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The second life of processed materials. Reuse and recycle of plasterboard. The case of the Italian Pavilion as a plausible scenario.

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Climate crisis and finite resources

The climate crisis is the most important challenge that human being must face in the coming decades. This manuscript aims to explore the more relevant aspects of reuse of materials and circular metabolism, encouraging resilience and sustainability. Our linear economy system leads to the indiscriminate and uncontrolled use of resources. It is an unsustainable system for survival, not only for the ecosystem, but also for communities and the city-system. A paradigm shift is needed, capable of subverting the economic and productive structure of today's society, favouring resilience, sustainability, diversity, recovery, and re-use of resources.

The concept of circular economy, as a production and consumption model that involves sharing, lending, reusing, repairing, reconditioning and recycling existing materials and products for as long as possible¹, plays a key role in such paradigm shift, and must represent a strategic input of great importance for the construction industry to transform the waste issue into an opportunity, to review the production and consumption systems in order to optimize the use of resources and lengthen the value chain avoiding waste and discard - which is now a necessity - making the use of resources more efficient to reduce impacts (SDG Rapporto Lombardia, 2019).

All the more so in this moment in which the European Green Deal, with the aim of addressing the challenge of energy efficiency, stimulates the launch of a "wave of renovations" of public and private buildings, and the Next Generation Fund will be provided with a mechanism that offers, among other things, the presentation of "National Plans for Recovery and Resilience" which, hopefully, can direct the construction sector towards practices more clearly oriented towards the circular economy.

We need to remember that Construction and Demolition (C&D) activities feed one of the main waste streams at European level, quantitatively comparable to the amount of municipal solid waste. According to Eurostat statistics, Construction and Demolition waste has a percentage impact on the European production of waste equal to almost 30% (over 840 million tons of waste every year), and in some countries it reaches higher peaks, as in Italy where the percentage ratio is approaching 40%.

It is therefore necessary to implement processes, already widely tested for some materials such as reinforced concrete and bricks, which allows to disincentive landfilling the inert produced by C&D activities through the preparation of eco-taxes, the development of techniques for selective demolition, the promotion of the use of resulting products from the recovery of waste from C&D processes in the construction of public buildings and the implementation of strategies to facilitate

the marching between supply and demand of aggregates recycled deriving from C&D (SDG Rapporto Lombardia, 2019) activities.

In Italy, over the last decades, there is evidence of the effectiveness and advantages of reuse and recycling of processed materials and resources which promotes circularity and a potentially infinite reuse.

Reuse and recycle: the case of plasterboard

Among the most controversial materials difficult to dispose is the plasterboard, whose treatment is regulated by a complex and bureaucratic legislation. Every year tonnes of plasterboard are decommissioned causing a large amount of CO₂ emissions, without considering the possibility of a future reuse.

At the 15th Venice Biennale in 2016, the curator Aravena proposed an installation of great impact and quality, a sort of Sustainability Manifesto, at the entrance to the Arsenale, "whose plasterboard and aluminum elements were recovered from the dismantling of the Biennale d ' Arte 2015, in the name of that "sustainability" which is one of the fourteen key words of "Reporting from the Front." What will become of these materials after the exhibition, however, we do not know, but it is very likely that they will also enter to become part of the mountain of waste produced at the end of the Biennale.²" (Ferrando D. T., 2016)

Taking the Italian Pavilion 2021 as a case study, this text illustrates the potential of recycling and reuse of plasterboard instead of a complete dismissal of it. Through an analysis of the embodied energy related to the reuse and recycle of gypsum board in the case of the Italian Pavilion and a comparative analysis of the proceedings and dismissal practices of other museums on the national territory, this text intends to bring examples of how the practice of recycle, and especially reuse, could help to reduce greenhouse emissions as a practice potentially extendible to all the canonical construction materials.

The second life of plasterboard: the Italian Pavilion 2021

The Italian Pavilion 2021 is designed according to the core principles that guide the entire design and installation process. The concept of resilience, widely present in our daily lives, recalls the themes of sustainability and circularity that should move the economy of a world on the road to the irreversible destruction of the global ecosystem. Unfortunately, these issues are still difficult to integrate into common practices. It is about a changing of paradigm and point of view, from the beginning of the transformation processes. It is a matter of transforming the linear structure of economy and production into a circular mindset, abandoning the canonical structure "from cradle to grave" to embrace the system "from cradle to cradle".

The Italian Pavilion 2021 tries to be a concrete example of this practice to explore its potential and difficulties, starting from the scientific assumption that conceived the reuse practice as an effective method for a drastic reduction of greenhouse gas emissions (Pomponi & Moncaster, 2016). It closes the circle of resources used, firstly allocating them for a reuse and then recycling them almost integrally. The ability to think and act in this sense leads to a subversion of the current production

system that foreseen to lead of large quantities of equipment to the disposal at the end of each exhibition edition. In Italy, the legislation imposes the total recycling of drywall, a material for which it is possible to recover almost the 100% of its components.

The difficult access by private individuals to disposal, the lack of information regarding the advantages for companies and the difficulty of the supply, still classify this material as a special waste difficult to dispose of, effectively not only from a legal point of view. Starting from the experiences conducted previously for other editions of the Biennale di Architettura di Venezia (2016 and 2018), the key concept of the Italian Pavilion 2021 is the design of a zero-emission exhibition. For this reason, not only a second life of structures and prototyping installation outside the Biennale, but an integral reuse of the existing structures has been planned.

The calculation of the embodied energy

The project of the Italian Pavilion was conceived starting from the setting up of the Art Pavilion 2019 curated by Milovan Farronato. Taking as a reference the concept of exaptation (S.J. Gould, E. Vrba, 1982), the structure was functionally co-opted and adapted to a new use (A. Melis, T. Pievani, 2021). For this purpose, a process of subtraction of volumes, opening or closing of openings, repositioning, and destination for other uses of some plasterboard panels not reusable in the new set-up was carried out. To verify the actual advantage that derives from such a practice, in opposition to the common disposal processes, it was chosen to calculate the amount of embodied energy proper to the Pavilion.

There are many approaches to the calculation of embodied energy. Among the most common are those based on processes, input/output, and hybrid methods. None of these are based on the same reference system, and thus, the results of the calculations produced are therefore not comparable. Indeed, according to several studies conducted to effectively define the limits of a standard system from which may derive a true calculation method, it has been concluded that there is no reliable information, consistent and accurate to allow a precise and immediate calculation of embodied energy.

The difficulties in defining an accurate calculation of this parameter are therefore to be found in the fact that such a process is constrained within limits due to the consistent costs, the time-consuming and the number of variables that need to be considered. Consequently, energy calculation has not become part of the common practices of the construction industry despite its usefulness (Dixit, 2017; Giesekam & Pomponi, 2018). However, it should be highlighted that the calculation of embodied energy is only one of the calculation procedures used to determine CO₂ emissions, and that it must therefore be supported by further analysis.

There is no doubt that, in any event, this is a key element in the overall assessment and a strategic tool for the evaluation of strategies for the reduction of greenhouse gases in the construction industry. To give foundation and validity to the action of reuse and, to a minimum, recycling of materials used in the preparation of the Italian Pavilion, a preliminary calculation of embodied energy has been produced to effectively define what the CO₂ reduction has been.

Potential scenarios

By conducting a comparative study, two scenarios have been determined (D. Hamdan, 2020):

1. Costs in terms of CO₂ in case of total decommissioning and recycling of the set-up of the Art Pavilion 2019
2. Costs in terms of CO₂ in case of re-use of the existing set-up, repositioning of facilities, other uses, and recycling of unused material.

It should be noted that, the embodied energy calculable is divided into two types: the energy attributable to the materials (for which it is also considered the supply and transport) and that attributed to the operational status, as the energy used during the life cycle of materials (Dixit et al., 2010).

Considering that it is a temporary installation and therefore limited in time, it has been considered the embodied energy related to materials, because such an installation will not reach an actual end of life of the material.

In order to conduct this study, the following variables were taken into account in relation to the amount of plasterboard analysed, converted into kg of CO₂ emitted. Also considering, as mentioned above, the costs of transport and procurement of materials. Below is the development of the calculations according to the potential scenarios considered.

Scenario 1: all existing panels are uninstalled and shipped to the disposal centre of Peccioli. For the Italian Pavilion 2021 the set-up is built using new products and materials.

- All panels are taken to the disposal centre
- Hypothesis of new facilities for the installation End exhibition.
- All the equipment is shipped to the disposal centre of Peccioli.

Scenario 2: Reuse of existing pavilion structures

- Reuse of plasterboard panels
- Uninstallation of plasterboard panels
- Re-allocation of uninstalled panels on display
- Re-allocation of part of panels as art supports for Milano schools
- Recycle of panels at the Plasterego Disposal Centre
- End exhibition. Re-allocation of plasterboard panels as artistic supports for Milano schools
- Portion destined to the disposal centre of Peccioli to be converted into granules for agriculture (Hamdan, 2020)

Considering the results there is evidence of an advantage in terms of greenhouse gas emissions avoiding, in the practice of reuse and reallocation of recycling products to a specific use rather than a generic re-placing on the market.

Despite the high percentage of CO₂ attributable to the whole set-up (and to the built environment in general), embodied energy is taken limitedly into account if compared to its potential application. This happens because of several factors and in particular: different calculation methods, different data packages considered, different life cycles hypothesized for the different used materials.

Critical issues

Considering further examples of museums and disposal companies several issues are raised.

The first is the lack of a direct line of communication between eco-centres and institutions. Often, the contractors are the only ones who interface directly with disposal centres. In fact, this further step, exacerbates the conditions in terms of economic investment and greenhouse gas emissions. Furthermore, this situation compromises the trade for recycling companies that introduce high-quality raw-second materials with very low costs, especially in relation to gypsum.

According to the first data provided by the disposal and recycling company Ecological Way present on the national territory and operating in central-northern Italy, the processing costs for recycling are quite high. Despite of these processes, the profit thresholds are not particularly fitting. The cost-benefit ratio for companies is still unbalanced, although particularly convenient for the production chain of building materials. Referring to the market price of recycled gypsum, this is around 15 - 17 €/tonne compared to 50 - 70 €/tonne of gypsum mined in quarries.

The second criticism concerns the legislative and bureaucratic aspects. In the classification of materials, plasterboard is considered a "non-hazardous special waste" and therefore disposal as urban waste is not possible. This concern leads to a long process of limitations to manage the disposal and transfer, reserved by means and specific authorizations for the transport activity.

However, according to Italian legislation, there is an obligation to dispose in recycling centres, even if this practice is in contrast with the absence of approved and equipped centres on a significant part of the national territory, the impossibility for private individuals to use gathering centres in their own city and the duty for producers to use recycled plaster only partially. The law, in fact, still allows the use of gypsum quarry even though it is running out and at much higher costs than the recycling material itself.

The new legislative decree issued in September 2020 (GU D.lgs 116/2020), states an improvement in the management and dismissal of drywall, repealing the EU indications (2018) that encourages a total conversion of the linear economy in circular economy, in the case of gypsum board, focusing on the potentially infinite recycling of its main component.

Conclusions

The core of the matter is therefore upstream, at the top of a political, economic, legislative, and infrastructural system that does not encourage the use of recycled material and still allows the exploitation of finite natural resources in an irresponsible and unsustainable way.

Such a regulation would certainly be useful and desirable to encourage a paradigm shift in the whole system, bearing in mind that such a model can certainly be applicable to the entire construction industry, reducing to a minimum the use of raw materials and energy required for production and construction processes, giving priority to the existing instead of the necessarily new.

A strong and intense campaign of communication would have an undoubted value and a weight consisting in rethinking and reconsidering good practices of reuse and recycling, not as renunciation, low value, and yield, but as an opportunity. Moving away from what are the commonplaces most deeply rooted in our social, economic, and cultural system.

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