Mountable and Demountable Construction Systems of Interior Building Partitions: Ecology and Sustainability in the Ephemeral Use of Space

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Abstract. This article presents the ongoing research on sustainable construction systems, in terms of interior partitions, as alternatives to masonry or plasterboard techniques.
Emphasis was given on assembly's simplicity, to guarantee an easy execution by anyone without specific preparation or knowledge in construction (so the common dweller can respond quickly and effectively to the changing behaviour and needs of the household), but also to emergencies resulting from unforeseen circumstances, such as the current pandemic situation.
The research was grounded on the use of materials with a reduced ecological footprint (based on Portuguese forest resources), and on modular construction processes (adaptable to most pre-existing situations). Additionally, such materials should allow a successive assembly and disassembly, using the same construction elements, a feature in which we can truly defend a decreased environmental impact. The purpose is to minimize waste and to create a circular economic circuit that continues after its components' lifespan, whose materials allow them to be recycled for other uses.
Methodologically, the existing partition systems, in terms of patenting but also market availability, were surveyed and analysed. Simultaneously, the consequences of the household's behavioural changes in the domestic space, as well as those imposed by lockdown and remote work, were studied for our proposals to respond to the assessed needs more effectively, in terms of privacy, and thermal and noise isolation.
The collected information was used to create several proposals for interior partitions, exploring different construction and assembly processes, with variable degrees of complexity (later prototyped to measure its viability), to reply to the dweller's different requirements in response to everyday life or exceptional circumstances.

Keywords: Walls, Demountable, Domestic Space.

1 Introduction

Even before privacy became a concern, according to its contemporary definition, dividing spaces and creating pathways has always been a concern - not only because of practicality but also due to social and ritual purposes - even if through movable objects (Krampen, 1989, p. 130).

Martin Krampen sought to establish a difference between architecture and design, in which the most obvious distinction was the scale of its constituent elements (object *versus* container). He also added that architecture is composed of spaces divided by fixed elements, while design achieves the same result, but through movable elements (1989, p. 139).

Although space remains a subject in architecture and design, the feature that sustains the current research in the domain of product design is the intention of transforming a wall (by definition, a fixed feature, only changeable through the destruction of its constituents) into a detachable object.

With this in mind, we will present our recent investigation at LIDA (Research Laboratory in Design and Arts) featuring demountable walls in which we tried to guarantee the same acoustic and thermal comfort of a plasterboard (or even brick) wall. Using modular elements, easily assembled by the common user, these solutions sought to be dismantled with equal ease, reusing their components into new walls, in another location and/or with different configurations.

The proposals, despite being walls, can be regarded as movable elements, and more important than being architecture, design, or engineering, is their ability to guarantee sustainability features that existing partition systems can't achieve: they recur to forest resources (pine wood), whose "production", by definition, has a negative CO2 footprint; they allow the reuse of their components through an easy assemble and disassemble method (which eliminates the need of demolitions and the resulting waste); they can be put together easily by the common dweller with no skills in carpentry; they are durable and hard-wearing; they allow the reuse of the wood, once the walls' life cycle ends, into other wood products and derivatives, which can be reintroduced into the market.

2 The Ever-present Need for Change

2.1 The Obsolescence of Contemporary Domestic Spaces

At a domestic level, the notion of an interior wall as a fixed element is sustained by the preconceived idea that the house's dwellers are solely Nuclear Families (parents and their children), which can be an idealized concept. It was sustained by Modernism in architecture, particularly through Functionalism, which determined the house as a merely practical spatial solution, without any kind of sociocultural context: a new form of science ('Translator's introduction', 2002, p. xx), but which in the middle of the last century was already considered as a "fiction, simulating efficiency" (Montaner, 2001, p. 232). In 1970, Mary Douglas, an anthropologist, established the definition of

“Domestic Space” as a place of symbolism and anthropology, opposed to the until then used definition of “Domestic Place” which considered the house as a place merely for practical uses (Cieraad, 2006, p. 1), as did the Functionalists.

This is the main idea behind the definition of “Household” as a house’s inhabitant (rather than “Family”), which, besides the above mentioned Nuclear Family, includes other forms of cohabitation: extended family, members that only occasionally live there but share the same domestic dynamics (Afonso, 2000, p. 156) – or even house-sharing by dwellers that don’t have any blood ties. This suggests that a (household’s) space that is static through fixed elements may not make sense nowadays, since different households use space differently (and move more frequently than ever, in which one household constantly supersedes another). And, if we consider the current migrant flows, the Western Nuclear Family also differs from those of other cultures, and, again, the contemporary house can become inadequate.

2.2 Unpredictability in the Use and Purpose of Domestic Spaces

The closest memory that we can have about the urgency in the transformation of the domestic space refers to the still lived moment of the pandemic crisis, that transformed kitchen, living rooms and bedrooms into offices, schools, or study rooms – uses that previously had no place in these spaces.

Scientific research in this area – the consequences of Covid-19 in the domestic space – is still rare, the most common being those of a socio-economic nature (Cuerdo-Vilches et al., 2020, p. 2), whose information may however serve as a support for future research. A paper describing Brazil’s situation (Loureiro & Campos, 2021) manages to be very informative about new domestic issues regarding the conviviality of the aforementioned functions: it states that domestic distractions (house chores, for example) have always been a problem for those who work at home, but once a room is shared, environmental noises become highlighted; also the scenario showed in video calls is mentioned (because of its domestic and unprofessional look).

Even to those who already had a home office, once it becomes shared, it also becomes an area as problematic as other rooms non-intended for work: constant phone and/or video calls become intrusive when carried out simultaneously. It should be noted that this study mainly covered people with greater financial stability and more spacious homes (considering the Brazilian context). However, the identified problems were the same in poorer or richer households, which makes us wonder if the problem doesn’t reside solely in a house or apartment´s area, but in their layout’s inadequacy to support new requirements, in terms of spatial separation, soundproofing, background’s aesthetic features, and, mainly, its transient characteristics (even if remote work becomes standard to some careers). What we can state with some assurance is that new and future demands in terms of space and use are unpredictable and likely temporary, like those imposed by the current pandemic situation.

3 Existing Products

3.1 Registered Patents

To briefly divide a space, or build a temporary wall, is not a recent problem, and we can find registered patents concerning this issue, referring to different circumstances to those we are currently researching. Maybe because the above-mentioned issues (a changing household and its behaviour) only recently have been identified, or because the need to separate different areas was first sensed in working or professional contexts. However, a survey regarding these case studies remains important because we can learn from them and include some of their features in the solutions we are researching. So, we focused our attention on systems that, besides being walls with movable features, can be applied to pre-existing elements like walls, floors, and slabs (which determine the dimensions of the components of our proposals, and the way they are built and fit into those elements).

Arne M. Kaufman (1974) designed a system of sliding panels ("Movable Wall Panel"), which, once open, created a separating wall. Its innovation consisted of a complex mechanical system, inside the panels, that would allow them to fit into the deformities presented by the slabs if heavy loads or machinery were placed upon them: springs placed internally would slightly change the panels' height once subjected to pressure. Although we are not thinking about such extreme environments for our proposals, the possibility to adapt to hypothetical irregular ceilings is still an interesting feature, even in housing structures.

Closer to a domestic environment, two other inventions are based on prefabricated panels that, joined together through connecting elements, can be made into walls. The Howard, Inc company's invention (Yu et al., 2017) can build cubicles or even walls up to the ceiling, eventually with doors, and consists of an internal structure whereupon it can be applied plasterboard or rigid insulation panels. It can even be used as a support element for office furniture. Like in the Aecemi, LLC company's invention (Hauserman-Winder et al., 2020) the whole system could be disassembled and its components reused in new walls. In this last example, the outside panels are also structural, which simplifies the internal structure, but in both cases, the panels' horizontal union is made through external elements.

The resulting walls are meant to be used in the work environment, and never once the domestic space is mentioned: possibly because its need in such an environment was not considered necessary or economically viable, or simply because its looks weren't "worthy" of being used domestically.

3.2 Marketplace solutions

When we discuss market available solutions, the word "reusable" is always associated with the prefabricated and temporary, but not in the sense that it's meant to replace a fixed wall: it's always seen as a short-term solution for sales stands or displays. Aluminium panel solutions, sustained by outside frames in the same material (*Temporary Wall Solutions | Durable Modular Construction Walls*, 2022) justify their relevance through their use in airports, malls and offices, without the waste, dirt, and inconvenience of demolishing plasterboard walls (*Simple, Reusable, Cost-Effective Modular Wall Systems*, 2022), with the added advantage of supporting advertising.

It is worth mentioning the "RealWall" product (*Temporary Wall Solutions | Durable Modular Construction Walls*, 2022), which manages to adapt to different heights since it is made of two panels that slide vertically through side rails: the juxtaposed area can vary from almost none to the complete upper panel, according to the ceiling's height. It's not mentioned how it's adjusted lengthwise, but it's said to be a practical solution that doesn't require skilled labour. Although the company states that it "has the look and feel of a traditional wall", the result always looks like something temporary.

These solutions are probably just a few of many available in the market, but it seems obvious that they can't be used domestically: their "look and feel", determined by material and assembly process, doesn't appear "cosy", probably because it was not required by its idealized use.

So, this "flaw" can be our starting point in designing our movable walls: the briefing should clearly state that its aim is a domestic product, installed in a domestic environment, with a dignified and permanent appearance, something that the above-mentioned products can't achieve.

3.3 Wood Solutions

Regarding available products, those made of wood deserve a separate chapter, because, in terms of material, they are closer to our current research, based upon Portuguese forest resources. The Systimber product (*Systimber - système de construction en bois massif | Méthode*, 2022), is made of solid wood, in which vertical elements (composed of two glued planks) are placed continuously, stuck together with metallic pins inserted in pre-drilled holes (a patented process, like the remaining system). Rubber stripes are placed into the joints to make the whole system flexible but still wind and watertight.

The design and execution of Systimber make it suitable for exterior walls, but interior walls can also be built, obeying the same principle: the vertical elements are precut according to a previously designed project, and assembled on site. Being an original and patented system, the brand provides scarce information about its product, but according to an available video on YouTube (*Systimber Democlip*, 2022), inside walls seem to be put in place before the construction of the "slab" of the above floor or roof. This, perhaps, is due to the thickness of the vertical elements that make them difficult to handle between floor and ceiling (also, it's probably oversized for interior walls).

Steko, a Swiss company (*HOME - Steko Holz-Bausysteme AG*, 2022), has a system that themselves define as "Lego for adults", composed of hollow wooden blocks (made of several elements joined together) that fit together vertically, just like Lego. The brand has a corner, top, and sloping pieces (for roofs), lintels for doors and windows, allowing a great number of solutions. Since they are hollow, as they are superimposed, they are filled with insulation stones (vibrated for an improved filling) for better thermal and acoustic insulation. The same process is used inside the building and since the wall grows vertically, it must be built before the upper floor or roof.

As solutions created for external walls, and for a permanent structure (being made of wood doesn't make them temporary or mobile), these systems don't allow a great deal of flexibility in changing internal spaces, neither an easy disassembly, nor the reuse of its pieces (it should be emphasized that this was never the idea behind its design, so it shouldn't be considered as a flaw). These are, however, the reasons that make us think that there is still room for a product that can assure what others are lacking: inner partitions easily executed, flexible, allowing disassembling and reuse of its elements, with a visual perception of quality and aesthetics, and easily applied in a domestic context.

4 Ecology and Material Resources in a Socially Responsible Design

The current project is part of broader research called "Forest for Future", of the Polytechnic of Leiria, which aims to employ innovative technologies based on Portuguese forestry resources. At LIDA our goal is to apply such resources in the development of the product that, in the previous pages, we have been finding necessary.

This is the first aspect of a socially responsible design: responding to a need, as opposed to creating one, which was a standpoint that began in the 1960s (Rachel Cooper, interviewed by Dos Santos, 2005). Victor Papanek was one of its main supporters, adopting, in his book "Design for the Real World" (1971), the radical opinion of considering Industrial Design harmful, since it appealed to unconscious consumerism: this was later deemed as an exaggerated and "moralistic" posture by Nigel Whiteley (quoted by Cipolla & Bartholo, 2014). It might be so, but Papanek had the merit of alerting the Design community to its role in a global social conscience that encompasses not only the well-being of the poorer (Third World included) but the whole planet, through an ecological stance involving production, use, and recycling (among other features): Gui Bonsieppe, in 2011, described a Designer as an "intelligent problem solver" of today's challenges like the "planet's sustainable development" (quoted by Fontoura et al., 2018, p. 511).

4.1 The Sustainable Unsustainability

One of the main pillars of our planet's sustainability is nature's ability to regenerate after the raw material is collected. The forest is one of the places where that can happen, hence its use as a resource in the current research project, keeping in mind that such forest must have the opportunity to regrow after the raw material is collected: only then it can be considered as part of a sustainable production and consumption chain.

We can, however, use another paradigm: to remain sustainable through unsustainability. In addition to native species, our territory (like others) has in its ecosystem exotic plants (species which occur outside its natural range). Over time these plants become Invasives, creating "fertile offspring often in large numbers and dispersing them beyond the mother plants", resulting in "significant changes in the ecosystem" (Marchante et al., 2014, p. 12).

This is the case for most species of Acacia, which the ones of Australian origin were introduced in Portugal in the 19th century. Its purpose was to cultivate the sterile and arid areas which at the time reached half of the Portuguese territory "with a special focus on sandy coasts and mountainous areas" (Fernandes, 2018, p. 182). Its invasive potential was noticed early on, also showing little economical potential (unlike eucalyptus, introduced in Portugal at the same time), perhaps due to the small diameter of their trunk, with some subspecies being closer to a shrub than to a tree. We can mention the Blackwood Acacia as an exception, since its heartwood has a "high proportion about the total volume of the tree" (Santos, 2020, p. 17), besides revealing one of the best mechanical properties and durability among the species available in Portugal.

Even then measures were taken (also through legislation) to control its expansion, but, according to Manuel Miranda Fernandes, the intended result was never achieved (2018, p. 186). This author proposes a solution that consists of the reassessment of the economic potential of these plants as raw material (in France its flowers are used in the perfume production), a stance that is also supported by Pedro Santos (2020, p. 14) who included the above-mentioned Blackwood Acacia in his PhD research which focused on CLT panels. Manuel Miranda goes further, suggesting a change of Acacia's species status from "invasives" to "infesting", which would define them as a resource, albeit risky and subject to tight control if its "reintroduction into the socio-economic system" takes place (2018, p. 188).

We, therefore, decided to, cautiously, support his proposal: to search for sustainable use for this species (ecologically, practical, and financial), even if their classification remains "invasive", contributing to its control or eradication.

We didn't, however, trusted solely in Acacia, also choosing a well-known species, in Portugal to sustain the main part of our investigation: Maritime Pine, which can be very sturdy, mechanically speaking (Santos, 2020, p. 17) is also our most common wood, which guarantees a low price (seven times lower than oak, for example).

5 Ongoing Research

Based on the information gathered so far, several proposals are under research, in a more, or less, advanced state. Besides these, other proposals were designed, but dropped along the way, which, rather than a failure, is part of the research process.

5.1 System 1C

Our first idea was based on a U-shaped "rail" bolted to the floor, in which we would fit vertical boards successively, thus creating the wall. Pinewood was chosen to build this "rail", as well as the remaining elements composing the system. A similar rail is also bolted into the walls and ceiling, albeit with additional dept (4cm instead of 2cm) to allow the vertical boards to be inserted: they enter the upper rail the full 4cm, after that they "fall" into the bottom rail 2cm. Since no glues, nails or even screws are used at this stage, it's easy to reverse the process, allowing most of the components to be disassembled without damaging them.

The vertical boards fit at the bottom and into each other, through a V-shaped profile, which adds robustness to the whole system and prevents gaps between them, which also contributes to better thermal and acoustic insulation.

Since all boards are placed vertically, it's easy to adapt them to different ceiling heights: we just cut them at the top, which is easy to do at home, with simple tools. Horizontally, to build different lengths, we can vary the number of placed boards (15cm wide), with the possibility of an additional "half-board" (7cm wide), or punctual supports applied in the vertical rails (which remain hidden). These supports are cut according to the gap in need of fulfilment, another task easy to perform in loco.

It's possible to apply a prefabricated door (200x80cm), and, since the system is relatively light, we also designed a sliding door/panel based upon the same featured elements. Additionally, there are top, corner, intersection, and junction elements.

One of the possible variations of this system could be using a type of wood other than the Pinus Pinaster: Cryptomeria, for example, a Japanese species introduced in the Azores in the XIX century, and widely available, could be an interesting option due to its lightness. As a consequence of its low-density material, it has its limitation when subjected to "large and prolonged structural stresses" (Gonçalves, 2013, p. 6), which is not the case in our proposal: the resulting wall is never structural, and it doesn't have any element in tension, causing deformities.

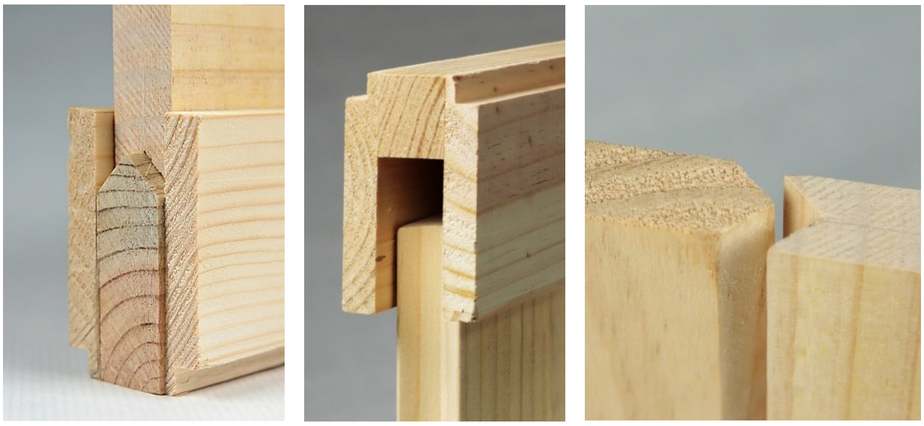

Fig. 1. Early prototypes of the 1C system: lower and upper sockets in the "U" shape rail, made of pine wood; fittings between vertical boards, whose "V" shaped profile guarantees a perfect fit (photos: Pedro Cá).

5.2 System 2 C

As said before, one of the main components of the ongoing research it's the sustainable use of our forest resources, also implying that use should be given to the invasive species. The above-mentioned Acacia, and all its sub-species, are mostly included in this class, therefore its use in this project can and should be considered, to control its growth or even attain its eradication, especially when past attempts to do proved to be unsuccessful (Fernandes, 2018, p. 186).

Most of the Acacia species are shrubs (Marchante et al., 2014), meaning that their trunk is not used to make boards, or even veneer (for example, to produce LVL: Laminated Veneer Lumber). Therefore, its use should be made into something different. If we recall the collected data regarding the shortcomings during the lockdown, we can recall heating and soundproofing as needs to be met.

There have been made successful experiments with plant residues for insulation panels (Gaspar et al., 2020, p. 166), and the composition of some acacia species could suit the same purpose, mixed with other vegetable residues with fibres of different sizes and shapes – a compound with better results, according to studies carried out in this area (Bakatovich et al., 2018, p. 81). If so, it would make sense to propose a collapsible wall system with sound and heatproofing that would address the dwellers' demands and the sustainability requirements that all our current proposals should meet.

Hence the present proposal, 2b, in which the obtained insulation compound, similar in shape and density to the above-mentioned studies, would be the core of a prefabricated sandwich panel with a 5mm plywood exterior.

These panels would be supported by beams or joists attached to the floor and ceiling, the latter with a 20cm depth, so they could be fitted in rooms of several heights (the panels have a hollow upper part that can be adjusted to the upper beam according to the ceiling's height.

The panels would also fit sideways into wall-attached joists, with additional joists placed between them, successively. Like in the previous system, we can design a sliding door/wall using the same detail as the fixed wall, but also use a prefabricated door (200x80cm). To do so we used the door and frame's width to determine the panel's width (42cm, two panels corresponding to the total width of the door and frame).

Since the panels have predetermined measurements in width, there are limitations in the possible length of the wall, even if we partially solve that situation with "half" a panel (with 22cm). They can, however, be proposed with different heights, with the upper beam responsible to bridge the remaining differences between those.

We are aware that the cost of natural fibres' insulation can be high when compared to the more common polymer solutions (like EPS and XPS, which can be twice as cheaper (Santos, 2020, p. 20)), but we should keep in mind that its use is also due to the attempt to eradicate our forests' invasive species.

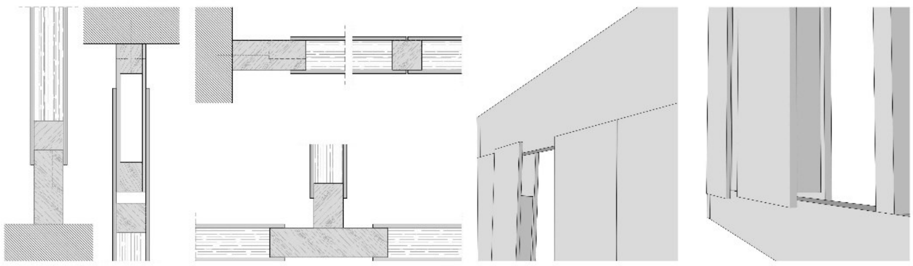

Fig. 2. System 2C detailing: lower and upper fitting system, and horizontal fitting (with corner solution); Perspective of the upper and lower fitting process, where the panels fit into the beams (illustrations by the author).

5.3 System 6B

This proposal sought to combine the characteristics of the previous systems: on one hand, the modularity and adaptability of system 1C; on the other hand, the possibility of offering an acoustic and thermal comfort like system 2B. Therefore, some complexity was added into the design of its components which, however, benefits its builder, not only through its result but also because the assembly process becomes easier.

We started with a common dimension of pine wooden boards (2600x150x2,5cm) to establish an initial module: we predefined several heights for this element (2400cm, 2500cm, etc.), with the upper beam (with 12,5cm in height) responsible to make up for the remaining difference.

Bars or joists (4x4cm) with metal staples will be placed between the vertical elements: these staples will fit in pre-carved slots in the above-mentioned boards, placed successively, until the last one is bolted, keeping in place the previous ones. The result is a double-wall, with the in-between filled with thermal and acoustic insulation, as in the previous system: in this example, however, the insulation is cut on-site according to the available space, instead of being fixed in a prefabricated piece.

Like in previous systems, door frames (for prefabricated doors) and top, corner, intersection, and junction solutions are provided to adapt the whole system to most situations.

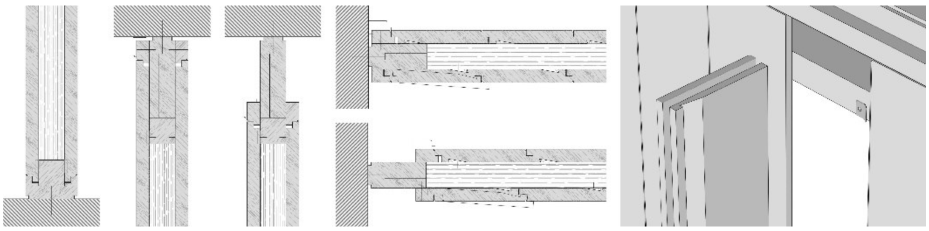

Fig. 3. System 6b detailing: lower and upper fitting system, and horizontal fitting (with the upper and side beams more or less hidden; Perspective of the interior of the boards with the socket in which the metal staples will fit (illustrations by the author).

5.4 System 7F

This last proposal is heavily based on the first one. The main difference is the use of Polycarbonate instead of wooden boards. The cutting and the fitting are similar, although their thickness is just 1cm (with narrower U-shaped “rails”). The idea is to propose a transparent wall (crystal clear or frosted, for instance) that, besides privacy and insulation, manages to get light passing through. We immediately think about office spaces (in which any of the above-mentioned systems can be applied) but we can also think of domestic spaces that require natural light besides separation.

Despite the changes in thickness, the 1C features remain, namely the possibility of applying a prefabricated door, a sliding panel, and top, corner, intersection, and junction solutions.

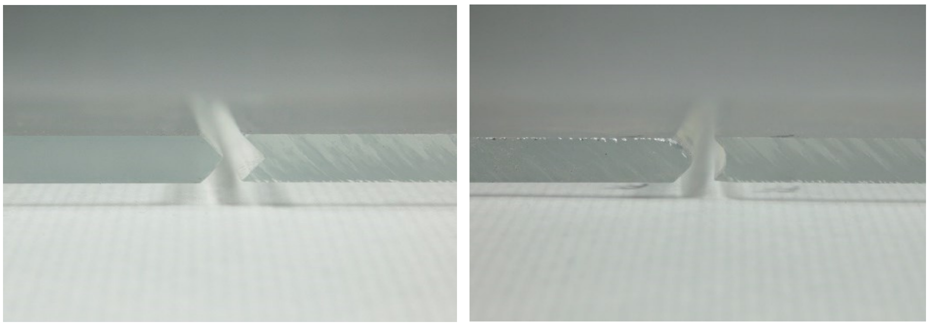

Fig. 4. Examples of early prototypes, with polycarbonate plates, cut with a circular saw and milling cutter (with the first performing better, with a more precise cut; acrylic was for now discarded since it has a lower melting temperature, which resulted in even more inaccurate sections). (Photos: Pedro Cá).

6 In Conclusion

Uncertainty, although it's something undesired, once it's inevitable, should be considered as an opportunity to rethink our constructive systems to make them comply, not only with the households' needs but also with ecological requirements. Sustainability is obtained, not only by using natural resources but also through the quality of the resulting product or constructive solution, which will make the subsequent construction last longer before it becomes unusable. Once the product reaches this phase, there is always the chance to transform and reuse it, introducing it again in the consumption chain.

Assembling and disassembling the same elements over and over, into partitions that can make the house evolve with its household, is also a way to be sustainable, avoiding demolitions and the resulting waste. But, for that to happen, these reusable elements must be part of a system whose features, besides technical quality, must encompass the proper aesthetics and dignity to be used in a house, and turn it into a home. Our present research is, therefore, aligned with these requirements and proposes constructive systems that can become part of a house, as well as part of its dweller's lives.

References

1. Afonso, A. I. (2000). Grupo Doméstico e Mudança Social: Abordagens quantitativas e qualitativas. *Etnográfica*, *IV*, 153–182.

2. Bakatovich, A., Davydenko, N., & Gaspar, F. (2018). Thermal insulating plates produced on the basis of vegetable agricultural waste. *Energy and Buildings*, *180*, 72–82. https://doi.org/10.1016/j.enbuild.2018.09.032
3. Cieraad, I. (2006). *At home: An anthropology of domestic space*. Syracuse University Press.
4. Cipolla, C., & Bartholo, R. (2014). Empathy or Inclusion: A Dialogical Approach to Socially Responsible Design. *International Journal of Design*, *8*(2), 87 a 100.
5. Cuerdo-Vilches, T., Navas-Martín, M. Á., & Oteiza, I. (2020). A Mixed Approach on Resilience of Spanish Dwellings and Households during COVID-19 Lockdown. *Sustainability*, *12*(23), 10198. https://doi.org/10.3390/su122310198
6. Fernandes, M. M. (2018). Acácias errantes, acácias infestantes: Notas sobre a ascensão e queda de uma utopia florida. *Lucanus*, *II*, 180–191.
7. Fontoura, A. M., Ogava, C. de C. das D., & Merino, E. A. D. (2018). A contribuição da gestão de design para a conscientização do consumo responsável como alternativa para o desenvolvimento sustentável. *DAPesquisa*, *7*(9), 510–526. https://doi.org/10.5965/1808312907092012510
8. Gaspar, F., Bakatovich, A., Davydenko, N., & Joshi, A. (2020). Building insulation materials based on agricultural wastes. In *Bio-Based Materials and Biotechnologies for Eco-Efficient Construction* (pp. 149–170). Elsevier. https://doi.org/10.1016/B978-0-12-819481-2.00008-8
9. Gonçalves, C. (2013). *Caracterização da madeira de Cryptomeria Japonica D. Juan produzida nos Açores* [Dissertação de Mestrado em Engenharia Florestal]. Universidade de Trás-os-Montes e Alto Douro.
10. Hauserman-Winder, P., III, S. F. F., Gindlesparger, M. E., Astorga, M. M., Campbell, A., Sieling, H., Nawrocki, P., Hicks, J. K., & Domenico, C. (2020). *Modular and reusable temporary construction wall* (United States Patent No. US10731339B2). https://patents.google.com/patent/US10731339B2/en?oq=temporary+walls
11. *HOME - Steko Holz-Bausysteme AG*. (2022). https://www.steko.ch/en/metanavigation/home/
12. Kaufman, A. (1974). *Movable wall panel* (United States Patent No. US3798839A). https://patents.google.com/patent/US3798839/en?oq=temporary+walls
13. Krampen, M. (1989). Semiotics in Architecture and Industrial/Product Design. *Design Issues*, *5*(2), 124. https://doi.org/10.2307/1511519
14. Loureiro, P. S., & Campos, P. E. F. de. (2021). Covid-19: Teletrabalho e tele-estudo em espaços residenciais. *Arquitextos*, *254.04*. https://vitruvius.com.br/revistas/read/arquitextos/22.254/8141
15. Marchante, H., Morais, M., Freitas, H., & Marchante, E. (2014). *Guia Prático para a Identificação de Plantas Invasoras em Portugal*. Imprensa da Universidade de Coimbra.
16. Montaner, J. M. (2001). *Depois do movimento moderno: Arquitetura da segunda metade do século XX*. Gustavo Gili.
17. Santos, P. (2020). *Hybrid performance-based wood panels for a smart construction* [Tese de Doutoramento, Universidade de Coimbra]. https://estudogeral.uc.pt/bitstream/10316/93165/3/Hybrid%20performance-based%20wood%20panels%20for%20a%20smart%20construction.pdf
18. *Simple, Reusable, Cost-Effective Modular Wall Systems*. (2022). https://www.mallforms.com/modular-wall-systems/
19. *Systimber democlip*. (2022). https://systimbercom.webhosting.be/wp-content/uploads/2016/07/SYSTIMBER-democlip-1.mp4
20. *Systimber—Système de construction en bois massif | Méthode*. (2022). Systimber | Bijgebouwen in massieve houtschakelbouw. https://www.systimber.com/fr/methode/

21. *Temporary Wall Solutions | Durable Modular Construction Walls*. (2022). STARC Systems. https://starcsystems.com/products/realwall/
22. Translator's introduction. (2002). In *The minimum dwelling = L'habitation minimum = Die Kleinstwohnung: The housing crisis, housing reform* (pp. xi–xxviii). MIT Press ; Graham Foundation for Advanced Studies in the Fine Arts.
23. Yu, S., Gingrich, B. R., & Tuttle, R. L. (2017). *Reusable architectural wall* (United States Patent No. US9650785B2). https://patents.google.com/patent/US9650785B2/en?q=reusable+wall&oq=reusable+wall