IV CONVEGNO INTERNAZIONALE

PRE-FREE UP-DOWN RE-CYCLE

PRATICHE TRADIZIONALI E TECNOLOGIE INNOVATIVE PER L'END OF WASTE

a cura di
Adolfo F. L. Baratta

anteferma

PRE·FREE
UP·DOWN
RE·CYCLE

PRATICHE TRADIZIONALI E TECNOLOGIE INNOVATIVE PER L'END OF WASTE

a cura di
Adolfo F. L. Baratta

anteferma

Comitato Scientifico

Scientific Committee | Comité Científico

Rossano **Albatici**
Università degli Studi di Trento
Paola **Altamura**
ENEA
Adolfo F. L. **Baratta**
Università degli Studi Roma Tre
Graziella **Bernardo**
Università degli Studi della Basilicata
Laura **Calcagnini**
Università degli Studi Roma Tre
Eliana **Cangelli**
Sapienza Università di Roma
Agostino **Catalano**
Università degli Studi del Molise
Michela **Dalprà**
Università degli Studi di Trento
Michele **Di Sivo**
Università degli Studi "Gabriele D'Annunzio"
Ornella **Fiandaca**
Università degli Studi di Messina
Fabio Enrique **Forero Suárez**
Universidad del Bosque
Francesca **Giglio**
Università Mediterranea
Roberto **Giordano**
Politecnico di Torino
Raffaella **Lione**
Università degli Studi di Messina
Antonio **Magarò**
Università degli Studi Roma Tre
Luigi **Marino**
Università degli Studi di Firenze
Luigi **Mollo**
Seconda Università di Napoli
Antonello **Monsù Scolaro**
Università degli Studi di Sassari
Elisabetta **Palumbo**
Rheinisch-Westfälische Technische Hochschule
Hector Saul **Quintana Ramirez**
Universidad de Boyacà
Alessandro **Rogora**
Politecnico di Milano
Andrés **Salas**
Universidad Nacional de Colombia
Camilla **Sansone**
Università degli Studi del Molise
Marzia **Traverso**
Rheinisch-Westfälische Technische Hochschule
Antonella **Violano**
Università degli Studi della Campania "L. Vanvitelli"

Atti del IV Convegno Internazionale
PRE|FREE - UP|DOWN - RE|CYCLE
Pratiche tradizionali e tecnologie innovative per l'End of Waste

Proceedings of the 4th International Conference
PRE|FREE - UP|DOWN - RE|CYCLE
Traditional solution and innovative technologies for the End of Waste

Acta de el IV Congreso Internacional
PRE|FREE - UP|DOWN - RE|CYCLE
Prácticas tradicionales y tecnologías innovadoras para la disposición de los desechos

a cura di | edited by | editado por
Adolfo F. L. Baratta

ISBN: 979-12-5953-005-9

Editore
Anteferma Edizioni Srl
via Asolo 12, Conegliano, TV
edizioni@anteferma.it
Prima edizione: maggio 2021

Progetto grafico
Antonio Magarò
www.conferencerecycling.com

Copyright
Questo lavoro è distribuito sotto Licenza Creative Commons
Attribuzione - Non commerciale - No opere derivate 4.0 Internazionale

Tutti i contributi sono stati valutati dal Comitato Scientifico, seguendo il metodo del Double Blind Peer Review.
All papers were evaluated by the Scientific Committee, following Double Blind Peer Review Method.
Todas las contribuciones fueron evaluadas por el Comité Científico, siguiendo el método de Peer Review doble ciego.

PRE|FREE - UP|DOWN - RE|CYCLE

pratiche tradizionali e tecnologie innovative per l’End of Waste

---

traditional solutions and innovative technologies for the End of Waste

---

prácticas tradicionales y tecnologías innovadoras para la disposición de los desechos

Indice
Table of Contents

Premessa / *Foreword*

Saggi / *Essays*

Ricerche / *Researches*

Architetture e Design / Architectures and Design

Laura Calcagnini
Architetto, PhD, Ricercatore universitario
Università degli Studi Roma Tre, Dipartimento di Architettura
laura.calcagnini@uniroma3.it

The environmental impact evaluation of building elements in architecture: the design for disassembly

*Environmental design, Disassembly, Recycling,
Low environmental impact, Building elements*

Summary

This paper is part of the broader research issues on the environmental quality of the technological design. In this context, an advancement of knowledge is being investigated with reference to the tools for environmental evaluation of the building elements in architecture. The theoretical assumptions are motivated because on building elements much has been defined to date for the scientific and technical control of the energy issues and less for that of the environmental ones. Furthermore, the adoption of design choices that contemplate construction technologies more compatible with the directives and practices connected with the life cycle of the building is an essential action for reducing environmental impacts in architecture.

The design for disassembly is a strategy which contributes to the environmental impact of the architectural design. In the framework of the research on the environmental impact evaluation of building elements, disassembly represents one of the themes whose definition needs to be deepened. This paper declines the dimension of disassemblability in the framework of the first phase of the research on the environmental impact evaluation of building elements in architecture. Some recent studies focus the attention to the possible strategies of the technological project for the reduction of the environmental impact represented by the disposal activities in the end of life phase with the aim of giving continuity between this last phase and the extraction of raw material and production of building elements. The assessment of the disassembly at the end of the building's life, with the determination of the percentages of recyclability and reusability of buildings materials that characterize the technological system, is a phase of the design process. This phase is the one in which the issue of environmental evaluation needs to be further investigated with reference to the technical elements.

Premise

This paper aims to report the first issues of a broader research on the environmental quality of the technological design. In this research field the author is investigating an advancement of knowledge with specific reference to the tools for environmental impact evaluation of building elements [1] in the architectural design.

The disassemblability defines a design strategy that contribute to the environmental impact of the design and the construction. Therefore, in the framework of the research on the environmental impact evaluation of building elements, disassembly represents a topic of necessary definition and deepening. In particular, in this paper the dimension of disassemblability is described in the framework of the theoretical issues of the first phase of research and as a parameter of a possible comparative tables of the environmental impact of building elements. In fact, the first theoretical assumption of the general framework of the research fulfills the question that on the building elements much has been defined for the scientific and technical control of energy requirements and less for that of environmental ones. Without this control, it becomes difficult to adopt design choices that contemplate construction technologies compatible with the directives and practices that govern the life cycle of the building for the reduction of environmental impacts. This control can be done more easily by having a comparative framework of building elements for architectural design characterized by energy and environmental impact indicators.

Environmental impact evaluation and disassemblability

The issue of environmental impact evaluation and disassemblability requires a brief declination of both topics to highlight the connection between them in the context of research perspectives on buildings elements. By environmental impact evaluation we mean the tools and parameters able to evaluate the impact on the environment of the building elements, products and materials. The environmental impact of building elements is related both to the production process of the materials and products that compose it and to their life cycle, and to their energy efficiency in use. The efficiency determines, in particular for the closing elements of the building envelope, the potential energy savings for indoor climate control and for the sources used to produce that energy, because if of fossil origin, they impact on the environment. A first critical issue emerges from the consideration that the energy performance is now measured on the building element, while the environmental performance refers to materials or products as parts of building elements, but not to the element as a whole. Therefore, there is no reference tool for the environmental performance of building elements. In the scientific literature on methodological tools for environmental assessment, although much has been written on the quantification of the environmental impacts of material resources and products for architecture [2], much less has been written on the impacts of building elements.

There are numerous scientific researches on Life Cycle Assessment (LCA) of materials and products as well as of the building system as a whole, but comparative references between solutions for buildings elements are rare. Besides science, also technology, as a consequence of the advancement of studies, researches and normative requirements, has made available many tools; among them, the most relevant are the Minimum Environmental Criteria (CAM), supporting and binding actions with low environmental impact. However, even in CAM the reference is prevalent to material resources for the design, considering to a very limited extent the issue of building elements. And yet, the latter become fundamental to make environmentally conscious choices in the architectural design, since the definition of the project itself passes through them. In the modus operandi of the project, the material choices go hand in hand with the technological ones, with the exception of some examples of architecture whose material suggestions for the cladding have conditioned the aesthetics of the architecture and consequently the technological concept: apart from these exceptions, the design of the technological solutions is coeval with that of the material choices and it is therefore important that these solutions can be accompanied by references to evaluate the environmental impact. As an endorsement of this consideration, Lavagna et al. [2018] state that in executive design, the definition of the products of the construction solutions due to performance parameters (mechanical, thermal, acoustic, fire behavior, etc.) is what can discriminate the choice of a material rather than another; therefore, the role of the design of technological units and building elements becomes hierarchically relevant with respect to material choices.

Last but not least, unlike the material choices, it is the choice of building elements to determine the reduction of possible environmental impacts through some features of the elements themselves such as dry construction and reversibility of the elements themselves.

In fact, to maximize reuse and recycling of materials and components, it is necessary for the designer to control choices and technological solutions with particular attention to the principles of reversibility because the latter allow to "deconstruct and enhance (from reuse to re-

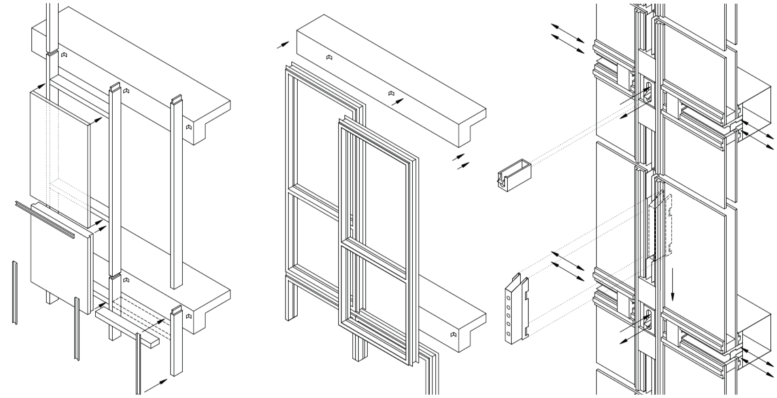

Figure 1. Modular façades [Source: Herzog et al, 2017].

cycling) as much as possible materials and components of waste from the building" [Monticelli, 2013, p. 159].

These issues call for technological solutions that rely on dry construction techniques that facilitate the assembly and disassembly of elements, such as modular façade (Figure 1), and even earlier to the design for disassembly that allows the implementation of these principles. The design for disassembly therefore becomes decisive, as noted in further recent research that has focused attention on the possible strategies of the technological design for the reduction of the environmental impact from disassembly and disposal activities in the end-of-life phase. The goal of such research is to give continuity between this last phase and the ones of extraction of the second raw material and production of the building elements, giving value precisely to the design for disassembly [Sicignano et al., 2019]. The quantitative assessment of the disassemblability at the end of the building life, with determination of the percentages of recyclability and reusability of materials is a phase of the process related to everything in the technological system that constitutes possible design alternatives such as the design of vertical and horizontal cladding systems. In the design of the technological system, the theme of disassembly requires to be further investigated precisely in reference to the building elements, in addition to just materials or products.

The design for disassembly

From the point of view of the evaluation of the environmental qualities of building elements, today we can recognize some reasoning plans and normative tools that enhance the theme of the design for disassembly.

On the one hand, the Design for Deconstruction approach, which aims precisely at the design for disassembly of building elements aimed at the recovery of materials and components both for building maintenance of the same and in the management of the end of life of the building components and the of the buildings themselves. This approach "constitutes a fundamental strategy for the implementation of the closed-loop model in the building sector" [Sicignano et al, 2019]. The strategy concurs, in the design phase, to determine the technological choices that fulfill several requirements simultaneously such as constructability, maintenance, energy saving, cost containment etc. The criterion of disassembly is therefore a design strategy that allows to fulfill more requirements at the same time.

It contributes to the overall reduction of environmental impacts of construction materials as a necessary action to allow the reintroduction of materials into the production cycle through reuse or recycling and fulfill the containment of waste production in the first place and the limitation of the use of virgin raw materials then. On the other

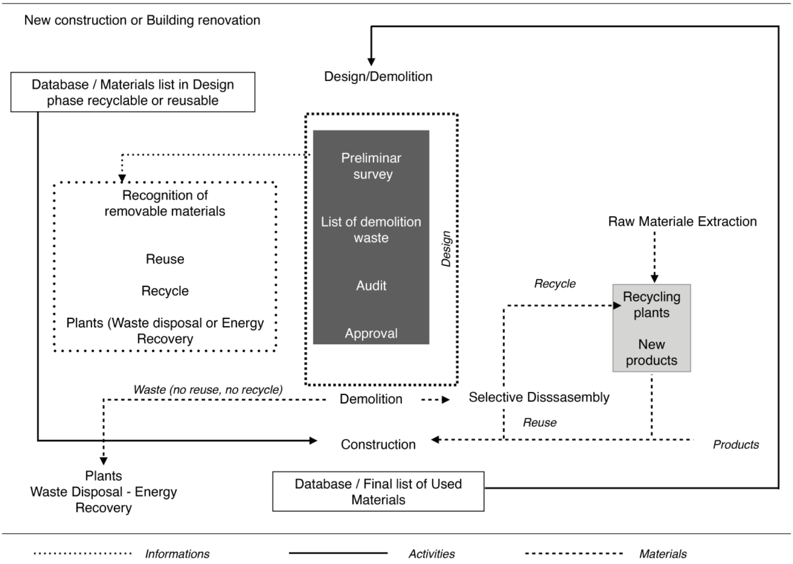

Figure 2. scheme related to the selective deconstruction process according to the UNI/PdR 75:2020 [Original from author].

hand, the issues that arise by existing legislation and technical tools.
The UNI/PdR 75:2020 Reference Practice [3] "Selective deconstruction - Methodology for selective deconstruction and waste recovery in a circular economy perspective" is recent. It defines selective deconstruction: "Demolition through a systematic approach whose objective is to facilitate the separation operations of components and materials, in order to plan disassembly interventions and the costs associated with the intervention and recover components and materials as intact as possible, not damaged or contaminated by adjacent materials, to maximize the potential for reusability and/or recyclability of the same". The aim of the practice is to define a methodology for selective deconstruction that promotes the reuse and recycling of construction and demolition waste. Directive 2018/851/EU of 30/05/2018 is referred to in the practice as the latter "makes explicit reference, in the context of Construction and Demolition activities, to the need to take measures to promote selective demolition in order to [...] facilitate reuse and high quality recycling through selective removal of materials, as well as to ensure the establishment of sorting systems for construction and demolition waste at least for wood, mineral fractions (concrete, bricks, tiles and ceramics, stones), metals, glass, plastics and gypsum", almost the entire family of traditional materials used in construction.
In the UNI practice, the design for disassembly (Figure 2) is governed by the different procedural phases, divided into design phase (preliminary and executive), operational phase and phase of updating the database / list of materials used in the built environment. The design approach is aimed at the identification of materials to be removed and destined for reuse, recycling and disposal with the specific identification of hazardous waste, or emissions during demolition, the estimation of the quantities of waste, the potential percentage of reuse and / or recycling and, finally, the potential percentage achievable with other forms of recovery from the demolition process. The outputs of the practice for the design phase are to obtain the demolition project

and a database with the quantification of waste that can be subjected to recycling or reuse processes. However, it does not directly address issues related to technological design, i.e., the choices that affect the life cycle of buildings, with reference to energy and environmental sustainability criteria. Less recent but the first normative reference on the subject are the CAM, they defined the environmental requirements for the realization of public works [Calcagnini, 2019]. CAM, sanctioned by the Ministerial Decree of October 11, 2017, makes mandatory the plan for the disassembly of complex products and the selective demolition of the building. Although it is the first national regulatory response in the face of numerous voluntary environmental certification procedures, CAM define a set of binding actions aimed at the realization of public heritage constructions with minimal environmental impacts [Bassi et al, 2019] and the control of the executive design. According to point 2.3.7 of Annex 2 of the Decree on CAM, the designs of new construction and demolition and reconstruction of public buildings must include both a plan for the disassembly of complex products (art. 2.4.1.1 of Annex 2) and the selective demolition of the building at the end of its life that allows the reuse or recycling of materials, building components and prefabricated elements (art. 2.3.7 and 2.5.3 of Annex 2).Making design choices for the fulfilment of the Criteria with reference to the determination of disassemblability means determining the technological choices of the project favouring the process of selective demolition of at least 50% by weight of the building components, excluding mechanical and electronical systems, and under the conditions that these components are recyclable or reusable. Of that percentage, at least 15% must be non-structural materials.

These minimum criteria, although they do not give specific indications in terms of measures for environmental assessment because they impose, in addition to selective demolition, the condition that materials and components selectively demolished are recyclable or reusable, they confirm disassemblability as a tool for reducing the environmental impact strictly related to the second life of building elements and materials themselves.

Perspectives of environmental impact evaluation

Existing approaches and tools, especially regulatory ones, are nowadays fundamental to determine a design and methodological direction for the disassembly project, but they point out the absence of parameters for the evaluation of the environmental value of this strategy.

The tools of science, such as LCA, allow an environmental comparison between different materials and products but not between building elements, with obvious limits to support the design process. In fact, the comparison between materials is insufficient for the purpose of "easily identifying the solution with the lowest environmental impact, since the best environmental profile changes depending on the environmental impact indicator" so much so that it can be said that "to date there are no shared and widespread methodologies or decision-making tools on a large scale, but the decision depends on the sensitivity of designers and/or builders" [Lavagna et al., 2018, p. 140].

The question to be fulfilled is to provide a tool to control and guide in the design process the choices of the technological design or building elements. There emerges the need to develop abacuses of building elements for which the level of disassemblability and the corresponding environmental impact is evaluated.

The scientific horizon that we aim to achieve in the light of the above aims, is to determine for types of technical elements a comparative synoptic framework of different prevailing solutions. These solutions would br accompanied, on the one hand, by the degree and the measure of disassembly of the element and the other, by the most widespread and significant environmental measures (carbon energy, embodied energy, etc.), and, to complete those of the energy performance of the elements (transmittance, periodic transmittance, density, etc.). Recent studies on the circular economy state that by 2050, CO2 emissions from materials used in construction could be reduced by almost half by virtue of strategies that consider efficient material use and reuse [Ojan, 2019]. The efficient use of a material means, again, its efficient use as a product or component of a building element and an efficient process of choosing design solutions.

The goal of current research, such as that of the author of this contribution [Calcagnini, 2021], is more specifically to aggregate a set of evaluation parameters per unit area of typical building elements. These would allow the construction of a comparison abacus aimed at providing the designer with a concrete reference towards solutions with less environmental pressure.

Notes

[1] Technical elements refer to the classification of the technological system according to UNI 7867 and UNI 8290. In them, the technological system is divided into three levels: classes of technological units (first level); technological units (second level); classes of building elements (third level).

[2] Such as the LCA methodology, the possibility of evaluating numerous indicators of environmental impact such as embodied energy, carbon footprint, etc.

[3] The reference practice is not a national standard but a non-binding reference that collects prescriptions related to practices shared by the "UNI Selective Deconstruction" Table. It was published on February 3, 2020. As stated in the same document, "The reference practices are available for a period not exceeding 5 years, within which they can be transformed into a normative document (UNI, UNI/TS, UNI/TR) or must be withdrawn".

Bibliography and bibliographic references

Bassi, A.; Ottone, C.; Dell'Ovo, M. [2019]. "Criteri Ambientali Minimi nel progetto di architettura. Trade-off tra sostenibilità ambientale, economica e sociale", *Valori e valutazioni*, 22, pp. 35-45.

Calcagnini, L. [2019]. “Materiali con contenuto di riciclato. I Criteri Ambientali Minimi negli Appalti Pubblici” in Adolfo F. L. Baratta (a cura di), *Il riciclaggio di scarti e rifiuti in edilizia. Dal Downcycling all’upcycling verso gli obiettivi di economia circolare, Atti del III convegno internazionale ‘Refuse, Reduce, Repair, Reuse, Recycle’*, Timia Editore, Roma, pp. 156-169.

Calcagnini, L. [2021]. “La misura ambientale degli elementi tecnici in architettura”, Ricerca del Dipartimento di Architettura, Università degli Studi Roma Tre.

Herzog, T.; Krippner, R.; Lang, W. [2017]. *Façade Construction Manual.* Seconda Edizione, DETAIL Business Information GmbH, Monaco.

Lavagna, M.; Bessi, A.; Meneghelli, A.; Moschini, P. [2019]. “The environmental dimension of detailed design. Experiences and future perspectives”, *TECHNE - Journal of Technology for Architecture and Environment*, 18, pp. 138-146.

Monticelli, C. [2013]. *Life Cycle Design in Architettura. Progetto e Valutazione di Impatto Ambientale dalla Materia all’Edificio*. Maggioli Editore, Rimini.

Ojan, M. [2019]. “La riduzione dell’impronta carbonio del costruito: il contributo dei materiali da costruzione” Disponibile da: www.ingenio-web.it (Consultato il 25.03.2021).

Sicignano, E.; Di Ruocco, G.; Melella, R. [2019]. “Valutazione quantitativa della disassemblabilità del progetto di ricostruzione di un quartiere in provincia di Salerno” in Garda, E.; Mele, C.; Piantanida, P. (a cura di) *Atti del Convegno Colloqui.AT.e 2019. Ingegno e costruzione all’epoca della complessità*, pp. 1151-1159.

UNI/PdR 75:2020. “Decostruzione selettiva - Metodologia per la decostruzione selettiva e il recupero dei rifiuti in un’ottica di economia circolare”.

Finito di stampare nel mese di
Maggio 2021

Il IV Convegno Internazionale PRE|FREE - UP|DOWN - RE|CYCLE, dedicato alle "Pratiche tradizionali e tecnologie innovative per l'End of Waste", si è tenuto sulla piattaforma Microsoft Teams il 28 maggio 2021. I contributi sono stati distribuiti, a seguito della procedura double blind peer review, all'interno delle tre sezioni che caratterizzano il Convegno Internazionale: Saggi, Ricerche, Architetture e Design. La partecipazione ha visto il coinvolgimento di numerosi atenei, centri di ricerca e start-up oltre al nutrito numero di membri del Comitato Scientifico. La raccolta degli Atti fornisce lo stimolo alla riflessione sulle pratiche tradizionali e la loro intersezione con le azioni più innovative, attraverso un ripensamento dell'End of Waste. L'elemento più interessante degli Atti è la varietà di prospettiva: sebbene non vi sia la possibilità di leggere i contributi in continuità, essi restituiscono un panorama che promuove la conoscenza e stimola ulteriori indagini e ricerche.

Adolfo F. L. Baratta è Architetto e Dottore di Ricerca. Dal 2014 è Professore Associato in Tecnologia dell'Architettura presso l'Università degli Studi Roma Tre e, dal 2018, è abilitato come Professore Ordinario. È stato docente presso l'Università degli Studi di Firenze e Sapienza Università di Roma, nonché Visiting Professor presso la Universidad de Boyacá di Sogamoso (COL) e la HTWG di Konstanz (DE). Dal 2020 è esperto della Struttura Tecnica di Missione del Ministero delle Infrastrutture e delle Mobilità Sostenibili. È autore di oltre 200 pubblicazioni.

ISBN 979-12-5953-005-9

9 791259 530059

€ 22,00