

Proposal for the development of an alternative system for wall lining interior partitions to improve existing housing performances, based on use of moulded panels of recycled pulp of cellulose

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Abstract

The present contribution deals with the development of a constructive system for wall lining of partition walls focused on the rehabilitation of existing dwellings that present deficits in terms of insulation and the layout of wired conduits.

The objective of this development is to carry out these constructive tasks with the greatest speed, cleanliness and least inconvenience and environmental impact.

Thus, it seeks to comply with the requirements of adequacy in buildings to intervene, save the inconveniences of current and past rehabilitation systems, and take a step towards the response to those needs that have arisen diachronically in the housing of installations in partition walls.

In response to the above reasons, a composite sandwich construction configuration was designed between the existing support wall body and the back closure plate. The element that joins both parts of the sandwich presents an adequate relieve moulded with a pulp recycled cellulose material called Biprocel.

Key words: *pulp cellulose / wired conduits / dry construction / wall lining / isolation / refurbishment*

1. Antecedents

In Europe the housing construction sector faces an extensive problem of renovation of the already existing heritage, in order to update its services according to the current needs and aspirations of its citizens: more comfort, less energy expenditure and more digitalization (Tezanos, F., Bordas F., 2000)(Ministerio de la Vivienda, 2010). This improvement of the built environment will be produced on three steps: city, building and housing, with a clear differentiation in terms of available resources and governance systems (Cuchí et Alter, 2011) (European Commission, 2011). In this communication, the authors will focus on this third scale and within this scale in one of the most constructive elements that is modified throughout the life of a home: the walls of interior partition. To face up to these challenges, the constructive techniques currently available in the market are not very efficient because they were developed in a very different historical environment:

- low-cost salary
- slow and inefficient work processes
- annoying and unhealthy work processes for the neighbourhood (noise, dust, waste, etc.)

How to solve this challenge in an alternative way, to be faster and more affordable?

- Take advantage of an existing change driver: the growing need for more cabling in homes does not seem to be stopped!
- Take advantage of the new "green" construction technologies to make the circular economy come true
- Foster home-scale renovation, avoiding complex community owners' management
- Take advantage of the dynamics of the real estate market (both rent and purchase)

2. Referents

Before dealing directly with this challenge, it is need to know basic existing references:

2.1 Studies on the current situation of wired installations in housing

According to a study carried out on a sample of 1.500 homes of 164 municipalities of 34 provinces from 15 autonomous communities in Spain (Toledano Gasca, J., De las Casas Ayala, J., Bedoya Frutos, C., 2010) It follows that the interior electrical installations of nowadays homes needs to be improved:

- 23.87% of switches in the living rooms have been modified.
- 25.4% of the switches in the bedrooms have been modified.

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- 23.6% of kitchen switches have been modified.
- 35.13% of the living room sockets have been modified.
- 40.93% of the socket outlets are hidden by furniture.
- 35.20% of the sleeping plugs have been modified.
- 38.07% of dorm room sockets are hidden by furniture.
- 29.6% of the kitchens plugs have been modified.
- 77.67% of the connectors in the living rooms have connected thieves, spools or extensions.
- 64.20% of the plugs of the bedrooms have connected spools or extensions.

At the same time, it is also observed that in the case of telephony, data and TV network:

- 31.7% of telephone connections have been modified
- 16.7% of telephony connections in the living rooms have been modified.
- 38.5% of telephone connections in the dormitories have been modified.
- 12.7% of telephone connections in the bedrooms are hidden by furniture.
- 33.3% of data and TV connections in the living rooms have been modified.
- 18.1% of data and TV connections in the living rooms are hidden by furniture.
- 40.7% of data connections and TV in the bedrooms have been modified.
- 13.8% of the data and TV connections of the bedrooms are hidden by furniture.

This study induces the need to develop simple and low impact technologies to make changes and / or relocations of the surface elements of the electrical installation.

2.2 Patents and commercial offer of products

The technologies for the layout of the current wiring facilities in building have three main solution strategies, none of which consider the removal of the old installations. (Fig. 1)

The wall lining systems seems now to be in the right position to be the solution to improve housing renovation and to support the new wiring layouts.

The dominant material for wall lining now is the gypsum laminated plate (ATEDY, 2011). The main cabling technique for wall lining is situating the cable conductors into a corrugated tube linked to the stud frame.

In this contribution we suggest to define an intermediate product that accommodates the capabilities of the two systems, wall lining and wired network, and allows the group to afford the objectives described in next chapter.

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Strategies	Weaknesses	Strenuous	Threats	Opportunities
- New clearances on the walls				
	- It further reduces the characteristics of the wall	- Noise, dust and waste - Insecure by the workers - Loss of time: make and lose	- Cheap	- There is no need to forecast
- Technical surface channels				
	- Loss of planer but not of habitable volume	- Visible: alters the final architectural aspect	- Easy handling	- Available everywhere and with all kinds of accessories
- Wall lining				
	- Loss of habitable volume	- Expensive	- Hidden	- Opportunity to improve other wall isolation performances: fire, acoustic, thermal, etc.

Fig. 1 Summary table of the diverse systems of layout of wiring in residential buildings

3. Objectives

This intermediate product must fulfil the next objectives:

GENERAL

1. Before the works: plan for adjusting time, cost and quality > apply industrialization and modulation
2. During the works: reduce the run time and avoid the generation of waste > apply small modules, stackable and of little weight

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3. After the works: improve the final technical quality of the set without altering the initial architectural aspect > keep the surfaces aspect

ESPECIFICS

4. Reduce the environmental impact of the new product
5. Facilitate the work processes: its format must be small, mouldable, stackable and weigh little. The material should be easily machined (cut, nail, screw, drill, etc.) and be easy to fix on the existing support, as well as to unite with each other.
6. Facilitate the accommodation of gypsum board plate
7. Facilitate the accommodation of wired networks
8. Facilitate the accommodation of thermal and acoustic insulation products

4. Methodology

- 5.1 Find a material that fulfils the objectives n° 4 & 5.

In this case, the well-positioned materials are the cellulose pulp moulds. Lately, within this family of materials, there have been innovations that have improved their mechanical performance and resistance to humidity (IMFA)(Federico N. Andrés, 2013) . Some years ago, a previous research (Montero, A, Zamora, JL.,2014) induces the possibility to apply cellulose pulp moulds technologies to architectural matters.

In this line, the case of *Biprocel* material, a product developed by a company born in the UPC, stands out from a research project on the transformation of paper waste. In 2011, the patent was published internationally at the request of the UPC and the project became a spin-off.

Biprocel is a suitable material in this application case because it can be modelled to offer the geometry necessary to fulfil its function and because it is a material that respects the environment, from the recovery of a waste, with the possibility of recovering the entire your own residue in the future (crouch to crouch). Also recover residues considered non-repellent (inks, loads and glues) and 100% of the water used in their forming process, they are recyclable.

- 5.2 Find a profile product that fulfils the objectives n° 1,2,3 & 6

- After a benchmarking action, it was concluded that a good product profile for the case set was the insulating panels developed for the radiant floorings.
- In order to define, with realism, what should be the thickness goal of the new product, it was concluded that this dimension was strongly marked by the thickness of the mechanisms used by the electrical industry, which is 50 mm. With the aim of maintaining the same aspect of today's finish, these two thicknesses had to coincide provisionally.
- The new product will be an intermediate panel that will solve by itself the contact between the laminated gypsum plate and the support wall. It is a question of

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a wall lining of the type called semi-direct. In these types of wall lining , the UNE 102043 (2013) standard specifies the type of fixations and the distances between them but with the assumption that the contact is made through a metal profile.

5.3 Modulate the relief of the cellulose panel in order to achieve the objectives nº 7 & 8

- admit the radius of curvature of the electrical wires to insert
- admit the dimensions of the surface mechanisms to be inserted
- admit the dimensions of the derivation boxes to insert
- facilitate the application and adherence of projected cellulose materials.
- facilitate the application and compaction of injected cellulose materials

5. Development of the new panel

5.1 Modulation of the panels

A square modulation of 60 x 60 cm is adopted, because it is very common for the construction of architectural interior spaces. The panels feature relief formed by two types: outputs of support of the plaster plate laminated and outputs to facilitate the insertion and anchorage of electrical wiring. In this relief streets of diverse width are practiced: street for the mechanisms of control and street for the boxes of connection and derivation. (Fig. 2)

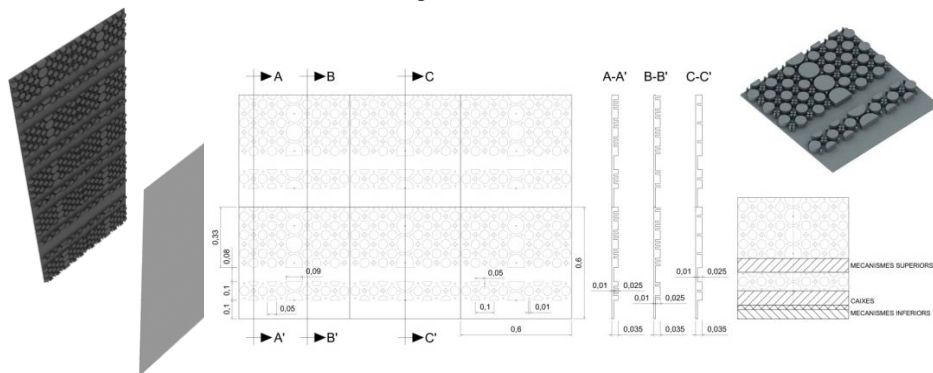


Fig. 2 overall view of the plate, perspective of its outputs and related sections

5.2 Jointing of the panels

The union between the contiguous panels is made by overlapping. In order to apply the panels to the surface of the wall, it begins with whole pieces from one corner and this will produce cutting waste only at the opposite ends and close to the door openings (doors)(fig. 3)

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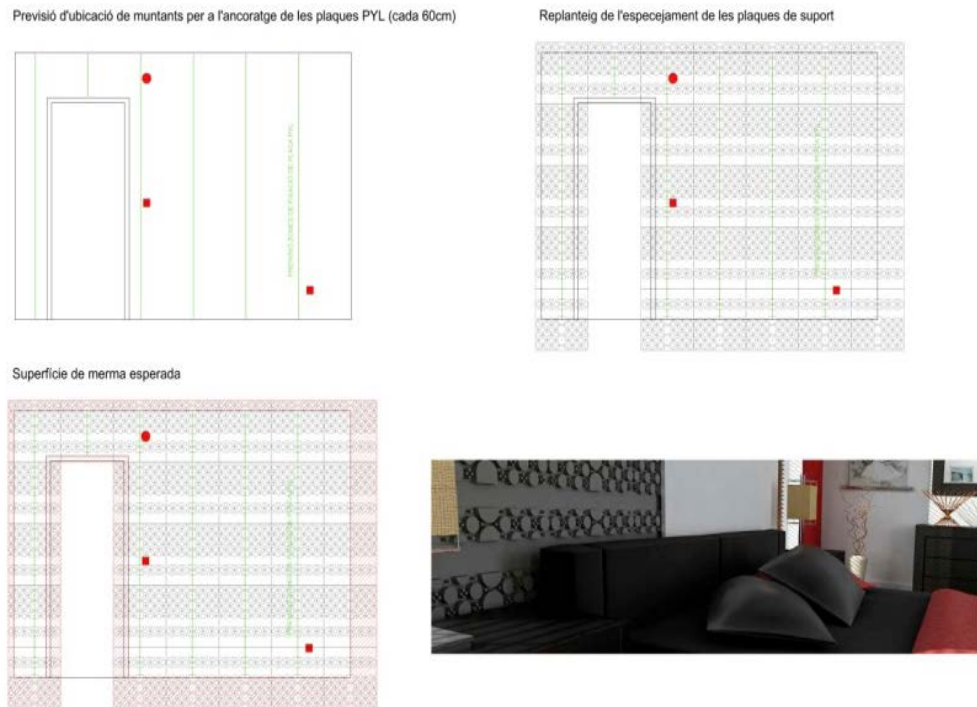
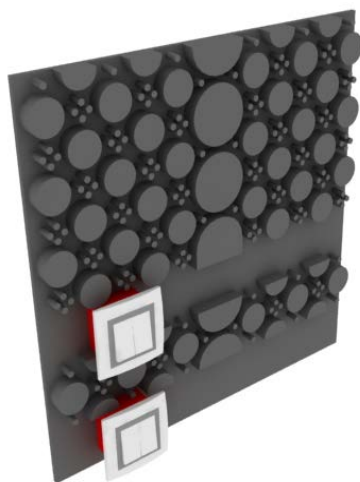


Fig. 3 general view of the application of panels on a type wall; the position of the control mechanisms and the cutting areas are also marked.

5.3 Accommodation of mechanisms

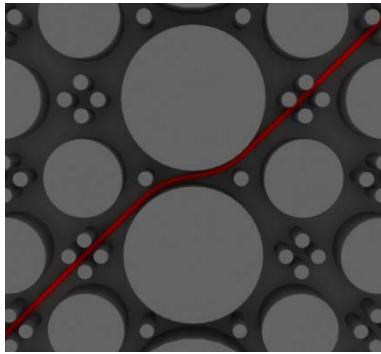


- 74mm street reservation for the socket mechanisms, located from the lower end of the module.
- 74mm streets reservation for switches located at 20cm from the lower end of the module.
- 100mm streets reservation for the derivation boxes located from the lower end of the module
- The casket dedicated to fitting the mechanisms of the electrical installation is fitted in the perimeter relief of the area designed to accommodate it. (fig. 4)

Fig. 4 perspective view of the location and dimensions of the streets

5.4 Location of wired

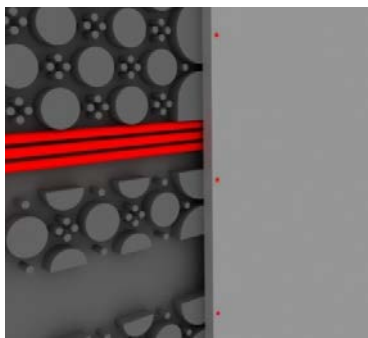
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- The basic outputs are 5 cm in diameter and are placed at diagonal, in vertical and horizontal alignments.
- In areas where it is planned to support simultaneously two contiguous plaster plates, the projections increase in diameter.
- In the free spaces between outputs, there are small sized outputs to facilitate the anchorage of the wiring path. (fig. 5)

Fig. 5 detail view of the insertion of a cable (red) in the different outputs

5.5 Fixació de la placa de guix laminat



- Line alignment of outputs of 10cm diameter in the center of the module, with an interstice between outputs of 1cm. (fig. 6)

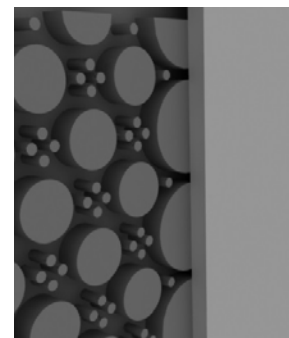


Fig. 6 detail view of the solution adopted at the outputs to support two contiguous plaster laminate plates.

6. Preliminary conclusions

- This research has proposed a new use for a material recycled procedure, which has been promoted by a research group from the same University. This material is respectful with the environment; it is proven by recycled material and generates 100% recoverable waste.
- This first design has responded to much of the premises set. The procedure developed for the application in work of the new product has been satisfactorily evaluated for its use in rehabilitation work.
- The new product can be complemented with the use of the insulating materials projected derived from the cellulose fibre. This incorporation would allow this new product to be applied to the improvement of the partitions that limit with unheated or local premises of other neighbours.

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7. Future challenges: what aspects are pending to develop?

- Improve the contact solution between contiguous pieces.
- Guarantee the physical resistance of fixing anchors between the plaster plate and the new product and between the new product and the pre-existing wall.
- Facilitate the mechanization and manipulation on the work of the new product to cover the connection and derivation boxes of the wired installation.
- Ensure the behavior of the new product in contact with thermal insulation materials from cellulose projections directly on their faces.
- Achieve an appropriate behavior to the fire of the new product without incorporating additives such as sodium borate, an element that hinders subsequent recycling.
- Gradually reduce the use of 5cm perimeter space around the renovated room.

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