

# Innovative Use in Contemporary Architecture of Materials Not Intended For Building

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**Abstract** – The contribution focuses on the trend that is developing with increasing prominence in contemporary architecture towards the use of materials and technologies from sectors other than the specific field of construction. This phenomenon has also characterized the evolution of architecture in the past, and thus cannot be considered an exclusive characteristic of the current period. Today, however, the accelerated scientific and technological development taking place in various fields of research and the awareness of the need to limit resource consumption lead to widespread experimentation with new solutions new solutions focused precisely on innovation in the use of materials. Of particular interest in this contribution is the spillover into the compositional sphere of experiments made at the level of materials and technologies, from the case of the Strawbale House by Sarah Wigglesworth and Jeremy Till (London) to the Dominus Winery by Jacques Herzog and Pierre de Meuron (Yountville, California) and the Curtain House by Shigeru Ban (Tokyo).

**Keywords** – Building materials, technologies, innovation, experimentation, resources

## I. INTRODUCTION

It is appropriate to first specify, with reference to the technological content of buildings, that the present study is limited to works carried out with non-advanced technical characteristics. The projects below described belong to different geographical areas, and their results were evaluated considering specifically their expressive aspect. A fragmentary picture has emerged that unites experiences of the organic trend, pop-art, ecological orientation, and minimalism, however vivid expressions of the cultures and contexts that generated them.

The most significant subdivision that can be formulated, in this first phase of a more extensive research, pertains to the level of awareness of architects in designing their architectural artifacts. This criterion basically identifies two extremes between which the works find place. In the first one the formal outcome regarding the use of new materials is uncontrolled, a natural consequence of choices directed to other aspects of design; in the second the same is, instead, sought as a primary factor. If, for example, Michael Reynolds and Samuel Mockbee, among the architects considered below, worked paying attention mainly to the environment and less to image, in Wigglesworth and Till the extreme care given to solutions of form, which makes the ecological motivation almost pretextual, is more evident.

## II. MATERIALS AND METHOD

We introduce the initial examples drawn from the U.S. context with a mention of the influence exerted in the middle of the last century by Bruce A. Goff. The extraordinary diversity of his fantastic architecture is based on the ingenious way in which he used poor materials and waste [1], [2], [3], [4]. The effectiveness of the teaching of Goff, in general, lies in the unconventional way in which he approaches his work as

an architect (Fig. 1). The radical commitment against dogmatic positions that he sustained constitutes an anticipation of the uninhibited approach to design demonstrated by not a few of his younger colleagues.

It dates back to the late 1960s, in California, the experimental work of a still young Frank O. Gehry who, detaching himself from the language of organic architecture and already turned rather to criteria of formal abstraction, designed the series of cardboard furniture Easy Edges (Fig.2). Stacked sheets of common corrugated cardboard are used as an alternative material for cost, ductility, lightness and strength in the manufacture of furniture elements, such as chairs, armchairs and small tables.



Fig. 1 Bruce A. Goff, *Al Struckus House*, Woodland Hills, California (1979-1982). Detail of the cylindrical stairwell with porthole windows.

This material, in short, in color, strength and impact was reminiscent of wood, and had the advantage of being load-

bearing and already finished: the suede-like surface did not require painting and the structure, elastic enough to deform and resume shape immediately, allowed the most various plastic configurations. Gehry returned to the same theme between 1979 and 1982 with the series *Experimental Edges*, designing and producing more rough and irregular prototypes, never produced at industrial level. The slight slip with which the layers are glued together contributes to the robustness of the prototypes. The industrial cardboard used for the interior of hollow core doors, available in thicknesses from 2 to 15 centimeters and with four different sizes of grooves constitutes the basic material [5].

On other occasions Gehry employs cardboard in blocks, as in the setting up of the temporary offices for Chiat/Day in Venice, California, carried out in the years 1986-1988 (Fig. 3). Within the shed that temporarily houses part of the company's activities pending the completion of the new headquarters, some of the interior walls appear covered in blocks of cardboard irregularly worked, so as to suggest the impression of rough containers within which is set off, by contrast, the modern audiovisual equipment [6].

In his celebrated house in Santa Monica, built between 1977 and 1978, he anticipates the *Cheapscape* poetics by adopting poor materials commonly used in industrial construction, such as corrugated sheets, wire mesh, plywood panels, wired glass. Gehry gives them originality in the seemingly precarious assembly that qualifies the work by its temporariness and by its explicit availability for transformation in clear opposition to criteria of invariability and closure [7]. The replacement of part of the floor of the bedroom on the second floor with a sheet of glass in order to provide more natural light to the living room below falls within this positive attitude towards a continuous re-discussion of the building.

Firmly oriented toward the issues of sustainability are the experiences proposed by Michael Reynolds in the territory of New Mexico, a state bordering California. His architecture, far more than Gehry's one, is directly affected by the interest, growing in public opinion since the second half of 1960s, for the reuse of waste materials. It is possible to read, in his review "Mother Earth News", that bottles and cans, "containers and packaging can surprisingly turn out to be useful materials for construction. The people of America could recover and make good use of six million tons of steel, one million tons of glass, one million tons of aluminium currently sent to landfills each year". Glass bottles, for example, "are enormously durable and have been used in construction since they were made by machine. In Rhyolite, Nevada, there is a house made of bottles of glass that is 66 years old, and in New Zealand stands a motel made entirely of the same material" [8]. Michael Reynolds began his practice as an architect in 1970 in Taos, soon becoming convinced of the potential of recyclable resources to limit construction costs. In 1974 he designs his first *can house*, a house of cans, and later insists in the design of energy-efficient buildings that he builds himself, employing aluminium beverage containers and tires.

The house made for the artist Ron Gobel has the walls composed of two layers of cans, worked in the transverse direction, and a third in the center of fiberglass or polyurethane. The 125,000 cans used in this case are empty, but on other occasions they are put in place full, to compose *walls of water* of appreciable thermal mass (Fig. 4).



Fig. 2 Frank O. Gehry, cardboard furniture Easy Edges series (1969). Picture of the architect with his creations.



Fig.3 Frank O. Gehry, temporary offices of Chiat/Day, Venice, California (1986-88). Interior walls covered with blocks of cardboard.



Fig. 4 Michael Reynolds, Beer Can House, Taos, New Mexico (1970s). Construction of a wall composed of a layer of aluminium cans.

Reynolds leaves in sight the circles of cans, or of bottles in other cases, to achieve a decorative effect. The walls are marked by the regularity of the design produced by the cylinders (Fig. 5). Regarding the installation, the architect points out that an advantage lies in the lightness of the pieces, which allows for easy workmanship: “even a child can build with aluminium containers” [9]. The use of blocks composed of six cans tied together in the shape of an equilateral triangle, on the other hand, proved to be unsatisfactory with regard to processing time.

Following the principle of “energy from the sun, materials from waste”, seeking to gradually reduce the cost of executing buildings to make them affordable to ever larger segments of the population, Reynolds built dozens of other houses, making modifications from time to time. The collective residences *Phase I* and *Phase II*, in which even the typology and social model are experimental, date to the early 1980s: in addition to living room, kitchen and bathroom, shared among community members, three large rooms are designated for private living. Curved walls and domed roofs continue to characterize its architecture, which, also for being partially dug into the ground, fits without forcing into the open natural context.

Regarding the use of glass bottles in the building sector, it is noted that this product, a real construction material in some houses of Reynolds, is sometimes employed only for the specific decorative aspect. This is the case of the Women Work Center built in Rufisque, in Senegal, designed by the three Finnish young women architects Saija Hollmén, Jenni Reuter and Helena Sandman on the initiative of the Helsinki University of Technology (Fig. 6). The buildings of the center look onto an interior courtyard, and part of the perimeter wall is enriched according to an orthogonal grid by the arrangement of bottle bottoms that become coloured light sources for the interior during the day and for the outside at sunset [10].

Another place significant for a innovative use of materials in construction is again located in the southern United States, in the territory surrounding the city of Newbern in Alabama. Here the group Rural Studio has been operating since the early 1990s. Composed of students from Auburn University's School of Architecture and led first by Samuel Mockbee, then by Dennis Ruth [11], Rural Studio studies, designs and implements interventions improving the living conditions of the most disadvantaged members of the black community.

In the territory that served as the background for the events narrated by Mark Twain, a model for American writers of a style based on the research of truth as the outcome of direct experience [12], this group considers life among the people as the basis for learning the most urgent needs on which to act. When Mockbee founded Rural Studio, as the text that provides the official version of this original experience explains, “American architecture had abandoned social and civic engagement, mainly looking at issues of style. The stars of the architectural firmament, overwhelmed by the new global economy and interested in new technologies, were designing buildings of increasing boldness for clients who arrived from all over the world” [13]. This comment highlights, by contrast, Mockbee's belief that the architectural profession has an ethical responsibility of commitment to the improving of the living conditions of underprivileged people. Rural Studio has carried out precise building interventions proposing the inventiveness of involved students, producing works implemented with inexpensive materials, mostly recovered or donated such as battered railway sleepers, old bricks, donated scrap metal, hay bales, corrugated cardboard, worn tires, car license plates and road signs. The architectural language is characterized by extreme practicality. It is not influenced by the organic tendency that the magnificence of nature elsewhere suggests, but rather by the rich and ancient tradition of the deep south, from which it takes up the broad roofs and habitable porches, the shape of sheds and barns, the capricious improvisations. The constructions by Rural Studio are usually asymmetrical and unconventional. The chosen and used materials are as innovative as the façades of buildings. But even the most futuristic construction appears anchored in the local area, adapting to it by scale and deriving form from local architecture.

The first houses built by Mockbee were intended to needy families selected by non-profit agencies such as Madison Countians Allied Against Poverty. Since 1991, with the call as a lecturer at Auburn University of Mockbee himself, the design and construction experiences continue to spread in the territory, often as a result of collaborations with local authorities. Mention is made below of some of the numerous works realized by Rural Studio, housing or community structures, significant for the use of materials generally unrelated to the building sector.



Fig. 5 Michael Reynolds, Phoenix House, Taos, New Mexico (2006). General view. The curved walls are decorated by the bottoms left exposed from the bottles and cans.



Fig. 6 Saija Hollmén, Jenni Reuter e Helena Sandman, Women Work Center, Rufisque, Senegal (1996-2001). View of the architects and the grid of bottle bottoms worked in the beside wall.



Fig. 7 Rural Studio, Bryant House, Mason's Bend, Alabama (2000). View of the storeroom with the cover obtained employing road signs discarded by the local Department of Transportation.

At 1994 dates Bryant House, a house built for an elderly couple who lived with two grandchildren in a trailer. The walls are made of hay bales weighing about four kilograms, wrapped in polyurethane and machined as blocks, secured with wire and covered with layers of plaster. The roof is made of panels of acrylic, put in place with a steep slope due to region's high rainfall rate. In the nearby shed, the roof is instead obtained by means of traffic signs discarded by the department of County Transportation (Fig. 7). More recent, built in 2000, is the Community Center of the Mason's Bend territory, a flexible space that can also take on the function of a chapel. The walls were executed with blocks of a pressed mixture composed of 30% clay and 70 percent sand, with a moderate addition of cement. The glazed part of the roof consists of a steel frame holding eighty windshields of the Chevrolet Caprice (Fig. 8) [14]. Finally, to conclude the series of examples, starting in 1997 Rural Studio built near Newbern a residence for the male students: on either side of a long wooden portico are lined two-places completely independent pavilions and the common restrooms, simulating the houses flanking each other on either side of a street. Various makeshift materials were used from time to time, so that both toilets coated with license plates donated by the county judge (Fig. 9) and the housing made of corrugated cardboard blocks protected with wax from the weather (Fig. 10) contribute to the variety of the ensemble.

Rural Studio constitutes a valuable experience in terms of teaching architecture as well. Every semester, a group of second-year students helps to design and build a house and learns about the social and ethical responsibilities associated with architecture. Another group of fifth-year students, meanwhile, works for the entire academic year designing and constructing a more complex architecture. Students learn to act

as a team, this being the first time, for most of them, operating together with someone else.

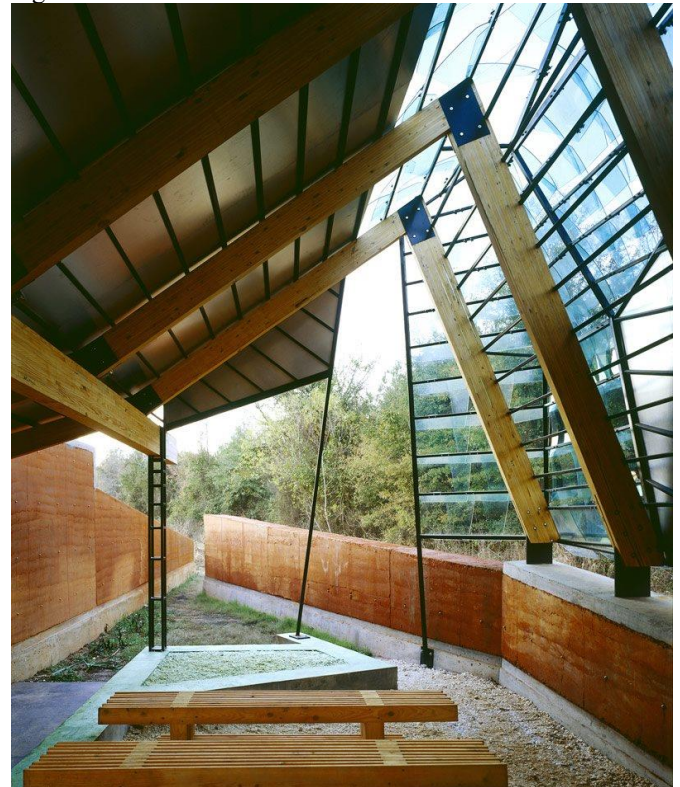


Fig. 8 Rural Studio, Community Center of the Mason's Bend territory, Alabama (2000). View of the large window made with windshields from scrapped cars.

Architecture education thus maintains a close adherence to the world of construction, and obligates students to participate in comprehensive construction experiences that begin with design and conclude on the construction site. The success of this method has produced the opening of the activity to outside students not enrolled in Auburn University's School of Architecture. Another consequence was the increase of the initiatives in the area, also accepting assignments not strictly in construction matters, such as the design and construction of a pedestrian bridge to enhance the Perry Lakes Park.

In its first ten years of operation, Rural Studio has involved three hundred and fifty students of the second year and eighty fifth-year thesis students. While enjoying a certain notoriety, the teaching model has not been imitated by other schools of U.S. architecture. According to Mockbee, this depends on the lack of initiative of the institution's competitors, who graduate architects sharing similar curricula because of their general propensity to avoid risks.

The projects of Japanese architect Shigeru Ban are also characterized by a deep interest in weak materials, to which surely the artist's early training at the Southern California Institute of Architecture in Los Angeles contributed. Shigeru Ban, while leading initiatives of assistance in territories devastated by dramatic events, and an advocate of the social responsibility of the architect in the face of the recurrence of catastrophic events that affect the global community, expresses a language that decidedly reflects lucid intellectual speculations. He results, with his cardboard tube structures, close to the recommendations of the movement modern more than many other colleagues working with glass and steel. Economy and search for new possibilities of utilization of

existing materials give Ban's architecture a character of lightness and essentiality in responding to the required function [15], [16].



Fig. 9 Rural Studio, student housing at Auburn University's School of Architecture, Newbern, Alabama (1997-2001). Detail of the coating of the common restrooms made of old license plates.

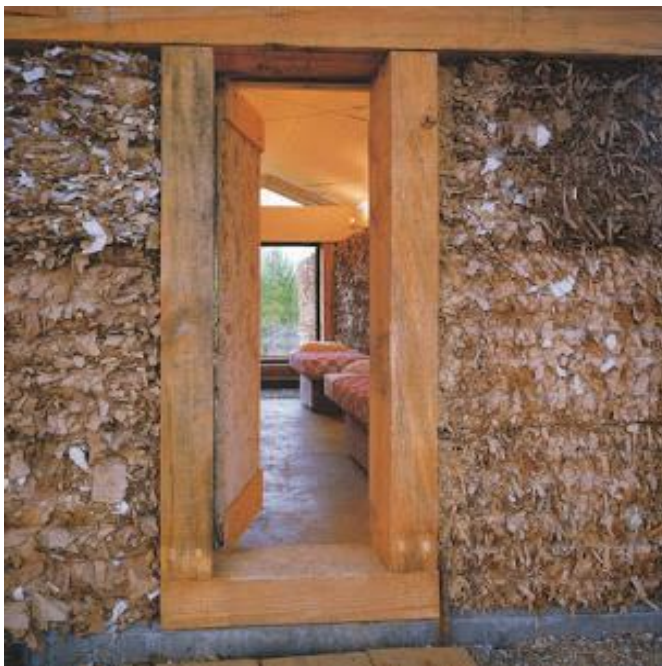


Fig. 10 Rural Studio, student housing at Auburn University's School of Architecture, Newbern, Alabama (1997-2001). Detail of the pavilion made of blocks of pressed cardboard.

His first experiments with alternative materials are dating from the second half of the 1980s. In the 1990s he made the long series of buildings based on the use of cardboard tube structures, in which he associates rigor of geometry, efficiency and economy, in the belief that it is possible to build height buildings by properly calculating the thickness of the cardboard and the diameter of the cylinders. The Community Center (Fig. 11) and emergency housing (Fig. 12) built in Kobe in 1995 following the destruction caused by the earthquake summarize the technological aptitudes and expressive qualities of this building element. The requirements were low cost, ease of transportation, the possibility of performing assembly without heavy machinery, and the ease

of disposal once the function was exhausted. The Community Center, named *Paper Church*, has a rectangular floor plan with sides of 10 and 15 meters, and can accommodate 80 people seated.



Fig. 11 Shigeru Ban, Community Center named *Paper Church*, Kobe (1995). View of the interior space and the cardboard tube structure recalling the shape of columns.

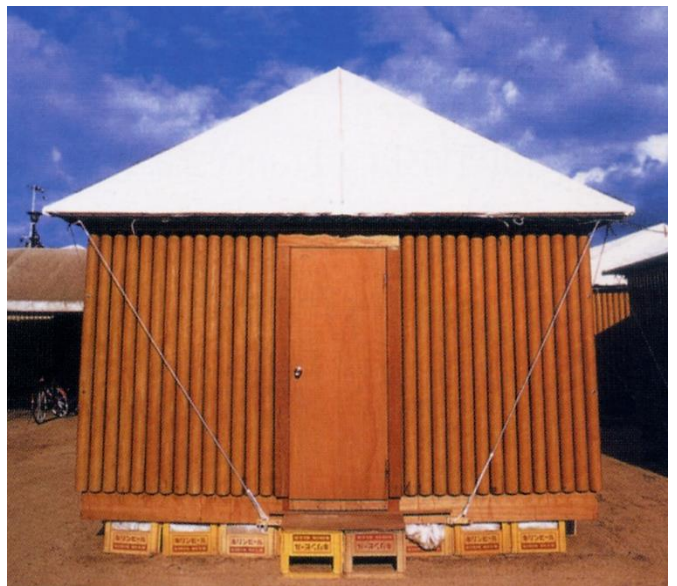


Fig. 12 Shigeru Ban, cardboard emergency housing, Kobe (1995). View of an element, realized by means of cardboard cylinders vertically arranged and set on bases of crates filled with sand.

It was executed in five weeks by one hundred and sixty volunteers. The vertical structure is arranged within a transparent screen of polycarbonate according to an elliptical design, consisting of fifty-eight cardboard cylinders, each with a length of 5 meters and with a diameter of 33 centimeters and thickness 15 millimeters.

The single units of the emergency housing, each one having an area of 16 square meters, were set on bases of crates filled with sand. The walls were made of cylinders of cardboard vertically arranged, with self-adhesive sealants applied between tube and tube. The covers were composed of two layers of canvas, which in summer could be spaced to facilitate

ventilation. These temporary houses were the result of a commission received by Shigeru Ban the previous year from the United Nations High Commission for Refugees (UNHCR) to design shelters for the people of Rwanda who escaped civil war, and were also used in Turkey after the 1999 earthquake.



Fig. 13 Shigeru Ban, *Curtain House*, Tokyo (1995). View of the house with the curtains open. On the second floor a *Paper Tube Chair* designed by the same architect appears.

and second floors (Fig. 13, 14), defining changeable facades without a form of their own, and suggesting a comparison with the *Farnsworth House* designed by Mies van der Rohe. The Japanese architect extends then to furniture his research into recyclable materials, designing in 1998 the *Paper Tube Chair*, a chair with a seat and back made of tubular cardboard.



Fig. 15 Sarah Wigglesworth and Jeremy Till, *Strawbale House*, Islington, North London (finished in 2001). Wing with walls having wooden structure, straw bale infill, corrugated sheet metal and polycarbonate cladding.



Fig. 14 Shigeru Ban, *Curtain House*, Tokyo (1995). View of the living room with the curtains closed.

In the same 1995, designing the Tokyo house known as the *Curtain House*, Ban instead proposed an unusual deployment of large curtains that softly envelop the building on the first

The result arrived at by Londoners Sarah Wigglesworth and Jeremy Till in their most significant work, the *Strawbale House*, is more hybrid. It is the house and professional studio that they designed and built in the English capital intending to test the possibilities of expression arising from the use in construction of unconventional materials [17], [18], [19]. The building is described as “a highly articulated architectural settlement, a collection of forms, materials and ideas, an assortment of volumes clad in different ways to give rise to a rich three-dimensional object” [20], and actually consists of three main bodies of buildings. The first one is the two-story block that houses the entrance to the dwelling, two stacked bedrooms and toilets. The vertical structure in this case consists of a wooden frame infilled with bales of straw. The walls are covered on the inside with lime plaster, on the outside mostly by corrugated metal sheet and in a lesser extent by transparent polycarbonate, a detail that indicates a certain narcissism in the environmentalist orientation of the architects (Fig. 15). The kitchen, living room, library and dining room flow continuously in the central part of the building that, elevated on slender steel pillars, is enclosed on the main front by a glazed diaphragm in which wooden panels of various shapes are inserted with refinement. The dining room, finally, borders the third block, which entirely houses the professional studio. This latter volume, rising near the boundary with a busy railway line, reflects the designers' need to minimize the transmission to the interior of noise and vibrations. It was therefore taken off the ground, where only the access to working spaces is located, by means of pillars set on shock

absorbers that reduce vibrations. The pillars are clad with pieces of recycled concrete retained by steel mesh. The wall of the overlying two floors of the professional studio facing the railway line was defended against the noise with sandbags filled with concrete, providing the decay over time of the fabric of the sacks and the prominence of concrete pillows brought into view (Fig. 16).



Fig. 16 Sarah Wigglesworth and Jeremy Till, *Strawbale House*, Islington, North London (finished in 2001). Detail of the facade facing the railroad, covered in bags filled with cement to mitigate the impact of noise.

The other walls, on the other hand, were wrapped in a heavy fabric to protect them from the atmospheric elements. The tower of books, besides, rises in correspondence to the second volume. It hosts the reading chamber at the top.

The variety of shapes and materials represents the more evident characteristic of this building, which combines low-tech construction materials and details of refined workmanship. In this aspect it is clearly distinguished from coherent, minimalist expressions such as the paper houses of Ban.

### III. RESULTS

Among the design proposals so far confronted on the topic of the innovative use in architecture of materials unrelated to the building sector, Shigeru Ban's contribution appeared to be the richest in potentiality with regard to the elaboration of a language that can reconcile the experimentation of materials with expressive rigor. Although the importance and breadth of the implications arising from the other already considered interventions, it must be acknowledged that his controlled and

quiet works know how to discreetly escape from excessive displays of form, of textural grain and colour. Manifesting a reluctant but firm awareness of their place in the wake of the Modern Movement, the buildings by Ban also suggest the identification of other architectural experiences that are similar for the way in which their authors have been able to design and carry out extraordinary architectural compositions. In the California-based Dominus Winery of the Swiss architects Jacques Herzog and Pierre de Meuron, for example, whose walls made up of cages full of stones echo a characteristic device of river engineering [21], or in the artificial ruins enveloped by rich vegetation of the apartment building designed by the French architect Edouard François [22] it is possible to recognize other contributions to a research focused on buildings in which the singularity of employed materials meets the regularity of the design.

### IV. CONCLUSION

This contribution is the result of a series of investigations conducted in the thematic framework of the history of building materials and techniques. The subject investigated includes a number of experiences that have strengthened the ecological approach to the design culture. A common thread linking the above cultural fields has been highlighted, which can be further explored given the today's interest in sustainable approach to environment and architecture, and the increasing centrality that environmental issues are assuming.

The above cases reinforce the belief that since the end of the last century a new sensibility has been changing the way of thinking about architecture and its meaning. During these years, in various ways, themes such as healthy living, geobiology, home ergonomics, housing hygiene, architectural biology and the rediscovery of traditional building techniques and typologies as new references for the building world appear in the architectural debate. The presented experiences have helped generate, in recent times, a new movement that generally refers to Baubiologie as a pivotal reference for design and construction interventions. Healthfulness, sustainability, respect and enhancement of the environment are the principles of building activity that have gained most importance in culture in recent years.

The here presented examples demonstrate that this approach cannot be separated from a special attention to the site, an organic typological and planivolumetric organization, the study of bioclimatic and passive solar capture aspects, and above all the use of renewable resources and natural materials.

Finally, it could be considered that giving dignity of language to simple materials, used without cladding, promotes the buildings' ability to age in their context.

### REFERENCES

- [1] J. Cook, *The Architecture of Bruce Goff*, New York: Harper, 1978.
- [2] R. Fiocchetto, *Bruce Goff 1904-1982*, Rome: Officina Edizioni, 1990.
- [3] A. Henderson, *Bruce Goff: Architecture of Discipline in Freedom*, Norman (Oklahoma): University of Oklahoma Press, 2017.
- [4] P. N. Nicolaides, *Bruce Goff and His Architecture*, London: Hassel Street Press, 2021.
- [5] P. Goldberger, *Building Art: The Life and Work of Frank Gehry*, New York: Alfred A. Knopf, 2015.
- [6] F. Dal Co, F. O. Gehry, K. W. Forster, H. S. Arnold, *Frank O. Gehry. The Complete Works*, New York: The Monacelli Press, 1998.
- [7] F. O. Gehry, *Gehry Residence Santa Monica, California, U.S.A. 1977-78, 1991-94*, Tokyo: Ada Edita Global Architecture, 2015.
- [8] "Build a Litter Perfect House!," *Mother Earth News*, n. 56, January-February 1979, p. 85.

- [9] S. Winston, "Recycled Solar Homes", *Mother Earth News*, n. 55, March-April 1979, p. 86.
- [10] "Saija Hollmén, Jenni Reuter and Helena Sandman, Women's Centre", *A+U, Architecture and Urbanism*, n. 8, 2002.
- [11] A. O. Dean, T. Hursley, *Proceed and be bold. Rural Studio after Samuel Mockbee*, New York: Princeton Architectural Press, 2005.
- [12] M. Cunliffe, *The literature of the United States*, New York: Penguin Books, 1986.
- [13] A. O. Dean, T. Hursley, *Rural Studio. Samuel Mockbee and an Architecture of Decency*, New York: Princeton Architectural Press, 2002, p. 1.
- [14] R. Rael, *Earth Architecture*, New York: Princeton Architectural Press, 2009, pp. 48-51.
- [15] R. Miyake, *Shigeru Ban. Paper in architecture*, New York: Rizzoli International Publications, 2009.
- [16] M. McQuaid, *Shigeru Ban*, London: Phaidon, 2003.
- [17] J. Till, S. Wigglesworth, *9/10 Stock Orchard Street: A Guidebook*, London: A Bank of Ideas Publication, 2001.
- [18] S. Wigglesworth, *Around and About Stock Orchard Street*, London: Routledge, 2011.
- [19] S. Charlton, E. Harwood, Eds., *100 Houses 100 Years. The Twentieth Century Society*, London: Batsford, 2017, pp. 174-177.
- [20] J. Soane, *New Home. Architecture & Design*, London: Conran Octopus Limited, 1993, p. 200.
- [21] R. Ryan, "Memories of Light, Curtains of Stone", in N Yoshida, Ed., *Architecture and Urbanism. Architecture in Stone*, vol. 331, Tokyo: A+U Publishing Co., 1998. pp. 24-27.
- [22] E. François, *L'immeuble qui pousse*, Albias: Jean-Michel Place, 2000.