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RESILIENCE, ADAPTATION AND MITIGATION UNDER A GREEN BUILDING APPROACH

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ABSTRACT

The primary objective of the paper[1] is to produce a model providing scientific support for the project development of retrofitting initiatives for public spaces and public constructions in Italian cities, to achieve increased levels of resilience and capacity for climatic adaptation while also heightening ecosystem quality and all aspects of environmental performance, primarily to increase energy efficiency through initiatives of urban and environmental upgrading and renewal under the Green City Approach. The methodological approach is based on the following steps: establishment of a reference framework and identification of technological systems subject to experimentation; definition of working scenarios and development of alternative analyses to be applied to them with innovative instruments; focus on the most appropriate solutions, based on the results of dynamic simulations; formulation of a working model that adapts itself to different contexts.

KEYWORDS

environmental resilience, climatic adaptation, climatic mitigation, technological retrofitting, green building approach

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In terms of relations between the key questions of resilience, adaptation and mitigation, on the one hand, and the technological-environmental retrofitting processes meant to provide a response to those questions, there are two areas in which the contribution of the green building approach, plus that of the perspective of the green economy and the related triggering of ‘circular processes’, all have an effect on the future of our built environment: the capacity for resilience and adaptation to macroclimatic change and to its macro and micro environmental impacts (UNEP, 2011; IPCC, 2019), as well as the capacity for resilience and adaptation in the face of problems tied to the increasing scarcity and non-renewability of natural resources (UNEP, 2012). In the first case, the idea is to reduce the vulnerability of urban systems to extreme atmospheric events, increase the capacity for ‘adaptation’ of buildings, open spaces and cities through the use of bioclimatic systems and augment environmental safety and comfort, to the point where — in the best possible outcome — the systems can be considered to have achieved a fully ‘resilient’ status. At issue in the second case is the capacity of the environment to react to ongoing ecological impoverishment and diminishment of natural capital, declining material and physical resources and energy threats, on account of the inefficiency and lack of renewability of the sources, to the detriment, in the long run, of the quality of life as well.

With reference to the two spheres of concerns addressed, it is of vital importance in determining their repercussions on the planning approach taken to initiatives in cities aiming at the green city model, that two key questions be raised: what fundamental principles, on an international level, present themselves as the theoretical underpinnings for interaction between the green city, the green economy and adaptive and resilient design? What methodological approaches are needed to ensure effective project development?

In response to the first question, we can identify, among the many principles tied to the concepts of ‘adaptability’ and ‘resilience’ (Tucci, 2018a), 9 that are also of significant importance to the green city approach, underlying the need both to ensure that plans are formulated with a certain degree of ‘temporariness’ and that a margin of ‘indeterminacy’ be accepted in the guidelines for, and the oversight of, moments of assessment before and after the initiatives. The principles can be grouped in three ‘triangulations’ consisting of: reflexivity, self-organisation and inclusivity; sturdiness, flexibility and adaptability; integration, connectivity and reactivity (EEA, 2012; Arup, 2015; European Commission, 2017). Reviewed on an overall, systematic basis, they would appear to fill two strategic functions, being capable of endowing urban systems with a general capacity to perceive changes and disturbances brought about by the surrounding environment, adapting their structures and functions to deal with the new conditions, without disturbing the flow of their own lives (EEA, 2012), and in particular to dynamically respond to processes of change underway and to the effects that arise from exogenous or endogenous perturbations, such as climate change or an ever-increasing scarcity of resources (European Commission, 2017).

The three ‘triangulations’ support three approaches of method and planning – to respond to the second question – specifically associated with ‘green’ and ‘circular’ economies. Seeing that they set themselves apart as innovative not only by how they deal with problems, but by how they view them as well, we can consider these approaches to be characteristic of interactions between the green economy, and green city and adaptive and resilient design. They are: the self-reliant approach, whose underlying principles are reflexivity, self-organisation and inclusivity; the error-friendliness approach, whose underlying principles are sturdiness, flexibility and adaptability, and the dynamic-responsive approach, whose underlying principles are integration, connectivity and reactivity (for an analysis of the three approaches, see: Tucci, 2018a).

And so we arrive at the third key question: how to take the next step, having codified a framework of theoretical assumptions and methodological approaches pertinent to the green city approach, and namely the formulation of possible strategic guidelines for achieving an effective heightening of the levels of capacity for adaptation and, looking to the future, of resilience on the part of cities and the built environment. It has been stated that the question of resilience would not appear to lend itself to planning, while its indeterminate scope and features make the task of establishing guidelines in advance, and subsequently measuring results, difficult to the point of necessitating reference to other disciplines for guidelines, as well as for indexes to be used in support of measurements (Schipper and Langston, 2015). Here too, a noteworthy source of assistance is the vision and research developed in a highly interdisciplinary manner by the green economy, from a green city prospective.

The White Paper titled Towards a European Framework for Action (Commission of the European Communities, 2009), reinforced by the subsequent UN-Habitat report Saving Cities: Adaptation as Part of Development (UN-Habitat, 2011), holds that possible options for ‘green’ action under initiatives designed to increase the capacity for adaptation and resilience of the built environment (always to be supplemented, to the extent possible, by mitigation efforts) can be classified under three main categories:

– structural ‘grey’ strategic actions, or categories of ‘physical’ (and therefore ‘structural’) initiatives that are carried out in the built environment, based on services of technological design and planning able to perform ‘deep renovation’ operations on buildings and infrastructures (selected from among existing resources because they are of essential importance to the socioeconomic wellbeing of society), so as to render them capable of resisting extreme events on a stand-alone basis (actions requiring a synergy of the three forces, with a particular focus on self-reliance);

– ‘green’ strategic infrastructural actions, meaning categories of ‘biophysical’ initiatives carried out in the built environment to help heighten the resilience of ecosystems through efforts that, although their ultimate goal is to stop the loss of biodiversity and the deterioration of ecosystems while reviving cycles of water supply, still use the functions, services and resources offered by ecosystems to arrive at solutions for resilience and adaptability that prove more effective in economic terms, and at times in

practical terms as well, than the exclusive use of grey infrastructures to provide a gradual, nature-based remedy [actions that also call for synergy of the three approaches, in this case with a particular focus on error-friendliness];
– 'soft' super-structural strategic actions, meaning the formulation and application of policies and procedures regarding the built environment, through the spread of green economy information and incentives designed to reduce or prevent the vulnerability not only of urban elements subject to 'grey' or 'green' initiatives, but of the entire system, in the face of both environmental mutations (climate change) and chronic problems (scarce resources), when such occurrences take the form of malfunctioning systems, unforeseen events and even catastrophes (in the case of these actions as well, synergy of the three approaches is necessary, with a particular emphasis on dynamism-responsiveness).

In the interests of preparing specific strategies of adaptation, resilience and mitigation custom-tailored to the problems described above, one last step must be taken, based on the more extensive framework of 'strategic axes' drawn up under the guidelines for green cities of the Green City Network (SGGE, 2017; Ronchi, 2017): there are 12 of these strategic axes designed to increase the capacity of resilience of the built urban environment, organised into three 'packages' corresponding to the categories of 'grey', 'green' and 'soft', all of which interact closely with one another, as shown by the fact that their potential repercussions fall upon the first of each of the three packages, meaning that which, for the purpose of this publication, is of the most interest: the strategic axis for 'augmenting the capacity for adaptation to the effects of climate change of architectonic systems, whether urban or territorial', as determined, with respect to each package, by its characterisation as 'grey', 'green' or 'soft'.

With regard to the formulation of the aforementioned matrix of strategic axes for increasing resilience in accordance with the three categories of guidelines referenced, the latter constitute full-fledged keys of analysis. These keys specifically address: 'grey structural' guidelines, including the sector of infrastructural and plant-engineering systems; 'green infrastructural' guidelines regarding vegetative areas and elements; 'soft super-structural' guidelines having to do with systems and plans of action involving the general population, stakeholders and government bodies and authorities.

Strategic axes of resilience in terms of 'grey structural' guidelines | In the case of the 'grey structural' guidelines, the strategic axes can be subdivided into four 'perspectives': that of adaptation to the effects of climate change by architectural resources, cities and the surrounding territory under measures of a 'grey' type (CMCC, 2017; Lucarelli, Mussinelli and Daglio, 2018); that of mitigation of the causes of climate change in the built environment (Hausladen, Liedl and de Saldanha, 2012; Santamouris and Kolokotsa, 2016; Losasso, Davoli and Leone, 2017); that of energy efficiency, bioclimatic techniques and renewable energy in architecture (Battisti et alii, 2015; Santamouris, 2015; Hausladen and Tucci, 2017); and that of the ecological quality of technological capital and the effectiveness of the circular use of resources (Lavagna and Palumbo, 2017).

The first perspective entails augmenting the capacity for adaptation of architectonic, urban and territorial systems through 'grey' actions. This strategy is elaborated under the four following guidelines: a) adaptation to risks of heat-island effect and heat waves tied to threats of global warming, extreme heat and elevated temperatures through 'grey' actions; b) adaptation to risks of difficulty with water management and supply tied to threats of intense precipitation, storms, pluvial flooding and inundations through 'grey' actions; c) adaptation to risks of shortages in water and food supplies tied to threats of drought and arid conditions through 'grey' actions; d) adaptation to risks tied to threats of extreme wind and cyclones, in the form of hurricanes and typhoons, through 'grey' actions.

The second perspective involves developing the capacity to mitigate the causes of climate change in the built environment under four specific groups of guidelines: a) acceleration of processes of 'deep energy renovation' and energy transition towards the exclusive, widespread use of intelligent systems based on renewable sources designed to reduce emissions; b) promotion of strategies of 'passive' mitigation within the system of buildings-open spaces; c) promotion of 'performance-based' methods of design, simulation and assessment for the city as a whole and individual constructions, in order to reduce the environmental impact of civil construction; d) reduction of climate-altering emissions through an ecological reorganisation of systems of urban transport.

The third perspective, which includes augmenting energy efficiency, bioclimatic performance and the use of renewable sources in architecture, can be broken down into: a) planning and optimising the bioclimatic behaviour of the urban constructed organisms addressed; b) drastically reducing the energy consumption of architectural designs and cities while increasing energy efficiency and promoting models for near-zero/net-zero/positive-energy districts; c) maximising the use of renewable energy through integrated, innovative components capable of on-site generation and accumulation of energy, followed by dynamic network distribution (smart grids); d) utilising ecological techniques, technologies, components and materials featuring low 'grey' energy.

The fourth perspective, whose objective is to increase the ecological quality of technological capital, along with the effectiveness of the circular use of resources, specifically involves: a) making more intensive use of land resources while drastically reducing urban expansion; b) developing local production chains based on lowering energy intensity and reducing carbon emissions while, at the same time, improving the effectiveness and sustainability of the related processes; c) providing incentives for reducing the consumption of resources and the production of waste while implementing forms of circular economic activity fuelled by the residual products generated by processes of production and demolition; d) promoting processes and products that utilise 'smart' materials, technologies and solutions which prove more efficient, adaptable and generally suited to the different needs they must meet.

Strategic axes of resilience in terms of 'green infrastructural' guidelines | The 'green infrastructural' guidelines take into consideration four specific strategic axes: increasing the capacity of adaptation of architectonic, urban and territorial systems through 'green' actions involving natural capital and ecosystem services, plus the ecological quality of green and blue infrastructures and the management of water as a strategic resource (Italian Presidency of the Council of the European Union, 2014; Hausladen, Liedl and de Saldanha, 2012; Andreucci, 2017).

The first strategic axis, meant to augment the capacity of adaptation of architectonic, urban and territorial systems through 'green' actions (Tucci, 2018b), is elaborated under the following four specific guidelines: a) adaptation to meet risks of heat-island effect and heat waves tied to threats of global warming, extreme heat and elevated temperatures through 'green' actions; b) adaptation to meet risks of difficulty with water management and supply tied to threats of intense precipitation, storms, pluvial flooding and inundations through 'green' actions; c) adaptation to meet risks of shortages in water and food supplies tied to threats of drought and arid conditions through 'green' actions; d) adaptation to meet risks tied to threats of extreme wind and cyclones in the form of hurricanes and typhoons through 'green' actions.

The second strategic axis, which calls for optimisation of natural capital and ecosystem services, gives rise to the following four specific guidelines of resilience: a) increasing the ecosystem services in urban and peri-urban systems; b) reinforcing urban ecological networks, promoting the ecological value of natural capital and augmenting vegetable capital and biodiversity; c) promoting the planning and creation of new green infrastructures; d) promoting nature-based solutions to increase the environmental quality of initiatives.

The third strategic axis, whose goal is to increase the ecological quality of green and blue systems for the establishment of infrastructures, includes the four following points: a) liberating public urban spaces from private vehicle traffic while regulating them in such a way as to restore their collective use and increase their ecological role; b) augmenting networks of pedestrian passageways and spaces, cycling routes and areas devoted to increasing the use of bicycles. Promoting intermodal transport; c) reinforcing lines of collective urban transport and metropolitan railway transport; d) enacting the PUMS (urban plans for sustainable mobility) to promote innovations in vehicles and services of shared mobility.

The fourth strategic axis, whose objective is to increase the capacity to manage water as a strategic resource, specifically involves: a) collecting and reutilising grey water resources and rainwater in buildings and open spaces; b) limiting water consumption while providing incentives for more effective and efficient use of water in buildings and open spaces; c) implementing forms and systems of purification and phyto-purification of waste water, including expansion of areas of urban greenery; d) utilising networks of purification facilities that produce high-quality effluents, in addition to treating-recycling the mud generated.

Strategic axes of resilience in terms of 'soft super-structural' guidelines | In terms of 'soft super-structural' guidelines, the general reference framework regards: augmenting the capacity of adaptation of architectonic, urban and territorial systems through 'soft' actions (BSUG et alii, 2011; Tucci, 2018a); procedures for the assessment of sustainability, resilience and LC in decision-making processes (Ferrante, 2013; Campioli, Torricelli and Mannino, 2017); procedures for the regeneration, upgrading, recycling and maintenance of existing resources (Cattaneo et alii, 2009; Pinto and Talamo, 2016); and innovative processes for gauging the resilience of public spaces (Battisti, 2014; Bologna, Rogora and Cafiero, 2017).

In terms of augmenting the capacity of augmentation of architectonic, urban and territorial systems through 'soft' actions, this is pursued through the four following specific guidelines: a) adaptation to meet risks of heat-island effect and heat waves tied to threats of global warming, extreme heat and elevated temperatures through 'soft' actions; b) adaptation to meet risks of difficulty with water management and supply tied to threats of intense precipitation, storms, pluvial flooding and inundations through 'soft' actions; c) adaptation to meet risks of shortages in water and food supplies tied to threats of drought and arid conditions through 'soft' actions; d) adaptation to meet risks tied to threats of extreme wind and cyclones in the form of hurricanes and typhoons through 'soft' actions.

As regards the systematic promotion of the processes mentioned, this includes the following guidelines: a) developing, in terms of methodology and application, tools to be used on the local level, through the implementation of instruments of estimate, assessment and environmental certification at the different scales of product/construction system/building/neighbourhood/city/territory; b) developing, in terms of analysis and knowledge, suitable benchmarks, targets and databanks focussed on evaluating the needs of the local territory; c) providing incentives for innovative procedures and planning for the approval and application on the local level of programs of circular production-use-production organisation; d) formulating, with regard to policies and regulatory measures, local measures meant to promote an environmental assessment and life-cycle approach, introducing modes of leverage and incentives to favour their application through competitiveness and cooperation.

In the interests of promoting and providing incentives for processes of resilient urban regeneration and upgrading, as well as the recycling and maintenance of existing resources, the following four specific guidelines are considered: a) promoting new real-estate tax measures under strategies of urban regeneration, so as to guarantee an organic, structural strategy of resilient regeneration for entire portions of cities under the main categories of intervention; b) promoting connection of the strategic sphere of urban regeneration with the complementary concern of limiting land consumption; c) placing the upgrading of public building stock at the centre of local urban policies while providing incentives for the upgrading of private real estate through forms of public/private partnership; d) providing incentives for subsequent virtuous processes of maintenance and management, and for the use of innovative technologies to provide advanced products and services for initiatives involving existing resources.

The strategic sphere pertinent to promoting and providing incentives for innovative projects and initiatives leading to the resilient qualification of public buildings includes: a) promoting ‘green public contract tenders’ as part of the process of upgrading public buildings; b) adopting and applying advanced ecological criteria, together with Minimum Environmental Criteria, in all types of initiatives involving public buildings; c) promoting progression from the smart-public-building to the smart-city approaches, and vice versa, completed with virtuous processes of feedback; d) providing incentives for, and facilitating, the application to public spaces and buildings of the regulatory changes introduced under the decree modifying the Italian Code of Public Contracts.

From this perspective, and based on the methodological approach illustrated in the first section of the present paper, a series of experimental initiatives were formulated and developed as the applied portion of the overall review of the results of the three research efforts of which the first author was the PI (see note 1). The primary objective: to produce a model providing scientific support for the project development of retrofitting initiatives for public spaces and public constructions in Italian cities, with the first area of implementation being Rome, in order to achieve increased levels of resilience and capacity for climatic adaptation while also heightening ecosystem quality and all aspects of environmental performance, primarily to mitigate climate change, reduce CO_2 levels and increase energy efficiency through initiatives of urban and environmental upgrading and renewal under the Green City Approach (OECD and ICLEI, 2016).

In order to transpose the methodological approach, the objectives and the outputs illustrated above into concrete project initiatives, three key elements of the experimentations shall be illustrated in the next three sections: a) the pursuit of resilience and adaptation in the eco-compatible design of systems, components and materials (see the second section); b) the pursuit of resilience and adaptation in a project designed to increase the energy efficiency of existing resources (see the third section); c) the pursuit of resilience and adaptation in the supervision and orientation of the details of the project initiative (see the fourth section).

Resilience and adaptation in the eco-compatible design of systems, components and materials | The transformation of the built environment confronts an innovative condition in which material resources are ‘designed’ to self-regenerate, triggering new life cycles, re-founding things and the relationships between things, places and landscapes (Fabian and Munarin, 2017). Therefore, adopting a circular approach means rethinking the process of the ‘resilience oriented’ project which, in relation to resources, interprets biological resource flows, which can be reintegrated into the biosphere, as a reference for technical systems, destined to be enhanced once more, in a ‘cradle to cradle’ vision.

The definition developed in the nineties by EPEA with Braungart and McDonough, according to which «Cradle to Cradle is a design concept inspired by nature, in which products are created according to the principles of an ideal circular economy. This differentiates Cradle to Cradle from conventional recycling and the concept of eco-efficiency. It is about eco-effectiveness and goes beyond conventional sustainability tools and approaches, which primarily show the negative influence of humans on the environment» (EPEA, 2019) is fundamental. Therefore, there are five basic criteria applicable in the project, such as: maximizing the use of renewable materials and energy sources or resources derived from reuse and recycling; extending the product's useful life through eco-design, 'design for deconstruction' (D4D) and the replace ability of building components; using sharing platforms for the management of materials and products among users, reducing the number of goods required; adopting 'product as service' approaches, in which the service associated with a product is purchased, instead of the product itself; enhancing products' end-of-life through reuse/regeneration/recycling approaches (Ellen MacArthur Foundation, 2012).

A significant challenge is the diversification and integration of circular strategies in the transformation process, promoting reuse, where possible, rather than recycling (Addis, 2005), the latter to be understood as 'upcycling', a practice that allows to preserve and/or increase the value of materials over time. The same concept of waste must be overcome from a design and technological point of view (McDonough and Braungart, 2002), adopting an approach that involves all interested stakeholders.

Technological design guarantees a complete application of the circular vision through a Life Cycle approach focused on reuse, 'upcycling', 'superuse' of components and materials as a system of reliable and replicable technical options at the supply chain level. In this sense, there are three crucial aspects in the choices: the accurate quantification of supply and demand for materials, including those incorporated in the built stock and the flows of waste/surplus/scraps re-usable in construction; an appropriate set of tools to support operators (materials databases, GIS mapping of sources, pre-demolition audits and software for monitoring waste production on the construction site); the adoption of the D4D approach, to allow the changing of the layout of a building over time without producing waste.

Continuity and discontinuity of materials reuse practices | In Italy, the circular approach to the b environment is rooted in construction processes consolidated on construction site practices oriented to the recovery and reuse of materials and components, differentiated over time by the creativity of the relationship with the existing (destruction, admiration, indifference) implemented in the different eras. The practice of reutilization, as well as of reuse – which has stopped since the industrial revolution, when the demolition and reconstruction of existing buildings became more common – represents a real constant. In the past, debris and rubble were often recovered and used, as a filling material, in the construction of parts of cities (Addis, 2005); monuments were used as quarries of materials (in particular stone and metals) or for the reuse of already worked components (beams, roofing, decorative apparatus) or for the 'progressive insertion' of the buildings (vertical stratification of architecture).

In this articulated scenario, since the second half of the twentieth century it is possible to identify RRR (Reduce Reuse Recycle) practices that fall within the concept of Recycling. Undertaken in relation to the industrial product design, this change of approach was initiated under the conscious pressure of environmental and not only cultural or economic motivations – in Italy even before than at the EU level – starting from the turning point marked by the Ronchi Decree in 1997 (D.lgs. 122/97), followed by the progressive strengthening of the EU guidelines on Circular Economy with the 'Roadmap towards an Efficient Europe in the Use of Resources' in 2011 and actions such as Closing the Loop in 2015 (Ghyoot et alii, 2018). The appropriateness of the concept, as an interpretative key of phenomena and practices that have always accompanied the design and/or construction of the inhabited space, is the subject of a large scientific literature (van Hinte, Peeren and Jongert, 2007). In the European construction sector, the use of waste of various kinds – not only from buildings, but also from flows of resources used in the industrial sector, which are as well part of the urban metabolism – has led, in Northern Europe and in the Mediterranean basin, to experimentations focused on the strategies of 'upcycling' and 'superuse', which intend the use of waste materials as the key resource of the architectural and technological project (Chinchilla, Arturo Franco, ARCò, Lot-ek).

However, the growing variety of international design experiences on RRR strategies raises the question as to if, after 20 years of experimentation, designers managed to achieve a recognizable architectural language of reuse, with a related solid design method, which at the beginning of the Millennium seemed still distant, despite the strong push of environmental drivers and their revolutionary cultural background (Lynch, Manzini, McDonough, Braungart): these profound innovations of scenarios and cultural expectations do not correspond to an adequate project research, which could redeem the practice of recycling from the current condition, as today it appears radically anchored to a mechanistic and technical matrix, which does not fully invest the understanding and emulation of biological processes, nor the involvement of the poetic and creative dimension of the architect, capable of proposing new languages and new design frontiers (Gangemi, 2004). To encourage the consolidation of this new language, work has begun with actions to transfer international best practices to our Country, which have intensified in recent years (Lendager and Vind, 2018), also thanks to the development of new contextual tools to support circular practices.

Research and experimentation in IACP neighbourhood of Torrevecchia in Rome | Contemporary design research and experimentation are oriented towards composing the interrelationships between the goal of a high Resource Productivity of building materials and the innovation in the project process with a Life Cycle perspective (Altamura, 2015), with the aim to transfer Reversible Building Design (Mulhall and Braungart, 2010) to the Mediterranean technological culture. From this point of view, the experimentation started in the urban area of Torrevecchia offers a complex palimpsest to test the potential of launching circular economy processes on a local scale, creating loops with the material and immaterial resources, available and potential, derived by recovery and regeneration operations (Harvest Map, Fig. 1).

The choice to operate the deconstruction project of part of the buildings passes through the disassembly of the components (Fig. 2), allows to realize the principle of flexibility of the building use and changing over time (Fig. 3), allows the repair, reuse and recovery of materials, products and systems, their updating or replacement (Fig. 4), with simplified accessibility to the different layers, aimed at the reversibility of connections (Carvalho Machado, Artur de Souza and de Souza Veríssimo, 2018; Ellen MacArthur Foundation, 2016). The developed experimentation also allowed to reflect on the selection of materials or waste coming from outside the project's confines, for an evaluation of the effectiveness of the integration of rapidly regenerating natural resources into the design solutions (Fig. 5).

The experimentation on Torrevecchia aims at the development of an interdisciplinary, punctual and detailed intervention methodology, specifically aimed at replicability, with strong application potential in the national context and in the transfer of methodologies and products at an international level, in support of the project developments carried out also on other Roman areas. From this design approach derives the potential for innovation at the product level, which can also be obtained with the technological transfer of reversible construction solutions between multiple sectors and between different building components (Densley Tingley and Allwood, 2015). From a methodological point of view, the pilot case of the Circular Retrofit Lab, created at the VUB in Brussels as part of the European project H2020 Buildings as Materials Banks (BAMB), constitutes an important reference for a 'research by design' approach and a 'process approach' vision.

The objective is, in fact, to be able to measure, in coherence with the EU research proposals, the efficiency and effectiveness (range, performance, quality and selectivity of the recovered materials) of the exploitation of complex and heterogeneous deposits of secondary raw materials (urban mines), for the definition of a Nearly Zero Impact of Materials approach, applied to the re-design of existing buildings, to the building process and to the production of components.

Resilience and adaptation in the energy-efficient project of existing buildings | In order to pursue, with effective results, the implementation of the objectives of resilience and adaptation in architectural and urban design, in the specific perspective of energy efficiency, it is necessary to reformulate the concepts that pertain to the technological design of architecture[2]: the performance value, aimed at increasing the resilience and adaptation capabilities of the building structure subject to intervention, is closely related to the specific technologies used and their level of integration in the reference building context. In this sense, the concept of 'deviant technologies' appears to be more up-to-date, that is deviant from traditional building standards and materials, capable of substituting the centrality of the architectural artefact with the complexity of natural elements (Vittoria, 1988).

The 'deviant technologies' can be re-defined as those technologies that identify technical procedures and solutions capable of rationalizing technical-design solutions and options, by proposing solutions which have high performance potential, are innovative and can solve the complex reference energy-environmental issues. The 'deviant technologies' are apt to understand that it is not enough to be 'reactive' to the demand but that it is essential to be 'proactive': researchers of a positive technological innovation for the environment, capable of guaranteeing excellence (Torricelli, 2010). If on the one hand the concept of 'deviant technologies' identifies the boundaries within which to redefine the technological dimension of reference, on the other it is extendable to the whole scenario of building and architectural production, being not originally and exclusively referred to the concepts of resilience and adaptation of the existing building stock. In order to define even more specific conceptual margins around the theme of technology for architectural and urban resilience in the energy-efficient design of existing buildings, the concept of 'reconfiguring technologies' is proposed (D'Olimpio, 2017), i.e. technologies through whose application and integration in buildings, the configuration of the latter is changed substantially at different levels: architectural, physical-constitutive, plant engineering.

For instance, the creation of a solarized space (such as a solar greenhouse) integrated with a building envelope that originally did not foresee it, in the context of an energy-efficient retrofitting, certainly reconfigures the building architecturally, in terms of layout of internal spaces, as well as specifically from the plant engineering point of view, in relation to a changed behaviour and renewed energetic functioning. Similarly, the construction of a photovoltaic façade aimed at using the energy-environmental potential related to a convenient solar exposure, is capable of reconfiguring the building from an architectural and energy point of view (from energy user to producer of energy). In this scenario, the reference technology must be able to generate and determine a reconfiguration of the building context in question, with respect to the various physical-constitutive parameters that characterize its state of affairs. The concept of 'reconfiguring technologies' can therefore be defined as a specific technological field comprising systems and technologies capable of carrying out an 'upgrade' of the building organism, which therefore evolves towards renewed architectural and physical-constitutive structures, according to the new and innovative performance requirements.

Energy efficiency intervention on the experimentation context of the IACP neighbourhood in Torrevecchia | In the experimental case study concerning the IACP area of Torrevecchia in Rome, the existing building was integrated with different design

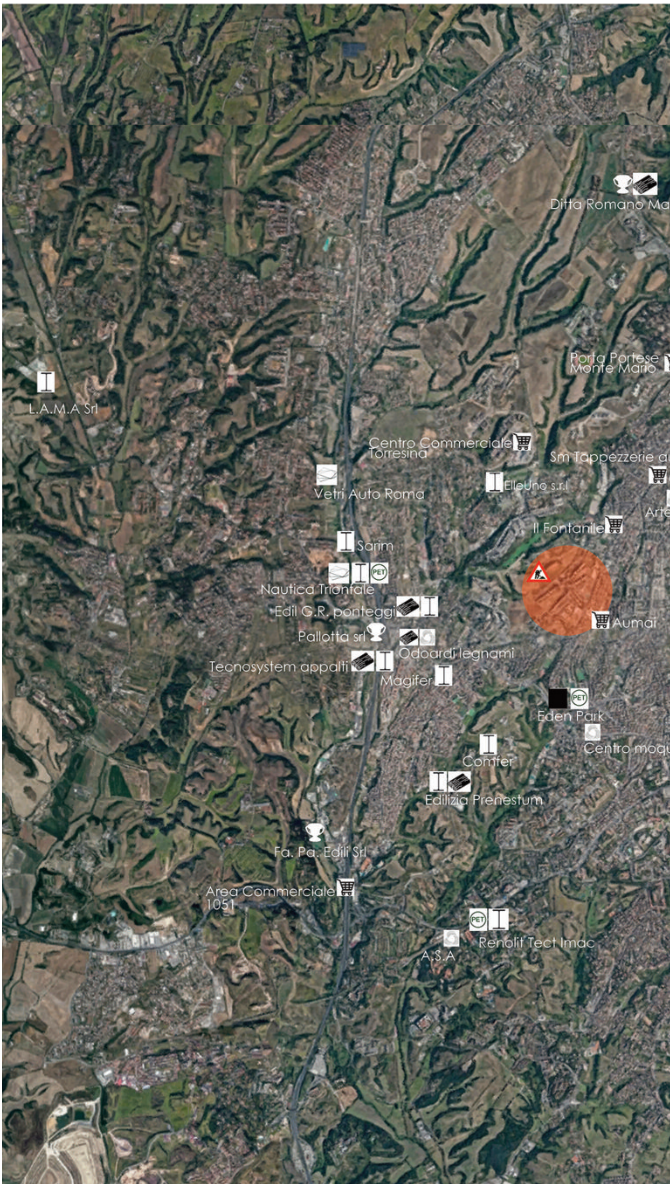


Fig. 1 | Example of Harvest Map developed in reference to the design solutions for the Torrevecchia area (credit: F. Tucci, S. Baiani, D. D’Olimpio, P. Altamura, F. Aloi, F. Fogli, V. Toppeta, 2019).

Legenda

- ● Area di progetto
- ⚠ Cantiere di Torrevecchia
- I Metallo
- 🪵 Legno
- ◇ Vetro
- ◎ Tessuti
- 🏆 Marmo e ceramica
- PET Plastica
- 🛒 Centro commerciale

Dal cantiere di Torrevecchia:

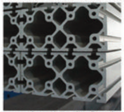
Calcestruzzo
Infissi
Vetro

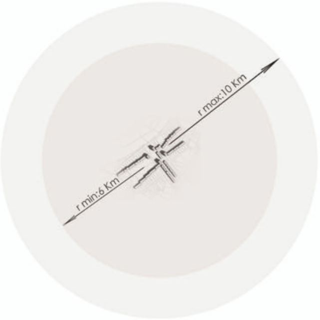
Impianti di recupero inerti di demolizione:

Seipa-Via di Porta Medaglia,131 (18 km)
Ecologica 2000- Via Ardeatina,1005 (17 km)

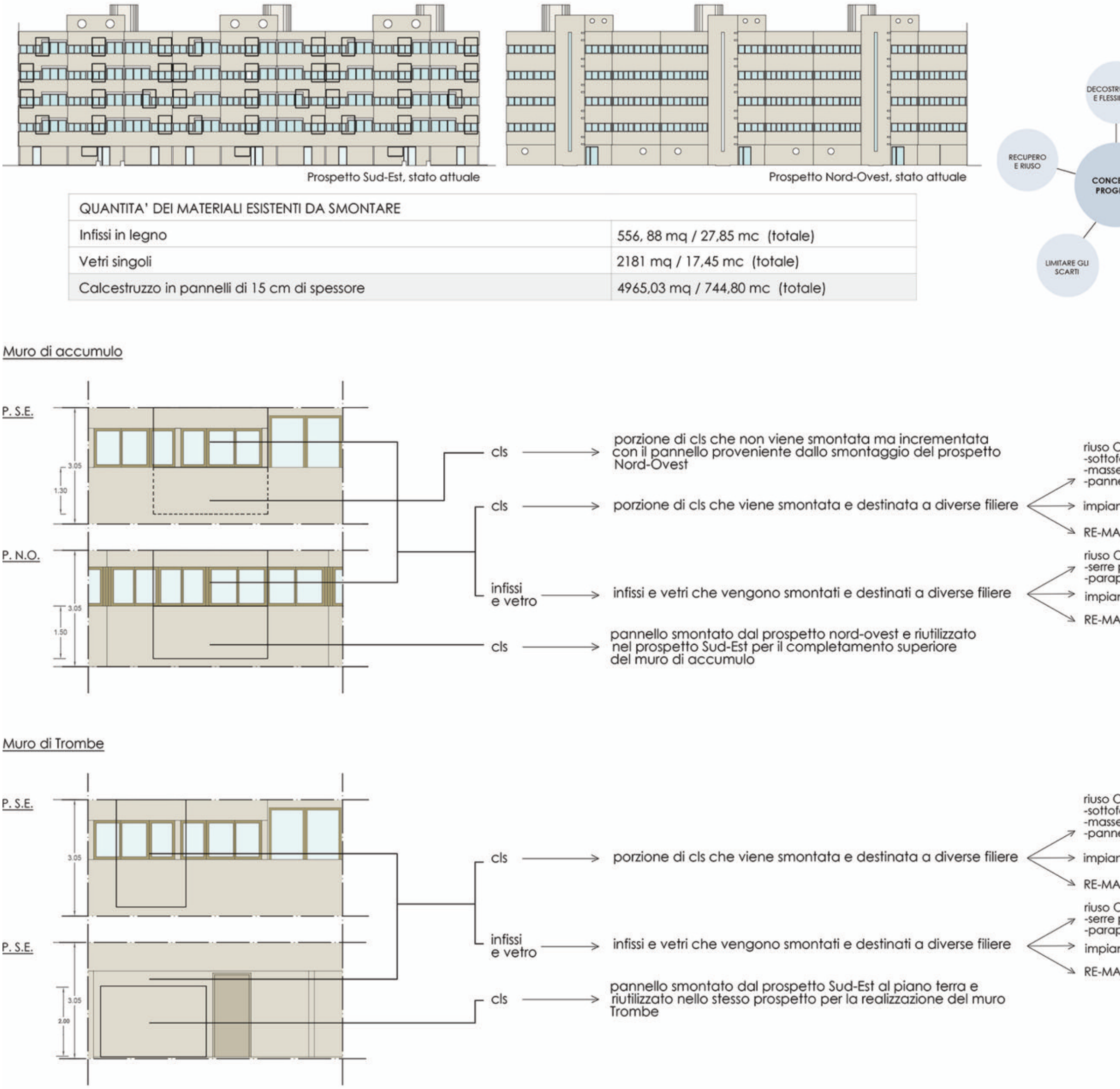

Lavorazione della ditta L.A.M.A


Lavorazione della ditta Romano


Lavorazione della ditta Renolit



Simbolo	elemento individuato	tipologia	descrizione	azienda	attività	indirizzo sito
I PET ◇	Metallo, Neoprene, PVC, vetroresina	Giacenza invenduta, scarto, rifiuto	Scarti ottenuti da riparazioni di gommoni, scarti di taglio di tubolari in neoprene, lavorazioni in vetroresina	Nautica trionfale	Vendita, riparazioni, deposito	Via Casal del Marmo, 712, Roma
I PET	Metallo, Plastica	Rifiuto	Giochi e giostre dismesse e smontabili nelle loro componenti primarie	Eden Park	Parco giochi, manutenzione	Via Mattia Battistini, 49, Roma
I	Metallo	Giacenzea invenduta, scarto, rifiuto	Smontaggio delle componenti di panchine, cancelli, portoni, serrande	Sarim	Vendita, manutenzione	Via Casal del Marmo, 690, Roma
◇ PET	Vetro, Plexiglass, Pellicole riflettenti per edilizia	Giacenza invenduta, scarto, rifiuto	Scarto prodotto dalle sostituzioni di parabrezza per auto, specchietti, pellicole decorative e riflettenti per l'edilizia	Vetriautoroma	Vendita, riparazione, sostituzione	Via Casal del Marmo, 609, Roma
🏆 🪵	Gres porcellanato, Parquet, Pietra ricomposta (materiali edili)	Giacenza invenduta, scarto	Giacenza invenduta di piastrelle, mattonelle, listelli di legno per i rivestimenti interni	Ditta Romano Magnante	Vendita, deposito	Via Trionfale, 10104, Roma
I	Metallo	Giacenza invenduta, scarto, rifiuto	Scarti di fogli di lamiere lavorati tramite taglio ad acqua e laser	L.A.M.A. srl	Produzione	Via Chivasso, 3/A, Roma
I PET	Polimglass, Ecotres, H.S.P.	Giacenza invenduta, scarto, rifiuto	Scarti di taglio di lastre ondulate/grecate e sistemi di gronda realizzati tramite coestrusione	Renolit Tecno Imac	Produzione, deposito	Via della stazione Aurelia, 185, Roma
◎ 🪵	Legno, Tessuti	Giacenza invenduta, scarto, rifiuto	Scarto di porzioni delle componenti di avvolgibili, tende, zanzariere	A.S.A.	Produzione	Via degli Andosilla, 33, Roma
◎ 🪵	Legno, tessuti speciali	Giacenza invenduta, scarto, rifiuto	Scarti ottenuti dalla produzione di porte, infissi, parquet, tende, pannelli, scarti di lavorazione cnc	Odoardi Legnami	Produzione	Via Boccea, 539/D, Roma
🪵	Legno	Giacenza invenduta, scarto, rifiuto	Scarti ottenuti dal taglio del legno per la produzione di parquet personalizzati	Stemau srl	Produzione, deposito	Via Refrancore, 26, Roma
I	Metallo	Giacenza invenduta, scarto, rifiuto	Scarti ottenuti dal taglio di componenti per inferriate, grate, persiane, infissi, portoni, cancelli, scale, recinzioni, soppalchi, verande	MA.GI.FER	Produzione	Via di Vallelunga, 80, Roma
◎	Tessuti	Giacenza invenduta, scarto, rifiuto	Scarti ottenuti dal taglio di rivestimenti interni per auto	Sm Tappezzerie auto	Produzione	Via Simone Mosca, 16, Roma
◎	Tessuti	Giacenza invenduta, scarto, rifiuto	Scarti ottenuti dal taglio di moquette, tappeti, zerbini, prato sintetico, carta da parati, tende	Centro moquette Contract	Produzione	Via Boccea, 309, Roma
◎ 🪵	Tessuti, legno	Giacenza invenduta, scarto, rifiuto	Scarti ottenuti dalla produzione di gazebi, inferriate, ombrelloni, infissi, paavimentazioni in legno, pensiline, pergole, tende, zanzariere	Artetenda	Produzione	Via dei Cristofori, 31/35, Roma
I	Metallo, vetri	Giacenza invenduta, scarti, rifiuti	Scarti ottenuti dal taglio e dalla lavorazione di componenti per inferriate, cancelli, ricenzioni, persiane, balaustre, scale, infissi, vetro	ElleUno s.r.l.	Produzione	Via Fratelli Grimm, 23, Roma
I 🪵	Metallo, Legno	Scarto, riufiuto	Smontaggio delle componenti tubolari metalliche e delle componenti lignee	Edilizia Prenestum	Noleggio, manutenzione	Via Garessio, 44, Roma
I 🪵	Metallo, Legno	Scarto, riufiuto	Smontaggio delle componenti tubolari metalliche e delle componenti lignee	Edil G.R. ponteggi	Noleggio, manutenzione	Via Vinovo snc, Roma
I 🪵	Metallo, Legno	Scarto, riufiuto	Smontaggio delle componenti tubolari metalliche e delle componenti lignee	TecnoSystemAppalti	Noleggio, manutenzione	Via Achille Bonanome, 20, Roma
🏆	Marmo	Giacenza invenduta, scarto, rifiuto	Giacenza invenduta e scarto ottenuto dal taglio di lastre e blocchi di marmo	Pallotta srl	Produzione, deposito	Via Valfenera, 14, Roma
I	Metallo	Giacenza invenduta, scarto, rifiuto	Scarti ottenuti dal taglio di profilati, lamiere, tondini, grigliati, griglie, tubazioni, travi, reti metalliche	Comfer srl	Produzione	Via dei Casali di Acquafredda, 15, Roma



QUANTITA' DEI MATERIALI ESISTENTI DA SMONTARE	
Infissi in legno	556, 88 mq / 27,85 mc (totale)
Vetri singoli	2181 mq / 17,45 mc (totale)
Calcestruzzo in pannelli di 15 cm di spessore	4965,03 mq / 744,80 mc (totale)

porzione di cls che non viene smontata ma incrementata con il pannello proveniente dallo smontaggio del prospetto Nord-Ovest

porzione di cls che viene smontata e destinata a diverse filiere

infissi e vetri che vengono smontati e destinati a diverse filiere

pannello smontato dal prospetto nord-ovest e riutilizzato nel prospetto Sud-Est per il completamento superiore del muro di accumulo

porzione di cls che viene smontata e destinata a diverse filiere

infissi e vetri che vengono smontati e destinati a diverse filiere

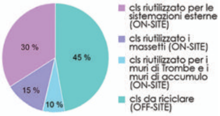
pannello smontato dal prospetto Sud-Est al piano terra e riutilizzato nello stesso prospetto per la realizzazione del muro Trombe

Fig. 2 | Deconstruction of concrete panels for the construction of thermal storage systems and Trombe walls in South-East elevation (credit: F. Tucci, S. Baiani, D. D'Olimpio, P. Altamura, A. Coroneo, A. Del Regno, 2019).

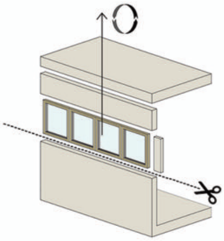
Prospetto Sud-Est, progetto

Prospetto Nord-Ovest, progetto

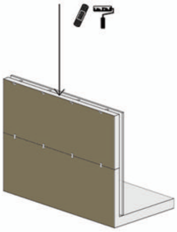
Materiale recuperato: CALCESTRUZZO			
Utilizzo	Singolo elemento	Tot. elementi	Tot. mat. recuperato
Muro di accumulo	8,28 mq / 1,24 mc	844,56 mq / 126,68 mc	1236,56 mq / 185,48 mc
Muro di Trombe	5,6 mq / 0,84 mc	392 mq / 58,8 mc	



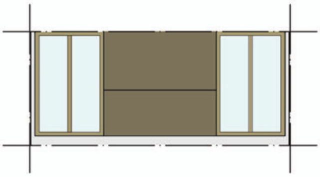
ON-SITE
ondi e sistemazioni esterne
etti
elli di facciata
nto di riciclo OFF-SITE
NUFACTURING
ON-SITE
per coltivazioni
etti
nto di riciclo OFF-SITE
NUFACTURING



Taglio della porzione di prospetto S.E. per la realizzazione del muro di accumulo

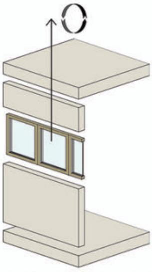


Aggiunta del pannello proveniente dal prospetto N.O., ancorato tramite staffe in acciaio e aggiunta di un pannello di fibrogesso di protezione e verniciatura con colore scuro per un miglioramento delle prestazioni

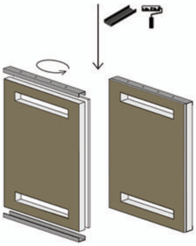


Prospetto S.E. dopo l'intervento

ON-SITE
ondi e sistemazioni esterne
etti
elli di facciata
nto di riciclo OFF-SITE
NUFACTURING
ON-SITE
per coltivazioni
etti
nto di riciclo OFF-SITE
NUFACTURING



Taglio della porzione di prospetto S.E. per la realizzazione del muro di accumulo



Porzione di cls proveniente dal PT del prospetto S.E., ancorata tramite binari in acciaio e aggiunta di un pannello di fibrogesso di protezione e verniciatura con colore scuro per un miglioramento delle prestazioni. Durante la posa viene ruotata così da proteggere maggiormente gli ambienti dalle perdite di sostanze nocive da parte dell'isolante.

Prospetto S.E. dopo l'intervento

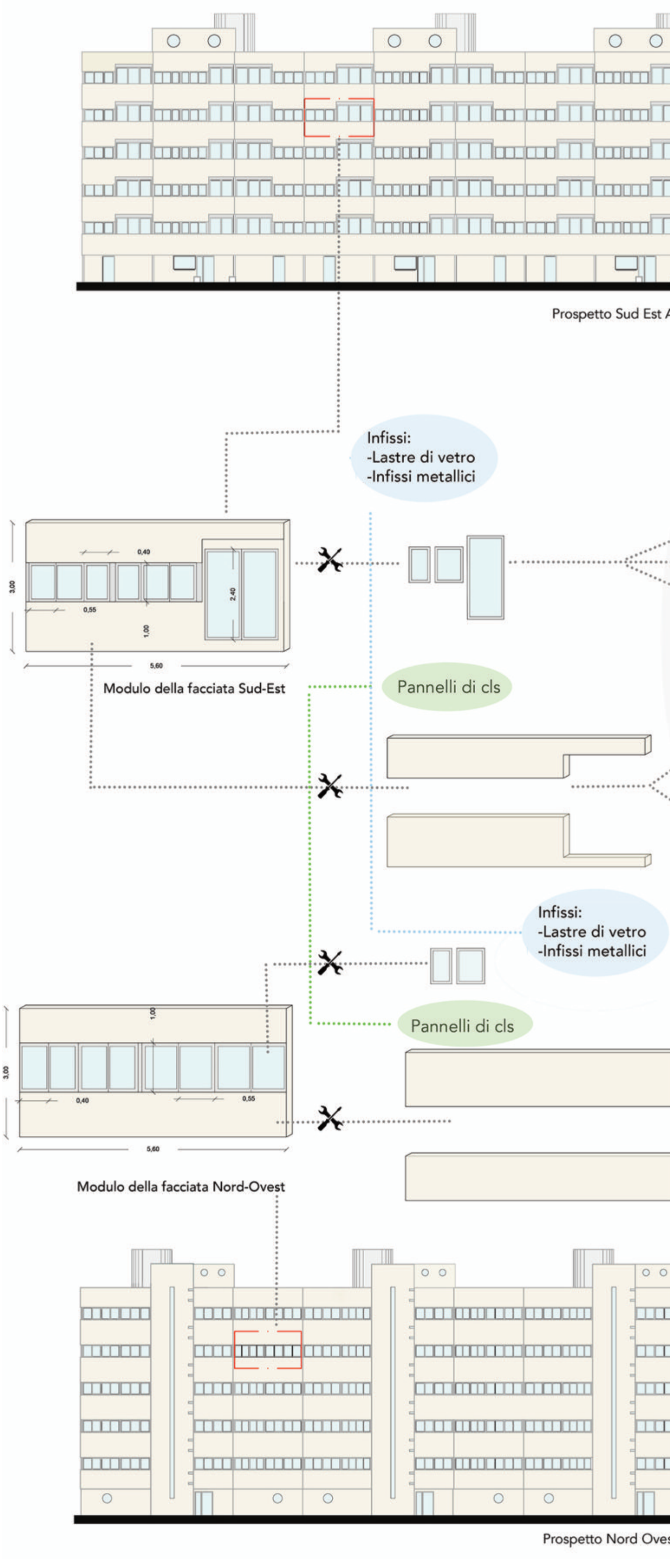


Fig. 3 | Deconstruction of window fixtures for the creation of the upper part of the façade and assessment of the cycle of materials for in-site and off-site reuse and recycling (credit: F. Tucci, S. Baiani, D. D'Olimpio, P. Altamura, F. Aloi, F. Fogli, V. Toppeta, 2019).

Attuale

STRATEGIE

CRADLE TO CRADLE

DESIGN FOR DECONSTRUCTION: prevenzione rifiuti

RIUSO DELL'EDIFICIO

SUPERUSE deli materiali e delle componenti

Prospetto Sud Est di Progetto

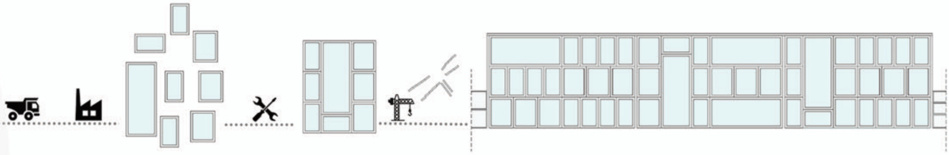
AZIONI TECNICHE

Riuso ON SITE

Remanufacturing

Riciclo OFF SITE

La componente metallica viene riutilizzata in cantiere per i telaio dell parapetto della copertura



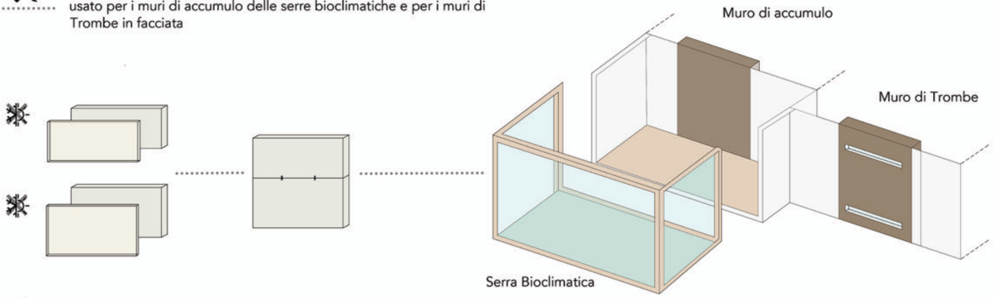
Gli infissi attuali vengono smontati e rilavorati in un' azienda locale per creare nuovi moduli che verranno destinati lle serre di coltivazione poste sulle coperture degli edifici

Una percentuale del materiale smontato verrà trasportato in altre aziende per essere riciclato

Riciclo OFF SITE

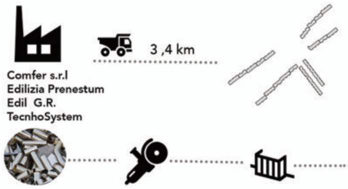
Riuso ON SITE

Il calcestruzzo che compone gli attuali pannelli di facciata viene riciclato e usato per i muri di accumulo delle serre bioclimatiche e per i muri di Trombe in facciata



Taglio
e rimozione dell'isolante .... Riconnessione .... Assemblaggio

st Attuale



Le componenti per il parapetto dei balconi sono composti da tubolari ri recupero derivati da scarti di lavorazione di un'azienda locale

Prospetto Nord Ovest di Progetto

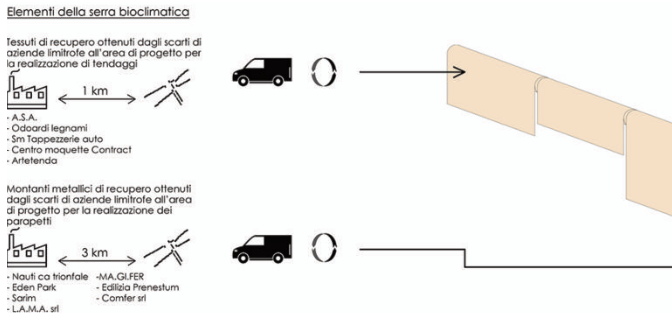


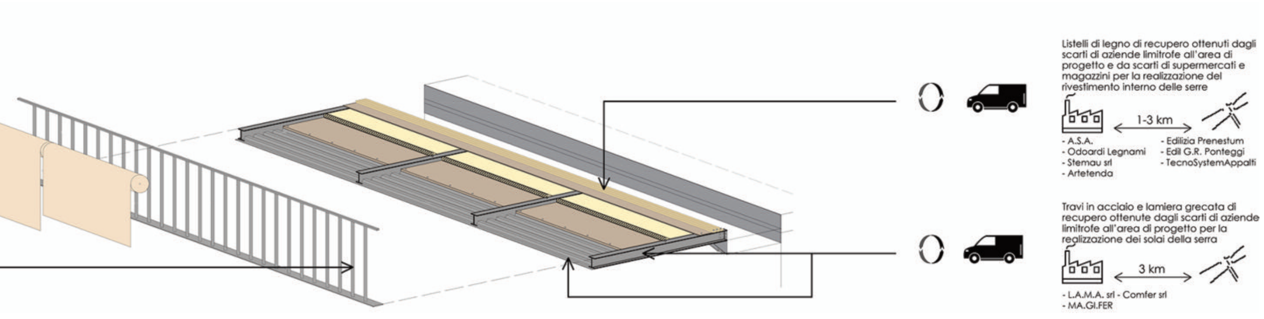
Fig. 4 | Reuse of materials from processing waste produced by companies adjacent to the project area, for the construction of components for bioclimatic greenhouses: fabric for summer sunshades; metal struts for the construction of parapets; wooden slats for flooring; steel beams and corrugated sheets for the construction of slabs (credit: F. Tucci, S. Baiani, D. D’Olimpio, P. Altamura, A. Coroneo, A. Del Regno, 2019).

and technical intervention solutions, in order to obtain specific energy efficiency, as part of an overall strategy of ‘energy and bioclimatic retrofitting’, capable of giving the building complex characteristics of resilience and adaptation to the microclimatic variability, induced by the reference environmental context.

In this specific case study, following an analysis of the local environmental conditions, of the building conditions, in physical-constitutive, construction and plant engineering terms, as well as of the environmental and energy performance that the building was able to guarantee, the project focused on the reconfiguration of the architectural organism through a rethinking of the building front, i.e. the façade. The latter was attributed the important role of providing specific answers in the direction of energy efficiency and microclimatic adaptation: expansion of inhabited spaces through the creation of new volumes placed before, integrated and annexed to the original front and block, housing solarized spaces characterized by direct solar gain functions (solar energy is directly transmitted to the inhabited space and to the building components and materials that constitute it), reconfigure the building front and the building as a whole, from an architectural, functional, energy and environmental point of view (Figg. 6-8).

Substantially the architectural and technological reconfiguration of the building interferes with all aspects and areas of the building system: from that of the architectural design to that of the material-constituent choices, from that of the ‘reconfiguring technologies’ used to that of specific plant technologies. The increase in permeability to external environmental energy flows, in this case due to the implementation of the transparent surfaces that delimit the solarized spaces, during the colder months determine solar gains that are achieved through solar collection and energy absorption by internal thermal masses; during warmer and hot seasons, the windows can be opened, in order to create environments more permeable to air flows, thus avoiding the greenhouse effect that characterizes the rise in temperatures typical of solarized spaces.

In this framework, the energy demand relating to plant systems is completely different and reduced, both in the winter and in the summer season. In this specific case, this concerns the re-proposal of technologies whose etymological root starts from ex-



periences that are certainly not innovative but re-proposed through new functional values and through new materials and components (glass with high technical-environmental performance, with specific characteristics of solar transmission and of energy saving, capable of exactly guaranteeing specific and programmed performances; materials for the absorption of thermal energy, capable of absorbing and releasing energy in specific moments and quantities, etc.). These materials and components have been defined within the scenario of technological innovation in building materials, currently more than ever proposing new technical solutions and product innovations, driven and supported also by the impulse of nano-technological research and nano-innovation.

Resilience and adaptation in the control of the sense of detail in the project: a matter of scale | If it is true, as Thomas Herzog writes, that a building is a 'node' in an energy field, this node in turn is both legible in relation to other polarities – with which a mesh is defined and gradually a fabric – and legible, on a microscopic level, as itself a summation of infinitesimal elements that make up the matter. Starting from this not necessarily fractal 'geometry' of the node, we can well understand how the same definition of detail varies according to the reference scale being analyzed and how, according to this scale, the incidence of the single factors has a variability not constant. Variability is an important element in the definition of the 'sense' of detail at different levels: at the area, building, system or individual technological construction level, to which are added the further possible interactions.

It is therefore possible to speak of 'detail' at the extended area level by highlighting design choices related, for example, to the morphology of the fabric, to the vast systems for collecting rainwater or waste, to name a few. Going down, then, of scale, the detail can relate to the individual building in the choice of interventions that affect the volume as a whole, to move on then to technological systems that specifically concern individual building components, up to the individual construction elements, elementary particles of the project. Not a simple summation of parts, but detailed choices – precisely – that specifically define the single organism (urban, building, multi or single-cell), interacting choices that vary according to a defined objective, strictly corre-

SISTEMA DI SCHERMATURA IN LEGNO

Bamboo Moso

La sceltadel tipo di bamboo è stata accuratamente scelta in merito alla sua alta sostenibilità

CARATTERISTICHE

risorsa infinita
Con la crescita di anche
1 metro al giorno,
il bambù Moso è la pianta con la
crescita più rapida al mondo

salutari
Le componenti sono
antiallergici e antistatici,
rendendo l'ambiente
ancora più confortevole

qualità garantita
I prodotti Moso
rappresentano la piu alta
qualità sul mercato e
sono garantiti per
30 anni

CO_2 neutri
Considerando il suo intero
ciclo di vita, questa specie
è altamente CO2 neutro.
Può essere riutilizzato infatti
per l'industria tuciolare

duro e resistente
La resistenza è
paragonabile a
quella dei legni più
duri, rendendo
le sue applicazioni
adattabili ad ogni uso

alta stabilità
Grazie alla composizione
delle singole strisce,
i pavimenti Moso sono
altamente più stabilienti
degli altri legni masselli

CICLO DI VITA

Definito "l'acciaio verde",
da costruzione resistente,

La sua produzione è molt
altre, producendo quasi 2
è utilizzabile come compo
primi 3-4 anni di vita.

FONTI

Azienda: "Only Moso"
https://onlymoso.it/
☎ (+39) 0721.1630100 / 0541.830001
✉ info@onlymoso.it

Azienda: "orange Fiber"
http://orangefiber.it/contact/

Azienda: "Due di Latte"
https://antonellabellina.wixsite.com/duedilatte/contatti
✉ info@duedilatte.it

SISTEMA DI SCHERMATURA TESSILE

I tessuti scelti sono tutti altamenti sostenbili concependo lo scarto alimentare come una risorsa.
Le aziende di riferimento producono tessuti tramite l'estrazione della fibra alimentare: una dalla case

CARATTERISTICHE

Lo scarto alimentare
viene trasformato in
fibra, la quale diventa
poi tessuto.

Il processo di produzione
è altamente ecologico:
viene infatti impiegata
una quantità pari al 0.02%
di acqua rispetto alla produzione
di tessuti in cotone

prodotti sono altamente
esistenti, tanto
da proteggere dai raggi UV,
dall' acqua e dal vento,
anche a distanza di tempo

I filati ottenuti
permettono di realizzare
qualsiasi tipo di tessuto.

I tessuti che ne derivano,
essendo totalmente naturali,
sono termoregolatori
e anallergici.

I tessuti sono assolutamente
adattabili ad ogni necessità.
I filari possono assumere
qualsiasi spessore
e qualsiasi colore.

CICLO DI VITA

OrangeFiber

La trasformazione
sottoproduzione a
in Italia, ogni anno
700000 tonnellate
agrumicoli

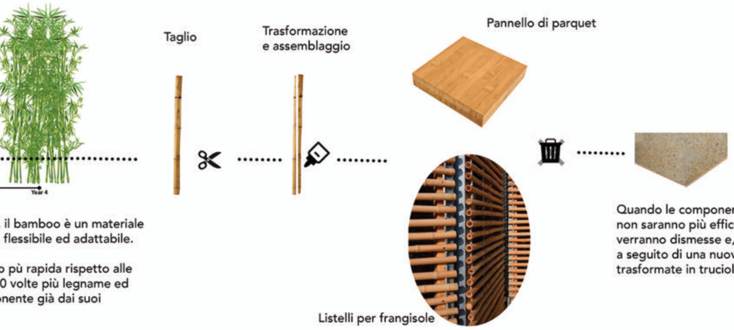
Due di Latt

Eccedenza del latte

La caseina viene sepa

Fig. 5 | Integration of materials from highly regenerated resources and from secondary materials of natural origin (credit: F. Tucci, S. Baiani, D. D'Olimpio, F. Mancini, J. Palmiero, M. Proietti, 2019).

UTILIZZO NEL PROGETTO



Taglio

Trasformazione
e assemblaggio

Pannello di parquet

Listelli per frangisole

Quando le componenti
non saranno più efficenti
verranno dismesse e,
a seguito di una nuova lavorazione,
trasformate in truciolato

il bamboo è un materiale
flessibile ed adattabile.

o pù rapida rispetto alle
0 volte più legname ed
onente già dai suoi

Il bamboo viene utilizzato
per realizzare gli elementi di schermatura
della serra bioclimatica

Prospetto Sud-Est di Progetto

eina del latte ("Due di Latte) e l'altra dal pestaggio degli agrumi ("Orange Fiber")

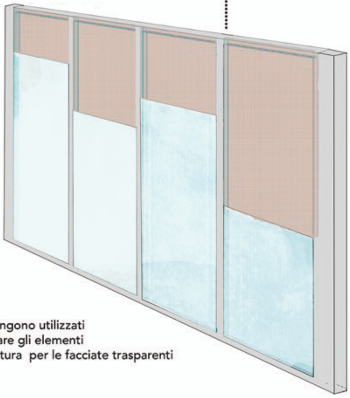
parte dalla
grumicola:
, abbiamo
di sottoprodotti

Estrazione della
cellusola dal pastazzo

Filatura

Tessitura

Riuso



I tessuti vengono utilizzati
per realizzare gli elementi
di schermatura per le facciate trasparenti

te

Estrazione della caseina

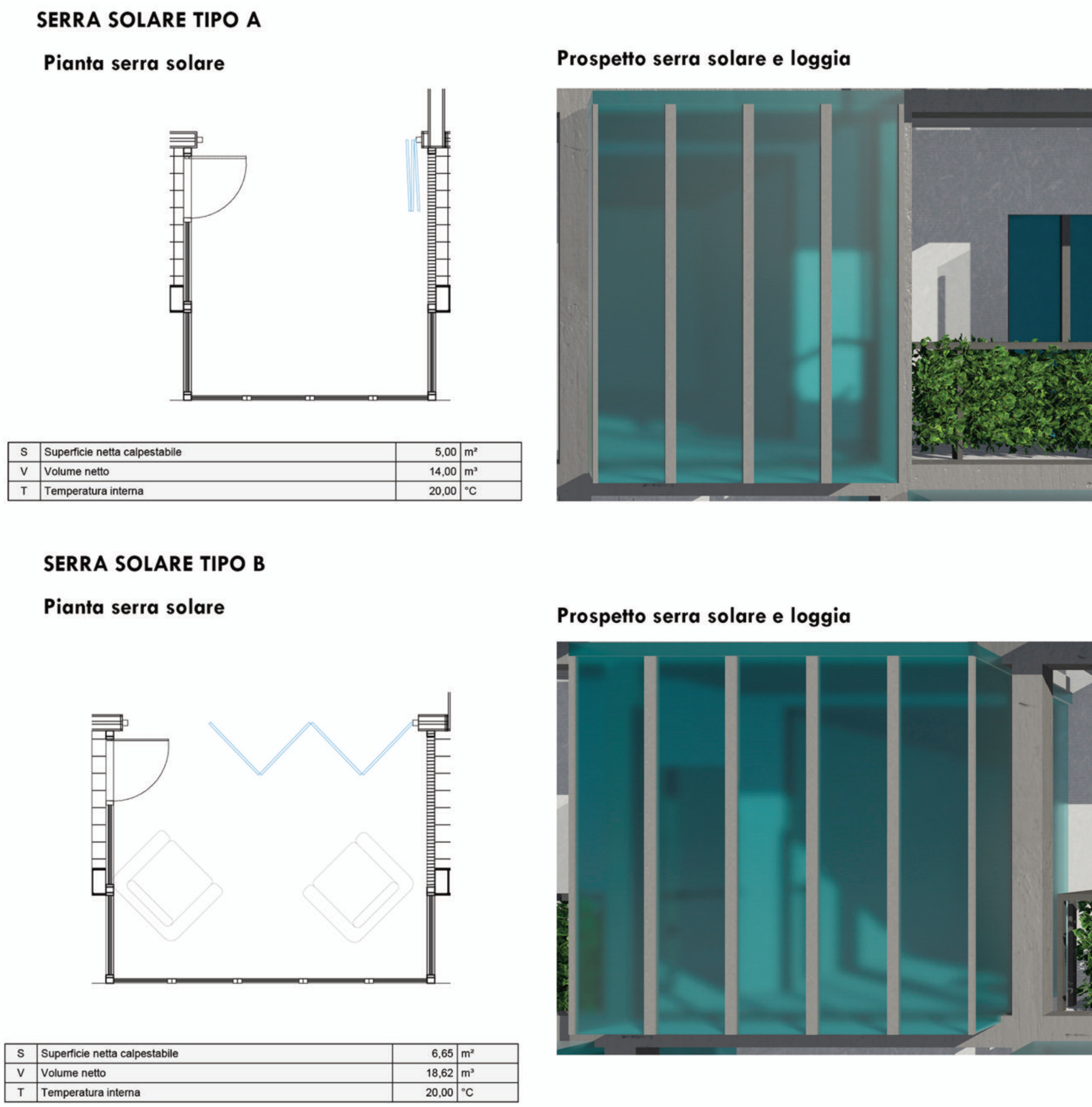
Trasformazione in fibra

Filatura

Tessitura

Riuso

rata dal siero, isolata, denaturata e poi trasformata in siero.



S	Superficie netta calpestabile	5,00	m²
V	Volume netto	14,00	m³
T	Temperatura interna	20,00	°C

S	Superficie netta calpestabile	6,65	m²
V	Volume netto	18,62	m³
T	Temperatura interna	20,00	°C

Fig. 6 | Energy efficiency intervention on the IACP context of Torrevecchia: construction of solarized spaces (credit: F. Tucci, S. Baiani, D. D'Olimpio, F. Mancini, J. Palmiero, M. Proietti, 2019).

	Radiazione solare globale giornaliera media (kW/mq)	Radiazione solare mensile (kW/mq)
Novembre	2.82	84,6
Dicembre	2.51	77,81
Gennaio	3.07	95,17
Febbraio	3.13	87,64
Marzo	3.34	103,54
Aprile (15gg)	3.09	46,35
Valori totali		495,11

Superficie delle vetrate (mq)	Superficie effettiva di captazione
10	*10*

L'energia solare effettivamente captata durante l'intero periodo di riscaldamento sarà pertanto:

kW/mq x mq	Energia solare captata kW
495,11x10	*4951*

Quantità di energia producibile ed utilizzabile
Qa = Qi x τ x α
Dove Qi è la radiazione incidente precedentemente calcolata;τ è il coefficiente di trasmissione del vetro o fattore solareα è il coefficiente di assorbimento della massa termica.

Qa = 4951 x 0,6 x 0,7 = 2079,42 kW anno
(anno inteso come periodo di riscaldamento)

	Radiazione solare globale giornaliera media (kW/mq)	Radiazione solare mensile (kW/mq)
Novembre	2.82	84,6
Dicembre	2.51	77,81
Gennaio	3.07	95,17
Febbraio	3.13	87,64
Marzo	3.34	103,54
Aprile (15gg)	3.09	46,35
Valori totali		495,11

Superficie delle vetrate (mq)	Superficie effettiva di captazione
12	*12*

L'energia solare effettivamente captata durante l'intero periodo di riscaldamento sarà pertanto:

kW/mq x mq	Energia solare captata kW
495,11x12	*59412*

Quantità di energia producibile ed utilizzabile
Qa = Qi x τ x α
Dove Qi è la radiazione incidente precedentemente calcolata;τ è il coefficiente di trasmissione del vetro o fattore solare α è il coefficiente di assorbimento della massa termica.

Qa = 59412 x 0,6 x 0,7 = 24953 kW anno
(anno inteso come periodo di riscaldamento)

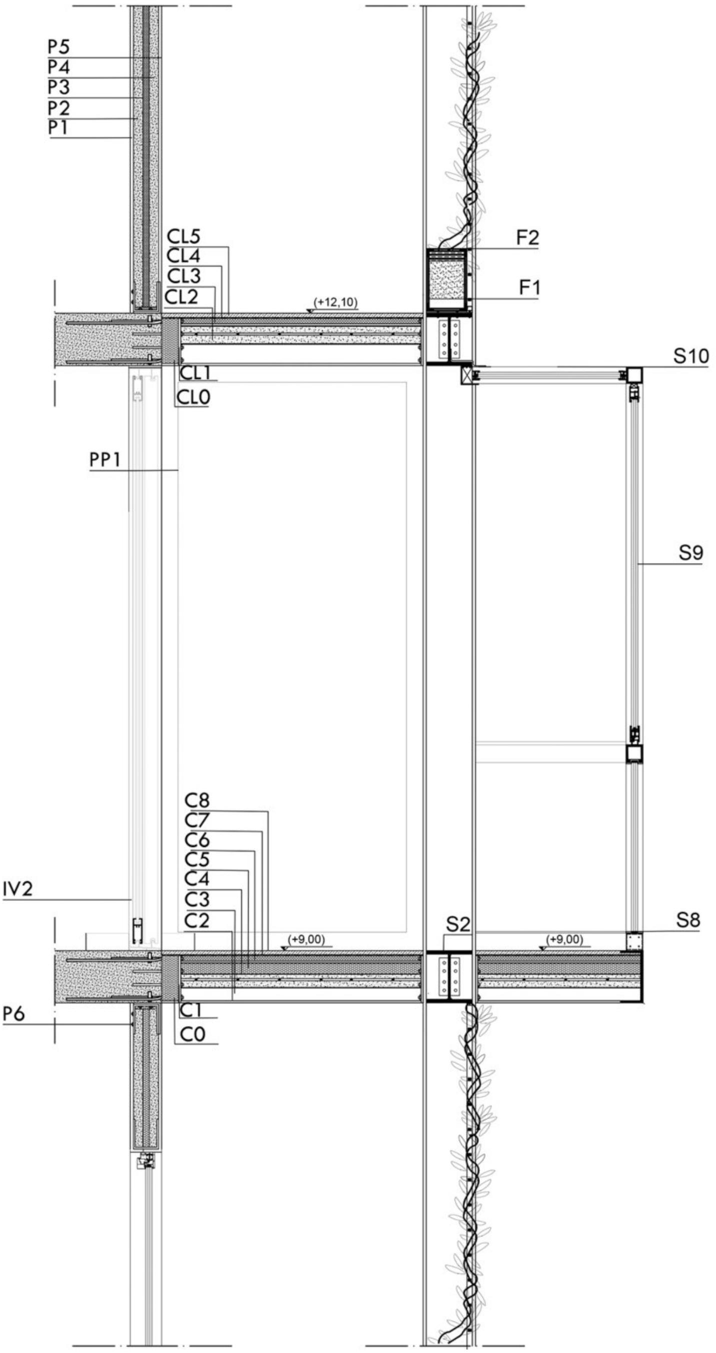


Fig. 7 | Energy efficiency intervention on the IACP context of Torrevecchia: vertical section on the new building façade of the project (credit: F. Tucci, S. Baiani, D. D'Olimpio, F. Mancini, J. Palmiero, M. Proietti, 2019).

lated to the needs of man but also of the environment (Los, 1990). The dual polarity, human needs/environmental specificities, determines or rather should determine the detail as an element no longer unique and static (suitable and adaptable for any external and/or internal climatic stimulus), but a variable element in a complex system of relationships. The dynamism of detail itself is expressed, at the various analyzed levels, through different design solutions that are able to respond to increasingly complex urban, social, cultural, need, performance, economic scenarios (WEF, 2018) and not least in relation to the theme of adaptation to climate change (EEA, 2008, 2012, 2016; European Union – Committee of the Regions, 2011; Wilby, 2008; Nikolopoulou, 2004), in a continuous metabolic cycle between input and output.

All this opens the doors to a considerable percentage of possible answers for each problem, and to the consequent need for systematization of the selection process that helps the designer in the evaluation of the detail or details that best meet the specific needs. A choice of one or more options that is built through a complex process of slow rapprochement from the general to the particular and vice versa, which lays its foundations on a careful knowledge of the state of affairs and an understanding of methodologies, techniques and tools that guide the action. Simulations, parametric software, BIM today are tools that help in this process of choosing the 'detail' by intervening from the design stages to the construction phase and allowing a constant and therefore dynamic evaluation of the phases. It can therefore be said that, in the transition from static to dynamic, the detail has also taken on a 'virtual sense', that is, its three-dimensional nature even before of the prototyping and/or realization phase, useful support in the decision-making phase, especially in the energy and environmental aspects.

The dynamism of the detail does not end, then, at the realization phase of the project, but we could say that it continues throughout all the life stages of the product, until its disposal. An interesting detail aspect is also the connectable one to the user information and training process. Thinking about detail today also means thinking about systems not only for data collection (environmental, consumer, etc.) but also for outsourcing of them, to help the individual user in the intelligent use of raw materials (such as lighting or natural ventilation) and the reduction of consumption (such as energy, water, etc.). A building envelope, for example, is not only a container but also an information transmitter (Tucci, 2014), that moves and changes quickly and dynamically in relation to internal and external stimuli.

The detail in the experimental case of the regeneration of the IACP neighbourhood of Torrevecchia, Rome | As framed in the previous paragraph, the detail affects different scales but also different fields of action in relation to the characteristics of resilience and invariance of the analyzed site. The control and passive use of microclimatic factors for energy and bioclimatic purposes, the use and integration of energy production systems from renewable sources, the control and reduction of pollution, waste products and more generally of environmental loads, are 'fields of action' aimed

to reduce the consumption and to improve the conditions of well-being not only hygrothermal terms, but also in socio-economic terms: all closely related fields, which affect not only the individual building, but the entire urban area.

Thus, as seen theoretically, even in the experimental studies carried out on the Torrevecchia IACP area, one or more design responses, concretely achievable through the choice of appropriate 'details', were defined for each potential need or risk, from the scale of the system to that of the component. There are two main categories of intervention: 'structural-grey' and 'infra-structural green' (EEA 2012, 2018; Tucci, 2019), leaving aside the 'soft' interventions in the discussion, which are in any case indispensable for a good result of the intervention to gain awareness on the issue of climate change and the concrete repercussions in those who live and use the area.

Starting from the addresses and intervention actions extracted from the research titled Adaptation to Climate Change of Architecture and Green Cities to Improve the Resilience of the Built Environment (Tucci, 2019), an attempt was made to connect to

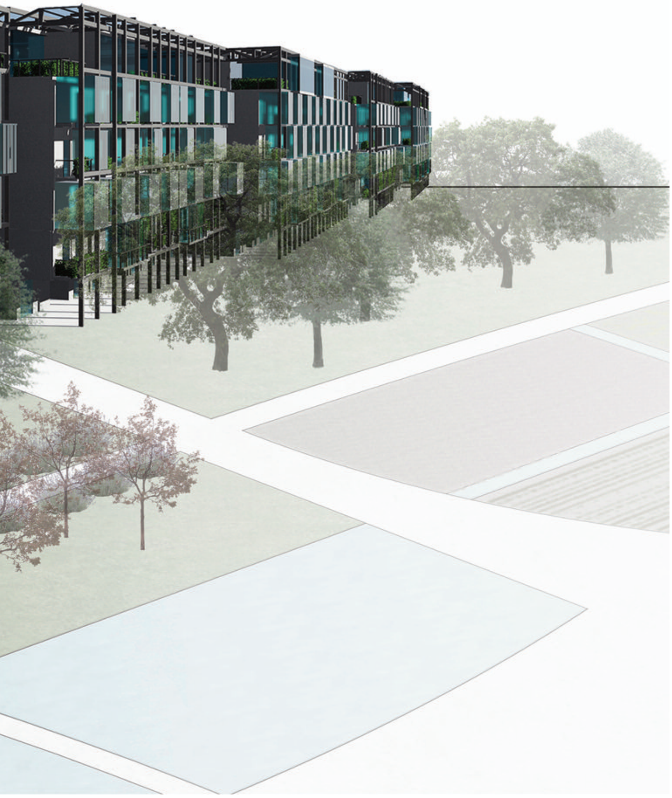


Fig. 8 | Energy efficiency intervention on the IACP context of Torrevecchia: the reconfigured building façade (credit: F. Tucci, S. Baiani, D. D'Olimpio, F. Mancini, J. Palmiero, M. Proietti, 2019).

each risk a grid of actions responding to need of the specific site and for each action the grey and green details adopted were specified, experimenting with various options, from the most conservative of the existing, compared to a cost/benefit ratio more oriented to the reduction of the initial investment, to more incisive transformations of the state of affairs, focused on maximizing the reduction of future consumption at the expense of a higher initial investment.

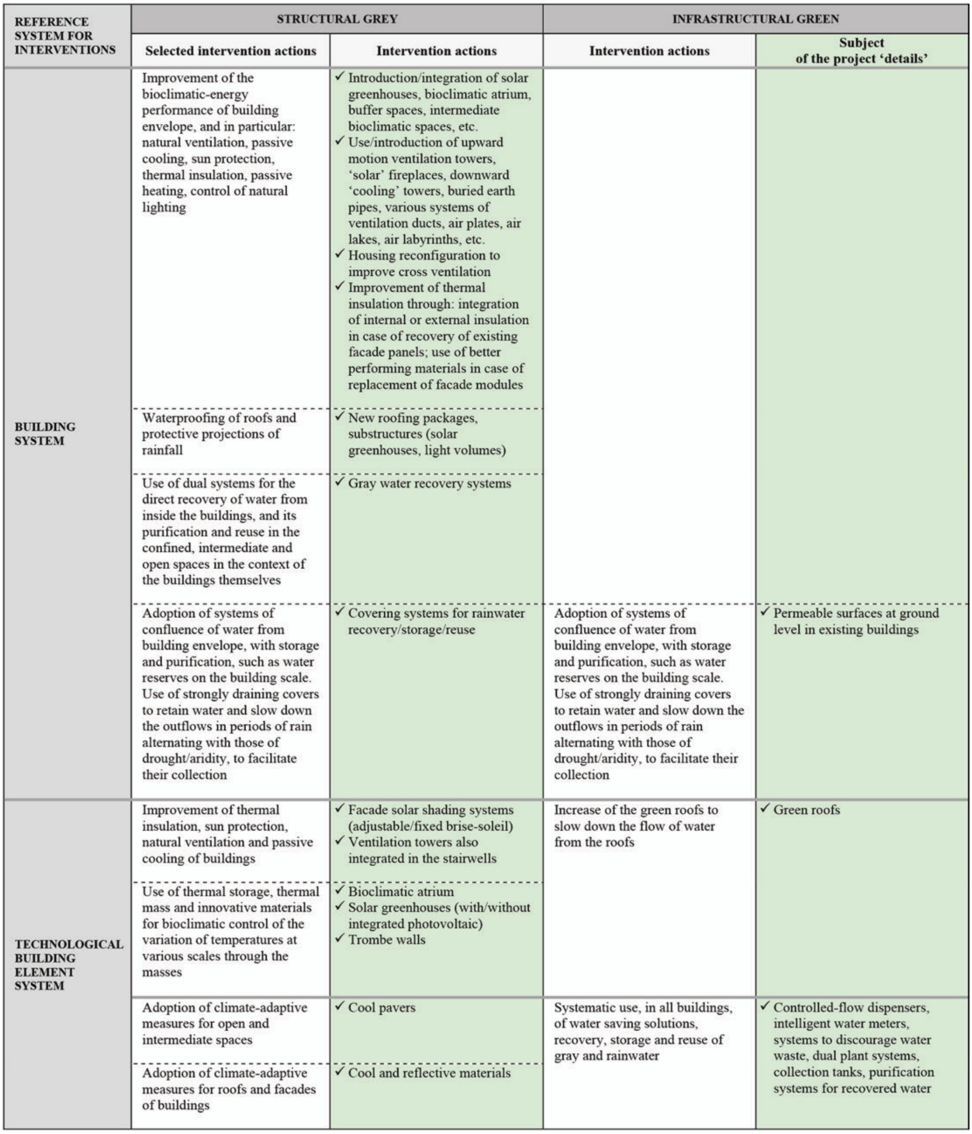
An important weight is connected to the 'details' of the area, or those design choices that aim to affect an extensive redevelopment of the entire IACP neighbourhood, starting from the improvement of the existing infrastructures up to the rethinking or modeling of the soil to improve the response in terms of accessibility or outflow of rainwater. At this juncture, green actions are increasingly gaining a very important role in possible design choices, in relation to the specific characteristics of the place. At smaller scales, the attention is mainly directed towards grey actions, that is, actions at structural and plant level that have concerned interventions to improve the perfor-

REFERENCE SYSTEM FOR INTERVENTIONS	STRUCTURAL GREY		INFRASTRUCTURAL GREEN	
	Selected intervention actions	Intervention actions	Intervention actions	Subject of the project 'details'
NEIGHBOURHOOD SYSTEM	Control of solar radiation-shading, orientation and morphology of buildings both in the complex of the urban form, both in the effects on open and intermediate spaces, and in the characteristics of the individual building	✓ Partial remodeling of the area (overcoming of unevenness, elevations, new surfaces, etc.)	Use and enhancement of green infrastructures for adaptive bioclimatic effects at different scales	✓ Procurement and regulation services: designing the water cycle, improving waste management and disposal (pneumatic waste collection systems) ✓ Accessibility: reduction of driveways, new cycle routes
	Controlled realignment of water runoff paths	✓ Rainwater collection systems	Enhancement of the use of bodies of water and elements containing artificial water	✓ Design of pools of water in the common areas
	Sustainable urban drainage systems			
	Construction of systemic rainwater recovery tanks, also connected to Rain Garden, Dry Wells, Planter Box systems, etc., to programmatically and widely cover entire areas of urban size/urban district. Use of water collection tanks from the streets and external spaces with storage and purification at the scale of the neighbourhood /around the building	✓ Rain garden and rainwater collection and reuse systems in outdoor spaces with storage and phytodepuration	Flood mitigation and temporary water storage, also using green spaces	✓ Increased drainage surfaces and rainwater collection systems
			Increase of the share of permeable urban pavements	✓ Permeable flooring for collective spaces
			Use of bio-swimming pools and urban bio-lakes to determine at the same time both the collection and storage of rainwater in periods of rain alternating with those of drought/aridity, and the confluence and purification of water for internal use in buildings and external in the open spaces	✓ Phytodepuration systems
			Creation of green windbreak barriers in the most suitable urban and peri-urban points	✓ Green barriers north side
			Conformation of urban corridors for channeling of the winds with trees and plant systems	
			Promotion of the widespread and systematic use of forms of urban farming in urban open spaces and vertical farming in city buildings, for a food supply that originates from within the city with the use of water collected and recovered in different areas and forms according to previous actions, strategic in periods of drought/aridity	✓ Urban farming common areas to integrate existing gardens

Tables 1a and 1b | Overview of actions and possible 'detailed' interventions articulated according to the two categories of 'grey' and 'green' structural interventions (credit: F. Tucci and G. Turchetti).

mance of existing buildings in terms of component, technological system and individual elements. Significant is the interest in the water cycle, studied in deep not only on a large area, but also as a recovery, storage and reuse system at the building and individual accommodation level. Finally, the use of passive rather than 'active details' is prevalent, from the exploitation of natural ventilation, to solar radiation shielding systems, to thermal storage systems (from Trombe walls, to solar greenhouses, to bioclimatic atrium, to name a few).

The Tables 1, therefore, gives a synoptic picture of the possible 'detailed' actions that have been designed and could be adopted at the various scales for an efficient and effective redevelopment of the neighbourhood, that can be translated, with the support of 'soft' actions, even in a deeper regeneration of the site.



REFERENCE SYSTEM FOR INTERVENTIONS	STRUCTURAL GREY		INFRASTRUCTURAL GREEN	
	Selected intervention actions	**Intervention actions**	**Intervention actions**	**Subject of the project 'details'**
BUILDING SYSTEM	Improvement of the bioclimatic-energy performance of building envelope, and in particular: natural ventilation, passive cooling, sun protection, thermal insulation, passive heating, control of natural lighting	✓ Introduction/integration of solar greenhouses, bioclimatic atrium, buffer spaces, intermediate bioclimatic spaces, etc. ✓ Use/introduction of upward motion ventilation towers, 'solar' fireplaces, downward 'cooling' towers, buried earth pipes, various systems of ventilation ducts, air plates, air lakes, air labyrinths, etc. ✓ Housing reconfiguration to improve cross ventilation ✓ Improvement of thermal insulation through: integration of internal or external insulation in case of recovery of existing facade panels; use of better performing materials in case of replacement of facade modules		
	Waterproofing of roofs and protective projections of rainfall	✓ New roofing packages, substructures (solar greenhouses, light volumes)		
	Use of dual systems for the direct recovery of water from inside the buildings, and its purification and reuse in the confined, intermediate and open spaces in the context of the buildings themselves	✓ Gray water recovery systems		
	Adoption of systems of confluence of water from building envelope, with storage and purification, such as water reserves on the building scale. Use of strongly draining covers to retain water and slow down the outflows in periods of rain alternating with those of drought/aridity, to facilitate their collection	✓ Covering systems for rainwater recovery/storage/reuse	Adoption of systems of confluence of water from building envelope, with storage and purification, such as water reserves on the building scale. Use of strongly draining covers to retain water and slow down the outflows in periods of rain alternating with those of drought/aridity, to facilitate their collection	✓ Permeable surfaces at ground level in existing buildings
TECHNOLOGICAL BUILDING ELEMENT SYSTEM	Improvement of thermal insulation, sun protection, natural ventilation and passive cooling of buildings	✓ Facade solar shading systems (adjustable/fixed brise-soleil) ✓ Ventilation towers also integrated in the stairwells	Increase of the green roofs to slow down the flow of water from the roofs	✓ Green roofs
	Use of thermal storage, thermal mass and innovative materials for bioclimatic control of the variation of temperatures at various scales through the masses	✓ Bioclimatic atrium ✓ Solar greenhouses (with/without integrated photovoltaic) ✓ Trombe walls		
	Adoption of climate-adaptive measures for open and intermediate spaces	✓ Cool pavers	Systematic use, in all buildings, of water saving solutions, recovery, storage and reuse of gray and rainwater	✓ Controlled-flow dispensers, intelligent water meters, systems to discourage water waste, dual plant systems, collection tanks, purification systems for recovered water
	Adoption of climate-adaptive measures for roofs and facades of buildings	✓ Cool and reflective materials		

Conclusions | The innovative aspect of the research was based on the attempt – which can be perfected with the future progress of its application – to build a model of use of types of technological interventions, assessed in their combined performance effects, that the ATER of Rome (the public Authority that finances one of the three researches mentioned, the one in the Third Parties agreement with Sapienza) can use not only in application terms for the development of the requalification interventions already scheduled, but also – it is the most interesting data – for the setting method of future intervention projects in similar contexts within the Roman territory.

The experimentation is concluded and the results are divided into two main categories: the implementation one, with the development of the most effective and efficient design solutions in the specific urban contexts where the ATER Authority of Rome plans to carry out the requalification and retrofitting interventions of the public open spaces; and the methodological one, with the construction of a usability system of innovative and traditional technologies in relation to the variation of the combined data of the environmental and fruitive context, of the biophysical and microclimatic characteristics, of the factors of natural ventilation and solar radiation, and of the nature of the materials and components used. An adaptive and strategic model of parameterized increase of the fruitive and environmental quality of the urban public space, also implemented with cross-assessments of the specific and overall performance impacts, of the ecological and intelligent management of water and of the bioclimatic enhancement of greenery role.

In desirable future steps, it is necessary to act on two evolutionary aspects of the research: to deepen the method of detecting the performance behaviors of biophysical and microclimatic factors in the analysis phases of the state of affairs, increasing the reliability of the data with detections, sensors used as samples or systematically; continue in the constant necessary refinement of the framework of indicators aimed to provide the parametric reference to support the design choices.

The experimentation aims to give voice to the ultimate goal of the Third Mission, integrating it strongly with the public University researches (which are the two of Sapienza University cited above) and providing a triple output, in terms of: increase of the fruition/environmental quality of the urban public space and the public housing systems subject of retrofitting; indirect improvement of socio-economic conditions as a consequence of better comfort, usability, livability and adaptability; opportunity for cultural discussion within the scientific community in the proposal for an intervention model in progress.

Acknowledgements

The contribution is the result of a common reflection by the authors. Despite this, the introductive paragraph and the paragraphs ‘Strategic axes of resilience in terms of grey structural guidelines’, ‘Strategic axes of resilience in terms of green infrastructural guidelines’, ‘Strategic axes of resilience in terms of soft super-structural guidelines’ are to be attributed to F. Tucci; the paragraphs ‘Resilience and adaptation in the eco-compatible design of systems, components and materials’, ‘Continuity and discontinuity of materials reuse practices’ and ‘Research and experimentation in IACP neighbourhood of Torrevecchia in Rome’ to S. Baiani and P. Altamura; the paragraphs ‘Resilience and adaptation in the energy-efficient project of existing buildings’ and ‘Energy efficiency intervention on the experimentation context of the IACP neighbourhood in Torrevecchia’ to D. D’Olimpio, the paragraphs ‘Resilience and adaptation in the control of the sense of detail in the project: a matter of scale’ and ‘The detail in the experimental case of the regeneration of the IACP neighbourhood of Torrevecchia, Rome’ to G. Turchetti.

Notes

1) The two researches referred to are an agreement with the ATER of Rome for the Energy-Environmental Requalification of Roman Public Housing (2014/2017), and a Research of Great Scientific Relevance financed by Sapienza University, the result of 'peer selection': Microclimatic Control, Adaptation and Mitigation in the Mediterranean Built Environment, from an Interdisciplinary and Multiscale Approach (2016-2019). The structure of the Research Group is as follows: Prof. F. Tucci (Principal Investigator), Prof. S. Baiani, Prof. D. D'Olimpio, Prof. R. Di Pietro, Prof. F. Mancini, Ass. Ric. PhD. V. Cecafosso, PhD. P. Altamura, PhD. G. Turchetti. With: PhD. D. Boni, PhD. A. Caruso, PhD. D. Iamonico, Arch. M. Giampaoletti, Arch. L. Herzog. Collaborators: Arch. C. Fiore, Arch. M. Fiorini, Arch. G. Sciarretti, Arch. V. Serani, Arch. F. Stradaioli, Arch. G. Vespa.

2) The requalification and energy efficiency of the existing buildings have, as intrinsic and fundamental concepts for the declination of the characteristics of their architectural, functional and above all environmental response, the concepts of resilience and adaptation. Adapting to the variability of environmental conditions, both daily and seasonal, is a peculiarity that must be inherent in the fundamental characteristics of an eco-efficient architecture, as a substantial factor in minimizing and controlling the energy inputs necessary to provide the necessary responses, in terms of environmental comfort, to changes in climatic and microclimatic conditions. This concept of adaptation, in a broader sense and linked to the changing of environmental conditions – seen also in relation to problems of a larger scale and consistency, including those related to the issue of climate change – can be included in the concept of resilience, introduced originally in physics in the nineteenth century to indicate the ability of materials to withstand temperature changes without causing damage to their structure and today used in different areas and disciplines, including that of environmental, construction and urban design, in which it finds application and specific significance in concepts such as those of resilience of urban systems, of ecosystems (where it expresses the ability of a system to return to a state of equilibrium following a situation of external shock), of engineering resilience (understood as the capacity of a system, also a building, to absorb an external shock and being able to quickly restore its initial state). From this point of view, architecture design, at an urban level and more specifically at that of the building organization, should currently include and develop the concept of resilience, which is relatively new but fundamental and strategic for an effective response to climate-environmental changing conditions, especially in a scenario of climate change, where this variability does not always take on connotations predictable with precision.

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