in Km
Knauf Fine	Wood Fiber		0,58	Luján de Cuyo, Pcia. de Mendoza	1.100	3,80
Durlock Clásica	Gypsum	4	0,66	Pcia de La Pampa	710	2,28
Isover Andina Isocustic	Fiberglass	4	0,70	Llavallol Pcia. de Buenos Aires	26	3,61
Standard Superboard	Concrete	1	0,57	San Justo, Pcia. de Buenos Aires,	14	3,61
CEP Plate	Papercrete	16	0	Pasaje Ortega al 900, CABA	0	0

Table 4 “Comparison of indicators of distances travelled by materials”. Source: the authors

Material	Price per m ² at 28/01/15
Superboard plate	\$ 97,22
CEP papercrete plate	\$ 30,00

Table 5 “Comparison of prices between the two main options selected”. Source: the authors

The price per m² plate corresponds to a social cooperative manufacturing equipped by means of a state subsidy and a work place provided by state or municipal institution. Raw materials, wages, insurance, social work, electricity, professional accountant, taxes, cleaning and contingencies were considered for the calculation.

3.8.- Ground floor survey

Shown below the surveys carried out for the said seminar. In (Fig 1) survey of Ground Floor and in (Fig 2 and 3) photographic survey.

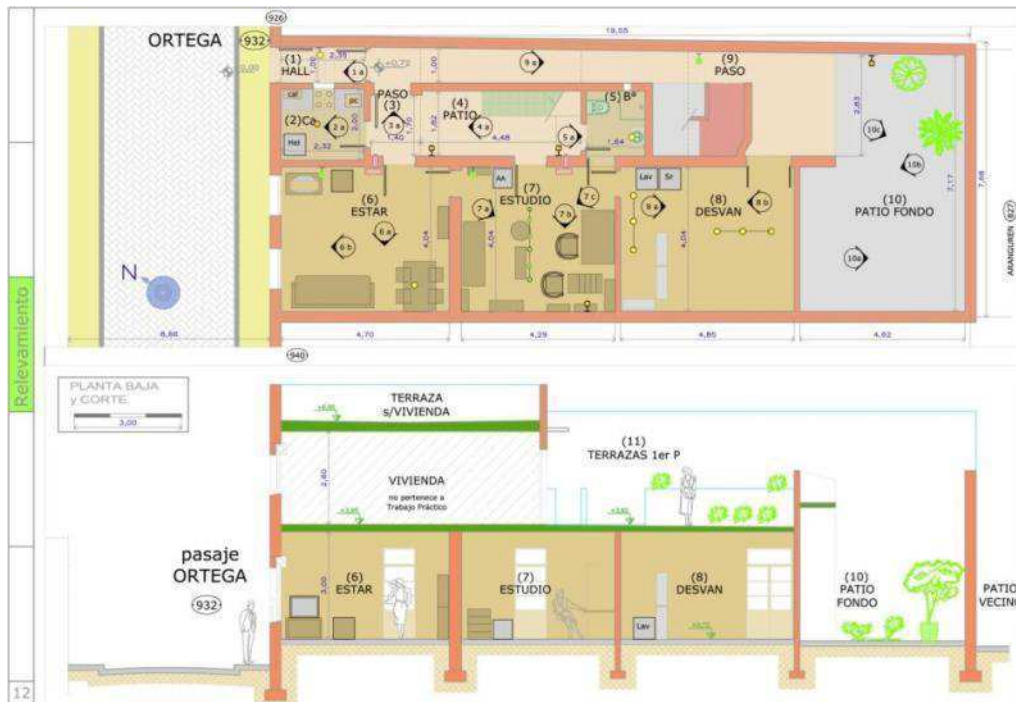


Fig. 1 "Survey plan of the Ground Floor". Source: the authors



Fig. 2 "Photographic survey of the Ground Floor". Source: the authors



Fig. 3 "Photographic survey of the Hall". Source: the authors

3.9.- First stage: ceiling of the hall made with the selected material

On the basis of a comparison of market products, including the raised in the Seminar thesis (Superboard) [13d] and applying the criteria in section 3.6 and 3.7 , we chose to use the plates for ceilings and wall coverings in papercrete designed within the project of reference (See Tables 3, 4 and 5). We discarded the use of Superboard because of their high unit weight, the Fiberglass plates because of the detachments of particles and the wood fiber plates because of its high weight. On the other hand, in all the products that were not selected, cuts were needed generating surpluses and requiring more tools and supplies.

The plates were assembled in half an hour by two people on omega decorative profiles, with satisfactory result (Fig. 4). Its advantages and possible disadvantages will be evaluated throughout two years from its placement.



Fig 4 “Plates used for the ceiling and ceiling of the Hall completed”. Source: the authors

3.10.- Description of lightweight papercrete plates used or to be used in this rehabilitation project: design, production process and molds.

Papercrete plates turn to be lightweight, resistant to fire and evidence properties of thermal and acoustic insulation. They can be compared with the gypsum boards, with the advantage that they do not rot in contact with water in the event of a leak. They can be used as plates for ceiling and interior walls cladding. They can be applied on a wall as a ceramic tile. Alternatively they can be mounted on metal or wooden slats, replacing the plaster and thus saving material and workmanship in this category. They are paintable, they can be sawed, bolted and nailed [9b]. The joints can be apparent and part of the aesthetics of the wall, without bands and putty for joints, which in drywall are frequently evident. They can be manufactured with different embossments (Fig. 5).



Fig. 5 “Some models of plates for walls cladding”. Source: the authors

The mixture is achieved by blending the paper with water, adding cement in the suitable proportion for the material to manufacture and an acrylic or vinyl additive to the mixing water to improve the properties of the mixture. The Formula used for the ceiling plates of the case study is: 1/2: 1: 1/8 (cement, liquefied and drained paper,

acrylic sealant). A mesh is also incorporated to withstand the bending, this mesh can be of metal, fiberglass or recycled plastic. There is the possibility to add color in the manufacturing stage in a simple and inexpensive way sprinkling the molds with ferrite before pouring the mixture. In this case it will be necessary to apply a water based finishing laquer to the plates. After moulding it should be applied manual or vibrated compaction. The molds that are used in this research are of our own design and are made mostly with construction waste such as expanded polystyrene, wood, phenolic wood and MDF for the main body of the molds and residues such as coffee pods, remains of pipes or PET bottles to achieve the perforations in the case of perforated plates or hollow blocks (Fig. 6).



Fig. 6 “Manufacturing of molds with recycled polystyrene and coffee capsules”.
Source: the authors

The Molds (Fig. 6) and plates for ceiling (Fig. 4) were entirely manufactured in the Faculty with students in internship programs, to evaluate this way if the process could then be carried out by unskilled workers. The molds for the plates of the second stage will be also manufactured by students and transferred on loan by the FADU. They will be tailored to not originate surpluses or waste, this will also prevent spending on freight, fuel and emissions caused by the transport of finished materials. At the construction site hired operators and university interns at the same time will be trained and will work in the manufacture of de plates, sharing knowledge and experiences that can be capitalized in the future for the formation of a social cooperative.

3.11.- Preliminary tests on papercrete (more information in link [9 c])

The preliminary tests were made on papercrete bricks:

- Workability: Tests of nailing, screwing, drilling and sawing. There were no drawbacks in any of the four operations.
- Fire resistance: performed on a domestic grill generating abundant fire with coal, branches, wood and dried leaves, in a way that should wrap the pieces and keeping it constant throughout the development of the test. 1) Lightweight Formula (1/4: 1: 1/8) (cement, paper, additive). It never took fire, after 1 hour of exposure it shelled a little on the face exposed to direct fire. Two hours later it was removed from the fire and cut in two with a shovel. It can be observed that the inside of the brick burned without flame. 2) Resistant Formula (1/2: 1: 1/4). It never took fire, after 1 hour of exposure it shelled a little on the face exposed to direct fire but less than the Lightweight Formula brick. Two hours later it was removed from the fire and cut in two with a shovel. It can be observed that there is no burning inside. The brick looked integer and was much harder to cut than the Lightweight Formula brick. It follows that the fire resistance is given by the cement. The fewer the cement and the greater the amount of paper, the lower the fire resistance, concluding however that in both cases the inhabitants would have enough time to escape in case of fire.
- Water Absorption and Dimensional Stability under Moisture: Completely dry bricks were weighed with a digital scale. They were submerged in a tub with 8 cm of water. After 24 hours there were removed from the water, dried with a

cloth and weighed again. The best percentages of water absorption obtained so far are: a) Resistant Formula Brick: 19.25 %, b) Light Formula Brick 85.23 %, showing that both measurements are much higher than in the Common Brick (6.19 %). In almost all the analyzed cases, the dimensions are kept unchanged, despite the great absorption, which demonstrates the excellent dimensional stability of papercrete bricks under conditions of extreme humidity. In both Resistant and Light formulas the faces were not deformed under the pressure of the fingers. In the Light formulas the bricks were moderately deformed in the edges under extreme pressure of the fingers.

- **Heat Transmission:** Three bricks were placed against the lid of an electrical stove previously warmed during 15 minutes. After 1 hour the temperature difference on the opposite face between the beginning and the final of the test was: a) Common Brick: 31.9 °, b) Resistant Formula Brick: 27,1 °, c) Light Formula Brick : 19.5 °. The Center has studies on concretes of similar thermal characteristics with a thermal conductivity (λ) of 0,18 W/mk realized in the National Institute of Industrial Technology (INTI).

During the period 2015-2016 it is planned to realize tests for the certification of the system that will be carried out in the INTI (National Institute of Industrial Technology), including thermal conductivity, flexural strength, fire resistance, water absorption, regulation of the Ambient Humidity and reverberation. Trials have been conducted on papercrete in several countries, particularly in the United States, mostly in accordance to ASTM standards [9d].

3.12.- Second stage: interior walls cladding

During this stage the walls cladding will be done using flat and embossed papercrete plates. The plates will be mounted on wooden slats forming an air chamber (Fig. 7). The existing cracks will be hidden this way, achieving a better hygrometric, thermal and acoustic performance which are fundamental topics for a divider wall.



Fig. 7 “Prior to the intervention image: wall with visible cracks (left). Photomontage of wall cladding design (right)”. Source: the authors

4.- Achievements

- There were achieved uniformity of weights, measurements and scantlings.
- There were achieved the expected variety of colors and patterns.
- The ceiling plates were mounted at the construction site by 2 persons in 1/2 hour.

5.- Difficulties

- Scarce funding to develop Research.
- Lack of technology to produce the material in the country.
- Extensive material drying time, having the need to emphasize research in natural additives and sustainable methods of drying.

6.- Conclusions

- 8,96 kg of not recyclable paper were recovered for a surface of 2,3 m², what would represent 90 kg used for manufacture plates for a housing of 50 m².
- Molds and plates were manufactured in 30 hours of workshop with 15 university interns without previous experience who were trained at the Center.
- There was not generation of garbage or surpluses.
- The expenses in charters, fuel and emissions referent to standard materials use were avoided.
- There was stated the lightness, ease of placement, and nice finishings of the installed plates, fulfilling successfully the planned function.
- This Project contributed to the use of MSW and CDW, to the reduction of the cement use and of the environmental impact produced by the traditional manufacture of blocks, bricks and revetments.
- It was possible the application of the triple line of sustainability from an environmental point of view as well as social because it was verified the feasibility of a fast training for people without prior training and economic since it was possible to reach a similar cost or even less than the market materials.

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