Lecture Notes in Civil Engineering

Rossella Corrao · Tiziana Campisi · Simona Colajanni · Manfredi Saeli · Calogero Vinci *Editors*

# Proceedings of the 11th International Conference of Ar.Tec. (Scientific Society of Architectural Engineering)

## Colloqui.AT.e 2024 - Volume 1

Springer

# Lecture Notes in Civil Engineering 610

**Lecture Notes in Civil Engineering** (LNCE) publishes the latest developments in Civil Engineering—quickly, informally and in top quality. Though original research reported in proceedings and post-proceedings represents the core of LNCE, edited volumes of exceptionally high quality and interest may also be considered for publication. Volumes published in LNCE embrace all aspects and subfields of, as well as new challenges in, Civil Engineering. Topics in the series include:

- Construction and Structural Mechanics
- Building Materials
- Concrete, Steel and Timber Structures
- Geotechnical Engineering
- Earthquake Engineering
- Coastal Engineering
- Ocean and Offshore Engineering; Ships and Floating Structures
- Hydraulics, Hydrology and Water Resources Engineering
- Environmental Engineering and Sustainability
- Structural Health and Monitoring
- Surveying and Geographical Information Systems
- Indoor Environments
- Transportation and Traffic
- Risk Analysis
- Safety and Security

To submit a proposal or request further information, please contact the appropriate Springer Editor:
– Pierpaolo Riva at pierpaolo.riva@springer.com (Europe and Americas);
– Swati Meherishi at swati.meherishi@springer.com (Asia—except China, Australia, and New Zealand);
– Wayne Hu at wayne.hu@springer.com (China).

**All books in the series now indexed by Scopus and EI Compendex database!**

Rossella Corrao · Tiziana Campisi ·
Simona Colajanni · Manfredi Saeli ·
Calogero Vinci
Editors

# Proceedings of the 11th International Conference of Ar.Tec. (Scientific Society of Architectural Engineering)

Colloqui.AT.e 2024 - Volume 1

Springer

*Editors*
Rossella Corrao
Department of Architecture
University of Palermo
Palermo, Italy

Tiziana Campisi
Department of Architecture
University of Palermo
Palermo, Italy

Simona Colajanni
Department of Architecture
University of Palermo
Palermo, Italy

Manfredi Saeli
Department of Architecture
University of Palermo
Palermo, Italy

Calogero Vinci
Department of Architecture
University of Palermo
Palermo, Italy

ISSN 2366-2557 ISSN 2366-2565 (electronic)
Lecture Notes in Civil Engineering
ISBN 978-3-031-71854-0 ISBN 978-3-031-71855-7 (eBook)
https://doi.org/10.1007/978-3-031-71855-7



This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

# Preface

The series of technical conferences on Architectural Engineering (AE) annually involve academics and experts to discuss about the recent advancements of the research in the building sector, to find and promote innovative solutions, both at buildings and components scales; to develop building systems and materials, able to improve the energy efficiency of buildings and counteracting climate changes; to ensure the well-being of users by guaranteeing indoor and outdoor comfort; to preserve the building heritage and safeguarding cities, landscapes and territories. Since its beginning in Vico Equense, Naples, Italy, where the first Colloqui.AT.e conference was launched in 2014, the series of conference have been centered on three different Topics related to the main fields of research in Architectural Engineering. Actually, from 2004 Ar.Tec. Scientific Society promoted a series of itinerants thematic conferences focused on: the intersections between architecture and technology (Rome, 2004); the preservation of the building heritage (Tourin, 2006); the design of the building envelope (Ancona, 2007) and of the care spaces, between complexity and innovation (Pavia, 2008); the earthquake and the strategies to remember, prevent and plan (Messina, 2009); sharing technical knowledge derived from the research on building design and construction (Rome, 2011).

Colloqui.AT.e2024, subtitled: "Architectural Engineering in Italy and Worldwide. Comparing Experiences", has also been structured upon traditional and emerging topics related to: "Construction and Conservation History"; "Construction and building performance"; "Building Design and Technologies" that allowed researchers and engineers to discuss at international level the latest developments in AE area. AE aims at providing "tools, methods, and models, including digital ones, for the knowledge and design of buildings, from the critical, systemic, functional, typological, technical, and constructive point of view", by exploiting also the technology transfer from other fields of research belonging to different scientific sectors close to it.

The three topics have been defined as follow:

## A_Construction and Conservation History

*A1. Materials and construction techniques in historical architecture*
*A2. Recovery, valorization, and reuse of existing building heritage*
*A3. Examples of interventions on monumental architecture*
*A4. Examples of industrial archaeology between knowledge and reuse*
*A5. Vernacular architecture: lessons learned and future projects*
*A6. Projects and policies for the regeneration of historic centers and suburbs*
*A7. Digital twins and immersive visualization for the valorization, management, and fruition of historical building heritage*

## B_Building Construction and Performance - Vol. 2, ISBN 978-3-031-71862-5

*B1. Traditional and innovative technologies and materials for buildings*
*B2. Modeling, simulation, and diagnostics under uncertainty for performance control*
*B3. Building pathologies and intervention strategies*
*B4. Building-human-environment relationships: extended accessibility*
*B5. Building management and maintenance for safety and quality of living environments*
*B6. Mitigation and management of vulnerabilities and risks for the preservation of the built environment*
*B7. Regulatory updates, quality control of the project and construction process*

## C_Building Design and Technologies - Vol. 2, ISBN 978-3-031-71866-3

*C1. Form, technique, and technology*
*C2. Circular Design, Embodied Carbon, and extended buildings life cycle*
*C3. Digital transition and design of 4.0 buildings*
*C4. Technological innovation: processes, patents, and products for the construction of the future*
*C5. Integral and participatory design for the quality of the built environment*
*C6. Adaptive and responsive buildings*
*C7. DfMA—Design for Manufacturing & Assembly and DfD—Design for Disassembly*

During the conference, 9 selected papers (among the 145 scientific contributions received) and three keynote lectures have been presented. The three volumes collect all submitted and double-blind peer reviewed papers as well as the contributes related to the three valuable key lectures that opened the conference sessions.

More specifically, these three lectures were kindly provided, for Topic A_Construction and Conservation History (Vol. 1), by James W.P. Campbell, Professor of Architecture and Construction History at the University of Cambridge and Director of Studies in Architecture and History of Art in Queens' College, Cambridge, UK; for Topic B_Building Construction and Performance (Vol. 2), by Mattheos Santamouris, Scientia, Distinguished, Professor of High Performance Architecture at University of New South Wales (UNSW), in Sydney, Australia, and past Professor in the University of Athens, Greece; for Topic C_Building Design and Technologies (Vol. 3), by Joachim Eble, Architect, founder and owner of Eble Messerschmidt Partner, Tubinga, Germany.

The research papers collected in these Volumes testify that today AE multi/interdisciplinary approach can effectively contribute to the analysis and solving problems affecting buildings, cities, and the built environment, by suggesting innovative technical solutions/materials/components and strategies, which are able to guarantee the preservation of the building heritage, the well-being of users, and the appropriate actions to counteract climate changes.

The eleventh edition of the Colloqui.AT.e conference has been jointly organized by Ar.Tec. Scientific Society and the Department of Architecture of the University of

Palermo, with the Patronage of: Department of Engineering of the University of Palermo, Sicilian Region, Agenzia del Demanio Sicilia, Provveditorato Opere Pubbliche Sicilia e Calabria - Ministry of Infrastructures and Transport, Confrestauro Association. The conference was also sponsored by: BCI Bautechnik Group Srl-Buffa S.r.l. (www.buffa.eu), CNT- Domodry S.r.l. (www.domodry.it), INNOVA S.r.l. (www.innovaenergie.com), MICROGEO S.r.l. (www.microgeo.it), XLAM Dolomiti S.p.a. (www.xlamdolomiti.it/en/), CusenzaMarmi (www.cusenzamarmi.com), Guglielmino Soc. Coop. (www.guglielminocooperativa.it), and S.E.P.A.M. Stone S.r.l. (www.sepamstone.it).

On behalf of the organizing committee of Colloqui.AT.e 2024, we express our gratitude to all keynote speakers, authors, as well as to the members of the international scientific and advisory committees. We also extend our appreciation to all the participants who took part in this important international scientific event.

Special thanks goes to the publisher, Springer Nature Switzerland AG and, in particular, to Pierpaolo Riva, for his support in publishing Colloqui.AT.e 2024 proceedings. This contribution enhances significantly both dissemination and impact of our research activities in the field of Architectural Engineering. As members of Ar.Tec. Scientific Society, we are committed to continuing the tradition of Colloqui.AT.e International Conferences of spreading knowledge, excellence, and innovation of our research works related to the building sector.

Rossella Corrao

# Organization

## Ar.Tec. Scientific Society Directorial Commette

| | |
|---|---|
| Fatiguso Fabio | Politecnico di Bari, Italy |
| Albatici Rossano | University of Trento, Italy |
| Cascone Santi Maria | University of Catania, Italy |
| Corrao Rossella | University of Palermo, Italy |
| Guida Antonella Grazia Maria | University of Basilicata, Italy |
| Poli Tiziana | Politecnico di Milano, Italy |
| Polverino Francesco | University of Naples “Federico II”, Italy |

## Scientific Committee

| | |
|---|---|
| Abita Matteo | University of L’Aquila, Italy |
| Achenza Maria Maddalena | University of Cagliari, Italy |
| Albatici Rossano | University of Trento, Italy |
| Arenghi Alberto | University of Brescia, Italy |
| Atzeni Carlo | University of Cagliari, Italy |
| Ausiello Gigliola | University of Naples “Federico II”, Italy |
| Basiricò Tiziana | Kore University of Enna, Italy |
| Bazzocchi Frida | University of Florence, Italy |
| Bellicoso Alessandra | University of L’Aquila, Italy |
| Bernardini Gabriele | Polytechnic University of Marche, Italy |
| Bernardo Graziella | University of Basilicata, Italy |
| Bertolazzi Angelo | University of Padua, Italy |
| Besana Daniela | University of Pavia, Italy |
| Campisi Tiziana | University of Palermo, Italy |
| Capomolla Rinaldo | Tor Vergata University of Rome, Italy |
| Capurso Gianluca | Tor Vergata University of Rome, Italy |
| Cascone Santi Maria | University of Catania, Italy |
| Castelluccio Roberto | University of Naples “Federico II”, Italy |
| Catalano Agostino | University of Molise, Italy |
| Chiarantoni Carla Antonia | Politecnico di Bari, Italy |
| Colajanni Simona | University of Palermo, Italy |
| Corrao Rossella | University of Palermo, Italy |
| Croatto Giorgio | University of Padua, Italy |
| Currà Edoardo | Sapienza University of Rome, Italy |

| | |
|---|---|
| D'Orazio Marco | Polytechnic University of Marche, Italy |
| Dalprà Michela | University of Trento, Italy |
| De Angelis Enrico | Politecnico di Milano, Italy |
| De Fino Mariella | Politecnico di Bari, Italy |
| Desogus Giuseppe | University of Cagliari, Italy |
| Di Donato Danilo | University of L'Aquila, Italy |
| Di Giovanni Gianni | University of L'Aquila, Italy |
| Di Giuseppe Elisa | Polytechnic University of Marche, Italy |
| Di Naso Vincenzo | University of Florence, Italy |
| Fasana Sara | Politecnico di Torino, Italy |
| Fatiguso Fabio | Politecnico di Bari, Italy |
| Ferrante Annarita | Alma Mater Studiorum Università di Bologna, Italy |
| Ferrero Marco | Sapienza University of Rome, Italy |
| Fiamma Paolo | University of Pisa, Italy |
| Fiandaca Ornella | University of Messina, Italy |
| Fiore Pierfrancesco | University of Salerno, Italy |
| Fiori Matteo Paolo Giovanni | Politecnico di Milano, Italy |
| Fiorito Francesco | Politecnico di Bari, Italy |
| Frangipane Anna | University of Udine, Italy |
| Fumo Marina | University of Naples "Federico II", Italy |
| Garda Emilia Maria | Politecnico di Torino, Italy |
| Garofolo Ilaria | University of Trieste, Italy |
| Gherri Barbara | University of Parma, Italy |
| Giannetti Ilaria | Tor Vergata University of Rome, Italy |
| Grecchi Manuela | Politecnico di Milano, Italy |
| Greco Alessandro | University of Pavia, Italy |
| Greco Laura | University of Calabria, Italy |
| Guardigli Luca | Alma Mater Studiorum Università di Bologna, Italy |
| Guida Antonella Grazia Maria | University of Basilicata, Italy |
| Gulli Riccardo | Alma Mater Studiorum Università di Bologna, Italy |
| Iannaccone Giuliana | Politecnico di Milano, Italy |
| Iannone Francesco | Politecnico di Bari, Italy |
| Iori Tullia | Tor Vergata University of Rome, Italy |
| Iuorio Ornella | Politecnico di Milano, Italy |
| Lione Raffaella | University of Messina, Italy |
| Lombardo Grazia | University of Catania, Italy |
| Lucchini Angelo | Politecnico di Milano, Italy |
| Mainini Andrea Giovanni | Politecnico di Milano, Italy |
| Malighetti Laura Elisabetta | Politecnico di Milano, Italy |

| | |
|---|---|
| Mangosio Marika | Politecnico di Torino, Italy |
| Maracchini Gianluca | University of Trento, Italy |
| Margani Giuseppe | University of Catania, Italy |
| Mazzucchelli Enrico Sergio | Politecnico di Milano, Italy |
| Mecca Ippolita | Pegaso Telematic University, Italy |
| Mele Caterina | Politecnico di Torino, Italy |
| Minutoli Fabio | University of Messina, Italy |
| Mochi Giovanni | University of Perugia, Italy |
| Mollo Luigi | University of Campania "L. Vanvitelli", Italy |
| Morandotti Marco | University of Pavia, Italy |
| Morbiducci Renata | University of Genoa, Italy |
| Morganti Renato Teofilo Giuseppe | University of L'Aquila, Italy |
| Mornati Stefania | Tor Vergata University of Rome, Italy |
| Moschella Angela | University of Catania, Italy |
| Munafò Placido | Polytechnic University of Marche, Italy |
| Pagliuca Antonello | University of Basilicata, Italy |
| Petriccione Livio | University of Padua, Italy |
| Piantanida Paolo | Politecnico di Torino, Italy |
| Poli Tiziana | Politecnico di Milano, Italy |
| Polverino Francesco | University of Naples "Federico II", Italy |
| Prati Davide | University of Bergamo, Italy |
| Predari Giorgia | Alma Mater Studiorum Università di Bologna, Italy |
| Quagliarini Enrico | Polytechnic University of Marche, Italy |
| Ribera Federica | University of Salerno, Italy |
| Rodonó Gianluca | University of Catania, Italy |
| Rosso Federica | Sapienza University of Rome, Italy |
| Saeli Manfredi | University of Palermo, Italy |
| Salvalai Graziano | Politecnico di Milano, Italy |
| Sangiorgio Valentino | "G. d'Annunzio" University of Chieti - Pescara, Italy |
| Sanjust Paolo | University of Cagliari, Italy |
| Santi Giovanni | University of Pisa, Italy |
| Sapienza Vincenzo | University of Catania, Italy |
| Sciuto Gaetano Antonio | University of Catania, Italy |
| Sesana Marta Maria | University of Brescia, Italy |
| Sicignano Enrico | University of Salerno, Italy |
| Stazi Francesca | Polytechnic University of Marche, Italy |
| Stival Carlo Antonio | University of Trieste, Italy |
| Tagliaventi Gabriele | University of Ferrara, Italy |
| Tosone Alessandra | University of L'Aquila, Italy |
| Turrini Umberto | University of Padua, Italy |

| | |
|---|---|
| Vinci Calogero | University of Palermo, Italy |
| Vite Clara | University of Genoa, Italy |
| Zerbinatti Marco | Politecnico di Torino, Italy |
| Zordan Marcello | University of Cassino and Southern Lazio, Italy |

## Organizing Committee

| | |
|---|---|
| Corrao Rossella | University of Palermo, Italy |
| Campisi Tiziana | University of Palermo, Italy |
| Colajanni Simona | University of Palermo, Italy |
| Saeli Manfredi | University of Palermo, Italy |
| Vinci Calogero | University of Palermo, Italy |

## Conference and Scientific Secretariats

| | |
|---|---|
| Bellomo Marco | University of Palermo, Italy |
| Cala' Adriana | University of Palermo, Italy |
| Castro Morales Kevin Aarón | University of Palermo, Italy |
| Famoso Martina | University of Palermo, Italy |
| Di Maggio Salvatore | University of Palermo, Italy |
| La Placa Erica | University of Palermo, Italy |
| Lombardo Luisa | University of Palermo, Italy |

## Administrative Secretariat

| | |
|---|---|
| Bellomo Marco | University of Palermo, Italy |
| Castro Morales Kevin Aarón | University of Palermo, Italy |
| Di Maggio Salvatore | University of Palermo, Italy |

# Contents

# High-Altitude Architecture Beyond Constructive Limits: The Fürggen Cableway Arrival Station

Antonello Pagliuca(✉), Pier Pasquale Trausi, and Giulio Grimaldi

University of Basilicata, 75100 Matera, Italy
antonello.pagliuca@unibas.it

**Abstract.** The experimentation of technological systems, developed during the 20th century, emancipated the characteristic ingenuity of the professionals of the time, engineers and architects, sometimes challenging the landscape context they were confronted with. High-altitude architecture, although of recent conception, has represented a dilemma in the design debate. Not identifiable with Alpine architecture, but from which it draws its essential aspects (relationship with nature, boundary-space, extreme environment), high-altitude architecture is part of the extensive built heritage of the last century. Of particular artistic relevance, this particular way of 'making architecture' fully embraced the 'sentiment' of innovation and experimentation initiated at the turn of the century, leading to the birth of architectural masterpieces in an 'uncontaminated' place. The arrival station of the Fürggen cableway, designed by the Turinese architect Carlo Mollino, has become an emblem of modern architecture at high altitudes. The use of traditional materials, such as stone and wood, relate harmoniously with innovative materials for the Alpine environment. The building, constructed on the crest of the mountain like a continuation of it, conceals a pumice concrete skeleton in its inner core according to an all-Italian construction solution: the Eliobeton-Pinottini system. Formulated with perforated pumice concrete blocks and stiffened with steel reinforcement, this system, patented in 1948, has a multifaceted use thanks to its technical and technological characteristics. The objective of the research is the knowledge of the elements that make up the artefact, through a methodological process that systematises all the useful information by means of archive and bibliographic analyses, with the aim of outlining a line of intervention for the conservation of the modern architectural heritage, which is not adequately valued.

**Keywords:** High altitude architecture · Furggen cableway · Carlo mollino · Eliobeton-Pinottini system

## 1 Introduction

From the earliest building realisations, the landscape and the geomorphology of the territory have been a fundamental aspect of the garrison's anthropic action, above all conditioned by the different functionally necessary housing requirements. About construction techniques and materials used, the evolution developed in parallel with, but complementary to, the affirmation of the different architectural styles and typologies


R. Corrao et al. (Eds.): Colloqui.AT.e 2024, LNCE 610, pp. 532–543, 2025.
https://doi.org/10.1007/978-3-031-71855-7_34

that occurred throughout the history of architecture. As the landscape context (maritime or mountainous) has changed, the "making of architecture" has found changes in the determination of accurate stylistic features that have led to its being framed according to well-defined methodological processes (Mediterranean architecture, high-altitude architecture, Alpine architecture, rural architecture, etc.). High-altitude architecture has always played a key role in the ancestral dualism between built and nature. Iconic examples of high-altitude architecture such as cabins, refuges, chalets, observatories, even though they may appear as "minor architectures", bring with them a wealth of multidisciplinary knowledge also linked to the difficulty of the environmental-climatic context in which they are located. It is through their relationship with nature that these works have acquired a precise identity linked to a complex interweaving of constructive, cultural, technical and symbolic reasons that form the basis for the conquest of physical spaces of an extreme nature. During the 20th century, the continuous progress of technical-constructive experimentation was also reflected in the high-altitude architectures and infrastructures, which saw, in addition to the already consolidated traditional design methods, the use of avant-garde structural and technological solutions (overhanging reinforced concrete slabs, curtain walls, etc.) as an expression of contemporaneity.

This research, part of a broader study on 20th century architecture and building systems, focuses on the development of 'high' building systems and techniques that allowed, especially through the application of innovative materials, the realisation of exemplary architectures marked, in a period of great ferment, by a language that was modern and futuristic in form and technique. In this specific example, the case study of the arrival station of the Fürggen cableway was examined, which made it possible to highlight the characteristics described above and to validate a deconstruction process of the technological and construction systems as a fundamental basis for a future intervention process on the building itself.

## 2 Research Objective and Methodology

### 2.1 A Preservation and Enhancement of a "Recent Past"

The research objective is part of a broader strand of analysis in which the historical, technological and architectural knowledge of the 20th century is the ultimate goal. This research is aimed at instilling critical thinking on the recovery of the architectural heritage of the 20th century, in order to promote virtuous paths linked to structured cognitive processes that allow for greater 'familiarity' with these architectural emergencies. The in-depth study of the main construction techniques used, the analysis of the technical-structural systems and the investigation of the main building materials, experimented and strongly used in a period of great avant-garde in the building and manufacturing industry, define the fundamental fulcrum of the methodological process.

### 2.2 The Methodology of Intervention: Awareness of Architectural and Construction Value

For a complete understanding of all the elements inherent in a specific piece of architecture from the vast Italian and international building heritage, it is necessary to consider

a methodological process that allows us to gather information as much as possible. For the analysis of the case study, a process was followed that included the examination of original documentation (preliminary and design sketches, historical photos available from Carlo Mollino's archive) combined with the consultation of sector manuals, in which the main technological systems used from the 1920s onwards are represented, provide a fundamental overview for understanding the case study.

These elements constitute a piece of primary importance for the knowledge of the constructive-technological characteristics and the historical framework in which the case study falls. The interpolation of this information with the data provided by consulting "unconventional" sources (advertising posters, manufacturers' catalogues) guarantees an in-depth study of all the new building materials of Italian manufacture [1]. All these notions have converged in a theoretical and practical system that is constantly being updated and serves as a *vademecum* for the "de-construction" of this architectural example in order to identify suitable proposals for its management and valorisation [2].

## 3 Arrival Station of the Fürggen Cableway

### 3.1 High Altitude Architecture

In order to address the analysis of the case study, framed within the context of high-altitude architecture, it is appropriate to take into consideration the stylistic feature that characterises the constructions of the mountainous landscape, built using traditional techniques and materials that, in terms of form and method of use, are taken up in the infrastructure of architect Carlo Mollino [3].

The main evidence of building activity in the mountainous landscape, which has seen a greater concentration of residential units in the valleys at the "foot" of the various highlands, has been characterised by construction sophistications and the constant presence of double-pitched roofs [4]. "Be it wooden or stone shingles, thatched or tiled, or sheet metal" [5], the pitched roof, with an inclination close to 45°, became a fundamental element for defence against the weather. Although the two-pitch typology (precisely designed "with the ridge placed in the right middle and often oriented in the direction of the prevailing wind" [5]) was present, especially in some Alpine localities, it was not difficult to find in traditional constructions roofs with two pitches and chamfered gables or four-pitch or hipped roofs [6]. Supporting this characterisation of mountain architecture is a further classification based on the materials used for structures and cladding. From this derives the presence of "all stone" artefacts, characterised by a masonry load-bearing framework, "all wood" artefacts, marked at the perimeter by a wooden structure, and finally artefacts in "mixed" technique [7]. The representation of how the architecture of these places has been varied throughout history, despite almost recurring climatic conditions in a mountain, and specifically Alpine, landscape, draws attention to a further issue, namely the experimentation with boundary spaces [8]. High-altitude architectures, regardless of the type of construction (refuges, mountain cabins, cableways, etc.), within a specific classification, each represent a unicum, marked by the particular composition of fundamental materials (wood, stone and steel) assembled as a whole, highlighting how the development of new construction systems and new materials made it possible to

search for settlement solutions that could adapt to the hostile environments of the high mountains (Fig. 1).

**Fig. 1.** Left, from top to bottom: mixed-structure huts; buildings with pitched roofs in chamfered gables; timber-framed buildings; Right, from top to bottom: mixed-structure buildings; stone-framed buildings; Photo source: Cereghini M., Nascita delle architetture alpine e classificazioni delle loro forme in "Atti e Rassegna Tecnica della Società degli Ingegneri e degli Architetti", Turin, no. 3, 1953.

### 3.2 Cervinia: Between Extreme Construction Site and "Land of Conquest"

During the 20th century, the ferment produced by building activity led, in various localities, to a multiple diversification of the "making of architecture" at high altitudes, promoted by a sort of settlement liberalism that led to the emergence of proposals, in some cases of great originality.

An emblematic case of such architectural testimony in the first half of the 20th century was the ski resort of Cervinia, at the foot of the Matterhorn and Matterhorn mountains. Founded in the mid-1930s, Cervinia immediately laid the foundations to be an "open-air building site" in which to test, in an environmental context close to the limit, the avant-garde of developing construction techniques [9]. From the construction of ski-lifts with increasingly bold technical solutions, such as the Breuil-Plan Maison cable way (built by the Società Cervino in 1936) or the cable way to the summit of Monte Fürggen (built by the Agudio company in 1939), to high-density housing solutions with multi-floor condominium typologies (from 6 to 12 levels), such as La Casa del Sole, by architect Carlo Mollino in 1947 [10]. The ensemble of these and other architectures, built in the Valle d'Aosta, have led to the delineation of an image of a 'vertical hyper-city' that, ascending the ridges of the mountainous relief, rises towards the sky [11]. Within this historical-architectural framework of the Valle d'Aosta landscape is the figure of architect Carlo Mollino who, from the early 1930s until his departure in the early 1970s, was a highly influential figure in the cultural and architectural scene in Turin.

A son of art (his father Eugenio was an accomplished engineer), Carlo Mollino distinguished himself from the outset for his eclectic and multifaceted personality that led him to take an interest not only in architecture, but also aviation, cinema, photography, design and above all mountains [12]. It was precisely his passion for the mountains, passed on by his father, that allowed him to deal with the language, expressiveness and sense of architectural making of vernacular Alpine architecture, realising various projects such as the Biancaneve hotel, the Capanna Mollino hut, the Lago Nero chairlift station, the Casa-Capriata for the 10th Triennale, the Garelli house in Champoluc and above all the Fürggen cable car arrival station.

The common thread running through all of Carlo Mollino's architecture was the expressive language he gave to his works. Irregular and aerodynamic forms, the unconventional use of materials typical of mountain architecture, the reworking of traditional techniques based on the form-structure relationship, were all elements of the critical thinking of the Turinese architect who, through an "anomalous" language (rationalist and organic, elegant and ambiguous, solid and sinuous) was able to "compose space in new relationships, […] as if it were an animated thing, independent of the artist's will" [13] without the artifice of absolute physical consistencies (Fig. 2, 3).

### 3.3 Tradition and Modernity at 3,500 M Above Sea Level

Commissioned by the engineer Dino Lora Totino "Count" of Cervinia, the arrival station of the Fürggen mountain cableway was a work much desired by the Turinese architect Carlo Mollino, even though it was not without its problems. The construction of this station was a part of the general project idealised by the Biella engineer: to lay the foundations for an extraordinary idea of tourist development in the Breuil valley. The implementation of this project had already been carried out by the Count after the construction of the highest cable way in the world at the time, able to transport skiers and visitors to Plateau Rosà up to an altitude of 3,500 m. The hypothesis to replicate this project for the Cervino mountain, imagining «to connect a micrometropolis directly to the mountain relief» [12] by docking on a ridge just below the summit, led engineer

**Fig. 2.** Left, overall view of the Cervinia alpine resort; Right, from top to bottom: Cielo Alto residences by Mollino C.; Pirovano refuge by Albini F.; S. Giacomo "Wagristorante" by Portaluppi P.; source: Bricchi L., Fürggen. Abitare la montagna, Master's Thesis in Architectural Design, Politecnico di Milano, 2017–2018.

Lora Totino to formulate a design that would include, as an intermediate stage, an arrival station on the Fürggen mountain.

Architect Carlo Mollino was left with the arduous and ambitious task of designing the building, to be constructed on the crest of the mountain range. Despite the logistical difficulties arising from the extreme construction site, marked by the impervious climate in which to work and the slow times for transporting the materials, the architect's skill in transforming the hostile site of Fürggen into an «alpine nest» [13] in which to receive the cable way cabin, led to a result of remarkable architecture at high altitude. The structure, in accordance with the typical characteristics of Mollino mountain architecture, is installed directly into the sheer rock face on three sides, representing its ideal continuation. The building, organised on four levels destined in ascending order for the waiting room and services, lodgings for the Finance and Carabinieri, restaurant services and restaurant lounge [14], is designed with overhanging platforms that gradually rise to the upper terrace.

**Fig. 3.** Top, from left to right: Garelli house, Mollino hut, X Triennial project - photo source: Bricchi L., Fürggen. Abitare la montagna, Master's thesis in Progettazione dell'Architettura, Politecnico di Milano, 2017–2018; Bottom: Furggen cable way station seen from the arrival platform - photo source: Ricuperati G., Solution of architecture in the very high mountains. Il sottile duca bianco in "Domus", Milan, 2006.

Although the project initially included a rotating panoramic structure on the roof, the difficulties related to the ruggedness and altitude of the site led to major changes in the design. The design variation also determined changes in terms of the uses to which it was to be put, leading to the exclusion of all planned rooms except for the restaurant, which was replaced by a bar, and the viewpoint reduced to a simple perimeter view. In terms of construction, the architectural work is structured with a mixed technique system in which traditional and innovative materials dialogue harmoniously, producing a bold and technically pioneering compositional solution.

The architect has used traditional materials such as wood and stone to provide, on one hand, the interior cladding and furniture, on the other hand, the solidity of the wall support in the ground. The technological avant-garde is highlighted on the top level through the use of a metal structure surmounted by a sloping roof of «extruded aluminium panels» [15]. This structure, probably conceived to give a sense of lightness

to the restaurant space, is supported by four double-knee trellis uprights [15] that also support the remaining overhanging platforms.

Considerable technological importance is instead given to the load-bearing skeleton of the building's inner core, in which the designer opted for an all-Italian construction system: the Eliobeton - Pinottini system.

This traditional type of system (patent no. 89355 of 15 October 1948, Turin), «composed by parallelepiped concrete blocks of pumice stone measuring 58 x 28 x 28 cm» [16], can be used both for the construction of ordinary walls and as a non-reusable formwork for load-bearing reinforced concrete structures. The peculiarity of this system is conferred specifically by the use of pumice stone as a building material, which is already widely present in Italian volcanic areas, such as Lipari and Tarquina islands; thanks to its porous nature, pumice stone becomes chemically comparable to a «glass with a high aluminium silicate content» [16]. With the main characteristic of possessing a very low specific weight, both in the dry gravel state and in the concrete conglomerate state, the use of this material (in the form of pumice bricks combined with pumice beton casting) was an important expedient for «decreasing the load of the load-bearing elements, making it possible to reduce the thickness and burden of the foundations» [16]. Widely used since the 1920s, pumice stone has won a place of excellence among the ranks of so-called "Made in Italy" materials [17].

This meaning, which is referred to an exclusive use of Italian-style materials, as a consequence of the prohibitionist dictates of the autarkic period, produced a necessary experimentation of innovative techniques applied in various production sectors, especially in the construction industry. The combination of the lithic element (containing 74% silica, 13% alumina, 3% iron oxides and 10% sodium and potassium compounds [18]) with cement made it possible to create a pumice-stone-based concrete mix. This material (in addition to its ability of having a reduced impact on the specific weight of the load-bearing structure in comparison to the specific weight of a brick wall) has also been widely used for its insulating characteristics, both thermal and acoustic. Thanks to «a conductivity coefficient of less than a third of that of brick walls» [18], pumice concrete has proven to be suitable for buildings constructed in hot and cold locations, reducing temperature differences between inside and outside. In addition to its thermally insulating properties, the material's porosity gives it an excellent noise-absorbing capacity; in the production process, the quantity ratio with the cement is unbalanced in favour of the pumice stone, resulting in a 30% noise reduction but at the same time a lower compressive strength. The multi-faceted nature of the element is translated into a multiplicity of applications in different forms: from casting in more or less regular formwork, mainly for the construction of external walls [19], to the production of lightweight blocks of varying sizes for the construction of internal partitions, external walls, cladding and slabs (Figs. 4, 5, 6 and 7).

## 4 Conclusions

The critical thinking behind a traditional restoration approach must also be able to be replicated for the architecture of the modern, as it is representative of a time that is now over. Exemplary works by important architects, built during the 20th century, represent

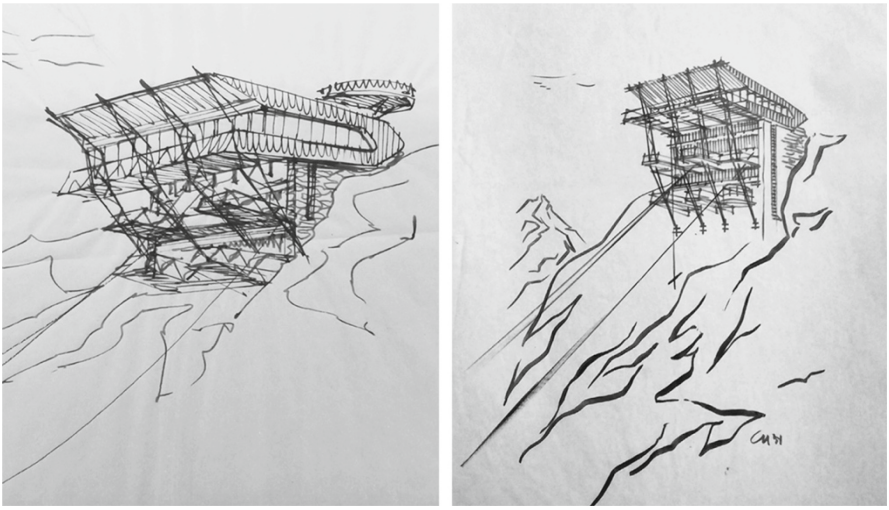

**Fig. 4.** Left: first draft project sketch of the Furggen cableway station - source: Bricchi L., Fürggen. Abitare la montagna, Master's thesis in Progettazione dell'Architettura, Politecnico di Milano, 2017–2018; Right: sketch of the final design for the Furggen cableway station - source: Mollino C., La stazione della funivia del Fürggen in "Atti e Rassegna Tecnica della Società degli Ingegneri e degli Architetti", Turin, no. 3, 1953.

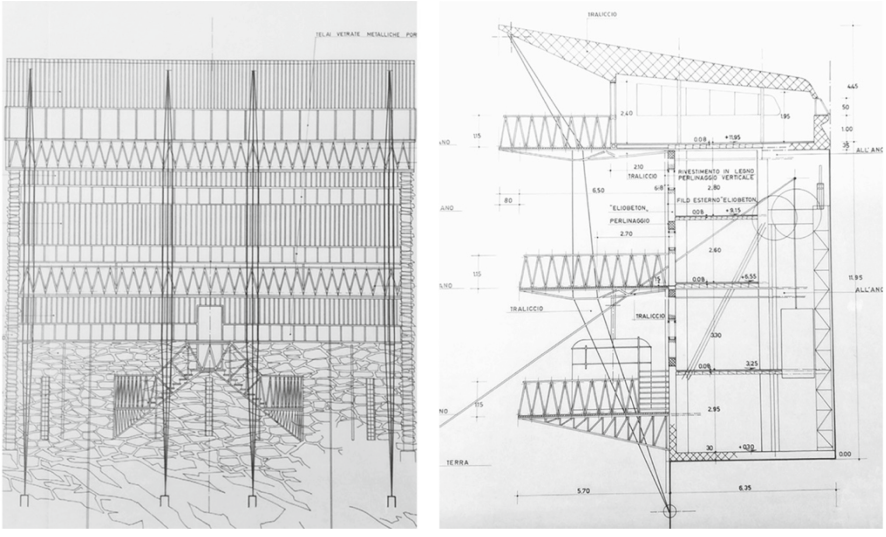


**Fig. 5.** Left: main view of the Furggen cableway station - source: Bricchi L., Fürggen. Abitare la montagna, Master's Thesis in Architectural Design, Politecnico di Milano, 2017–2018; Right: cross-section of the Furggen cableway station - source: Mollino C., La stazione della funivia del Fürggen in "Atti e Rassegna Tecnica della Società degli Ingegneri e degli Architetti", Turin, no. 3, 1953.


**Fig. 6.** Left: posters of the "Eliobeton-Pinottini" system and the "Galpomice" company; respective source: AA. VV., Atti e Rassegna Tecnica. Society of Engineers and Architects in Turin, Turin, 1954 | Pagliuca A. Materiali Made in Italy, Avanguardia Italiana nell'Industria delle Costruzioni del Primo '900", Gangemi Editore, Rome, 2019; Right: construction site of a building made of pumice stone concrete slabs - source: Griffini E., Costruzione Razionale della Casa, Hoepli, Milan, 1932.

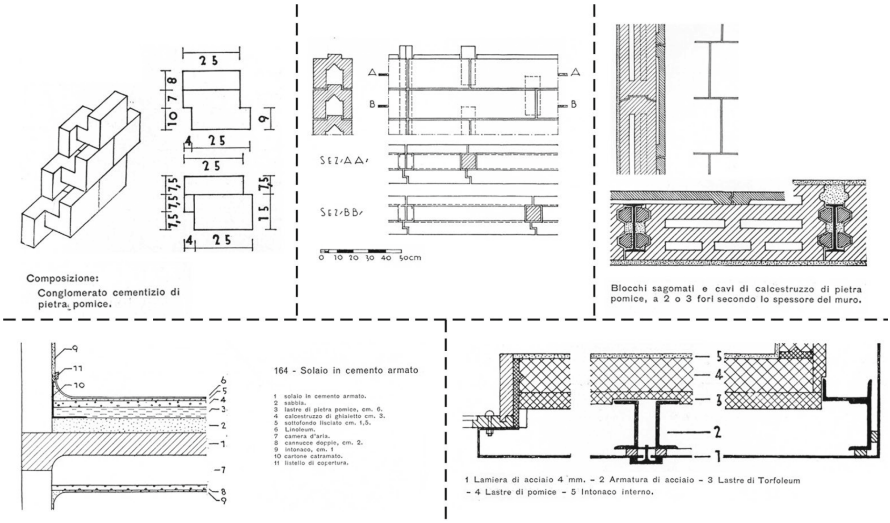


**Fig. 7.** Examples of pumice stone concrete application. Top, from left to right walls: "Triol" block system; "Lupescu" system; "Heka" system; Bottom, from left to right slabs: with pumice stone slabs; with "Braune and Roth" system; Source: Griffini E., Rational House Construction, Hoepli, Milan, 1932.

a legacy of contemporary building today. Despite the fact that they stand as emblematic examples of the 20th century, it is still difficult for restorers, who approach a restoration project on them, to understand which is the best methodological process to follow in order not to irreversibly damage their historical identity.

This results in a lack of awareness of the value of these architectural artefacts, which is at the root of inadequate attention to the architectural heritage of the Modern.

In order to overcome this problem, it is evident that a system must necessarily be structured in which the knowledge of the themes of the modern built environment can be brought together, in order to allow greater "confidence" in identifying the strengths and weaknesses of the architectural work.

In this direction, the presence of an expert figure in technical architecture can act as a guide for the restoration of the Modern [20], namely the technologist.

It is precisely the technical elements that make up the artefact (the details, the construction systems, the materials used) that characterise 20th-century architecture and for which an in-depth analysis is necessary in order to draw a more appropriate approach to intervention.

The study on the arrival station of the Fürggen mountain cableway has made it possible to validate this process of analysis on the 20th century heritage, making it possible to highlight the avant-garde and experimental identity typical of the works of that time and, through a process of deconstruction, provide an intervention methodology capable of guiding the meta-design phase of the project for the recovery and valorisation of the asset.

A scrupulous preventive knowledge is perfectly suited to the needs of modern heritage architecture, in which the structural components are concealed by complex constructional artefacts, and for which a more thorough awareness can be translated into a prudent intervention.

From the examination of the Fürggen cable way station, which is part of a broader strand of research on the subject of the recovery of the Modern, it is evident how, for the conservation of 20th century architectural works, an in-depth knowledge of the technical and technological elements of the asset itself cannot be excluded. The frequent presence of materials and constructive solutions of the historical heritage, nowadays obsolete and unfortunately out of production, becomes itself a preponderant factor of protection and safeguard; the conservation of these elements must drive to a sense of deontological responsibility that can only and exclusively be revealed by a ready familiarity with the constructive characteristics of the period.

## References

1. Poretti, S.: Nuovi strumenti nel restauro del moderno: il caso del Padiglione Tavolara. In: Gizzi S., Poretti, S. (a cura di) Il padiglione dell'artigianato a Sassari. Gangemi Editore, Roma (2007)
2. Iori, T., Marzo Magno, A.: 150 anni di storia del cemento in Italia. Gangemi Editore, Roma (2011)
3. Cereghini, M.: Costruire in montagna. Architettura e storia. Edizioni del Milione, Milano (1956)

4. De Rossi, A.: Costruire in alta quota. “ARChALP”. Foglio semestrale dell’Istituto di Architettura Montana, Torino (2011)
5. Cereghini, M.: Nascita delle architetture alpine e classificazioni delle loro forme. “Atti e Rassegna Tecnica della Società degli Ingegneri e degli Architetti di Torino”, 3 (marzo) (1953)
6. Bolzoni, L.: Architettura moderna nelle Alpi italiane: dal 1900 alla fine degli anni Cinquanta. Quaderni di cultura alpina, Scarmagno (TO), Priuli aVerlucca (2000)
7. Mollino, C.: Tabù e tradizione nella costruzione montana. “Atti e Rassegna Tecnica della Società degli Ingegneri e degli Architetti di Torino”, 4 (aprile) (1954)
8. Doglio, G., Unia, G.: Abitare le Alpi. Editore l’Arciere, Cuneo (1980)
9. Bernardi, M.: Il Cervino e la sua storia. Edizioni Cervino, Torino (1944)
10. Hosquet, C., Bich, L.: Come eravamo quando nella conca del Breuil nasceva Cervinia. Q.art 92, Aosta (1993)
11. Fantin, M.: Cervino 1865–1965. Editori Tamari, Bologna (1965)
12. A.A. V.V.: Carlo Mollino 1905–1973. Editore Electa, Milano (1989)
13. Pace, S.: Carlo Mollino architetto (1905–1973): Costruire le modernità. Editore Electa, Milano (2006)
14. Rey, G.: Il Monte Cervino, 2nd edn. Collezioni Montes/Hoepli, Torino (1962)
15. Bolzoni, L.: Soluzione di architettura in altissima montagna: La stazione fantasma. “Domus” 889 (2006)
16. Mollino, C.: La stazione della funivia del Fürggen. “Atti e Rassegna Tecnica della Società degli Ingegneri e degli Architetti di Torino”, 3 (marzo) (1953)
17. Trivellin, E.: Storia della tecnica edilizia in Italia: Dall’unità ad oggi. Alinea Editrice, Firenze (1998)
18. Lavagnino, R.: Uso della pomice come materiale da costruzione. “Atti del Sindacato Provinciale Fascista degli Ingegneri di Torino e del Sindacato Regionale Fascista degli Architetti del Piemonte” (1932)
19. Pagliuca, A.: Materiali Made in Italy, Avanguardia Italiana nell’Industria delle Costruzioni del Primo ‘900”. Gangemi Editore, Roma (2019)
20. Poretti, S.: Modernismi Italiani, architettura e costruzione nel Novecento. Gangemi Editore, Roma (2008)

# Author Index




R. Corrao et al. (Eds.): Colloqui.AT.e 2024, LNCE 610, pp. 811–812, 2025.
https://doi.org/10.1007/978-3-031-71855-7