

Integrated Refurbishment of Traditional Mediterranean Buildings for Sustainable Tourism: Insights from the Aeolian Island Summer School 2024

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The Aeolian Island Summer School 2024 (AISS|24), held in Zucco Grande on the island of Filicudi, brought together students, professionals, and academics to address the challenges of revitalizing fragile Mediterranean heritage contexts. Through field surveys, theoretical lessons, and collaborative workshops, participants developed sustainable design proposals integrating traditional Eolian architecture with contemporary technologies. Passive features—such as thick stone walls and shaded outdoor areas—were reinterpreted with renewable energy systems to achieve energy self-sufficiency while preserving architectural integrity. The program also tackled seismic retrofitting using local materials and advanced structural techniques, and proposed sustainable mobility solutions including floating docks and solar-powered inclined elevators to enhance accessibility. Design strategies emphasized architectural grafting, reversible interventions, and adaptive reuse to support tourism-related functions such as culinary spaces and scattered accommodations. Concluding its fourth edition, AISS|24 demonstrated the transformative potential of design-based, interdisciplinary education. It highlighted how heritage conservation, environmental sustainability, and community revitalization can be integrated into replicable models for marginal territories.

Introduction

In the face of accelerating climate change, resource depletion, and widespread socio-cultural fragmentation, the built environment has emerged as both a site of vulnerability and an arena for innovation.¹ In peripheral and fragile contexts, there is growing interest in the potential of traditional settlements to serve as models for sustainable regeneration.² These historical environments, shaped by centuries of adaptation to climatic, topographic, and socio-economic conditions, offer a repository

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1. Donagh Horgan, and Branka Dimitrijević, "Social Innovation in the Built Environment: The Challenges Presented by the Politics of Space," *Urban Science* 5, no. 1 (2020): 1.

2. Hai-fan Wang, and Shang-chia Chiou, "Study on the Sustainable Development of Human Settlement Space Environment in Traditional Village," *Sustainability* 11, no. 15 (2019): 4186.

of resilient spatial and material practices.³ At the same time, they are exposed to abandonment, degradation, and the pressures of undifferentiated development. This paradox has prompted scholars and practitioners to seek integrated approaches that reconcile the preservation of cultural heritage with the urgent demands of environmental sustainability, social cohesion, and territorial revitalization.

Traditional Mediterranean settlements represent a fertile ground for this inquiry. Characterized by compact morphology, passive design strategies, and construction systems rooted in locally available resources, they exemplify a form of architecture that is both context-responsive and culturally embedded.⁴ These settlements can be interpreted through the lens of critical regionalism, not as nostalgic remnants, but as dynamic systems capable of informing contemporary design agendas.⁵ Moreover, when understood as part of broader socio-ecological landscapes, they align with emerging paradigms in landscape urbanism and heritage-led regeneration, which emphasize the integration of ecological, cultural, and infrastructural dimensions across scales.⁶

Within this framework, the Aeolian Islands offer a paradigmatic case study. This UNESCO-designated archipelago off the northern coast of Sicily is marked by a convergence of natural beauty, vernacular architecture, and intangible cultural heritage.⁷ However, many of its historic settlements, especially those in remote or topographically challenging locations, have suffered from long-term depopulation, infrastructural obsolescence, and neglect. Their regeneration requires more than conventional conservation; it demands interdisciplinary, participatory, and experimental models that are able to address complex challenges such as energy autonomy, seismic safety, sustainable tourism, and inclusive mobility.⁸

The Aeolian Island Summer School (AISS), now in its fourth edition, emerges as a design-research initiative that responds to these challenges through an innovative pedagogical framework. Organized by the University of Catania in collaboration with the Order of Engineers of the Province of Catania, AISS combines architectural education, design experimentation, and community engagement within a real-world context. Each edition is framed around a specific site and thematic focus, enabling participants—students, academics, and professionals from multiple disciplines—to explore context-sensitive design solutions that bridge tradition and innovation. The 2024 edition

3. Zihan Chen, Su Liu, Wei Liao, and Junxue Zhang, "Construction of Security Pattern for Historical Districts in Cultural Landscape Based on MCR Model: A Case Study of Chaozhong Street, Changsha City," *Sustainability* 15, no. 13 (2023): 10619.

4. Maria Philokyprou, Aimilios Michael, Eleni Malaktou, and Andreas Savvides, "Environmentally Responsive Design in Eastern Mediterranean: The Case of Vernacular Architecture in the Coastal, Lowland and Mountainous Regions of Cyprus," *Building and Environment* 111 (2017): 91-109.

5. Keith L. Eggener, "Placing Resistance: A Critique of Critical Regionalism," *Journal of Architectural Education* 55, no. 4 (2002): 228-237.

6. Grete Swensen, Vebjørn Egner Stafseng, and Véronique K. Simon Nielsen, "Visionscapes: Combining Heritage and Urban Gardening to Enhance Areas Requiring Regeneration," *International Journal of Heritage Studies* 28, no. 4 (2022): 511-537.

7. Simona Calvagna, Antonio Gagliano, Sebastiano Greco, Gianluca Rodonò, and Vincenzo Sapienza, "Innovative Multidisciplinary Methodology for the Analysis of Traditional Marginal Architecture," *Sustainability* 12, no. 4 (2020): 1285.

8. Mehrdad Chahardowli, Hassan Sajadzadeh, Farshid Aram, and Amir Mosavi, "Survey of Sustainable Regeneration of Historic and Cultural Cores of Cities," *Energies* 13, no. 11 (2020): 2708.

(AISS|24) focused on the abandoned village of Zucco Grande, on the island of Filicudi. This site, characterized by its architectural authenticity, ecological fragility, and socio-spatial isolation, provided an ideal setting for rethinking sustainable tourism and heritage recovery through collaborative design. This paper investigates how a learner-centered, design-based methodology can be employed in fragile, heritage-rich environments to develop sustainable, place-specific regeneration strategies. The AISS|24 program is presented not only as a case study, but as a replicable model for integrating environmental, structural, and cultural sustainability within architectural education and heritage practice.

The pedagogical structure of AISS|24 was rooted in active learning and research-by-design methodologies. Participants were engaged in a sequential process that combined theoretical instruction, fieldwork, interdisciplinary workshops, and digital prototyping.⁹ The approach reflects a broader trend in architectural education that emphasizes project-based inquiry, transversal competence-building, and context-embedded knowledge production. By situating learning within a real territorial context and involving local stakeholders, the Summer School fostered a reflexive, collaborative, and situated understanding of design as a socio-technical and cultural practice.

This paper presents the conceptual underpinnings, methodological articulation, and main outcomes of AISS|24. Its aim is twofold: first, to demonstrate how the integration of traditional know-how, sustainable technologies, and digital design tools can support innovative, low-impact interventions in fragile heritage contexts; and second, to reflect on how design-based educational models can contribute to the broader discourse on ecological transition, cultural continuity, and territorial resilience in Mediterranean settings. In doing so, the paper seeks to position AISS|24 as a replicable framework for action-oriented research and transdisciplinary learning, with relevance for similar marginal or depopulated areas undergoing socio-environmental transition.

The educational approach of AISS|24 also aligns with the objectives of the European Education Area and the UN's 2030 Agenda for Sustainable Development, particularly Target 4.7, which emphasizes the need to ensure that learners acquire the knowledge and skills necessary to promote sustainable development.¹⁰ Furthermore, the program reflects principles advocated by the New European Bauhaus, particularly in its emphasis on inclusive, place-based, and transdisciplinary learning.¹¹

Methodology

The AISS|24 was structured around a learner-centered and research-by-design methodological framework that emphasized active, situated, and interdisciplinary learning (Figure 1). Building upon the pedagogical foundations established in previous editions, AISS|24 reaffirmed the importance of shifting from passive

9. Christiane Reilly, and Thomas C. Reeves, "Refining Active Learning Design Principles through Design-Based Research," *Active Learning in Higher Education* 25 (2024): 81-100.

10. Kalterina Shulla, Walter L. Filho, Salim Lardjane, Jan H. Sommer, and Christian Borgemeister, "Sustainable Development Education in the Context of the 2030 Agenda for Sustainable Development," *International Journal of Sustainable Development & World Ecology* 27 (2020): 458-68.

11. María J. Rosado-García, Renata Kubus, Ramón Argüelles-Bustillo, and María J. García-García, "A New European Bauhaus for a Culture of Transversality and Sustainability," *Sustainability* 13, no. 21 (2021): 11844.

knowledge transmission to an experiential and participatory educational model. This approach foregrounds the co-production of knowledge through immersive design challenges, real-world engagement, and iterative collaboration among diverse actors.

Rooted in the principles of constructivist learning and informed by the literature on design-based research (DBR¹²) and project-based education, the methodology promoted the development of critical thinking, transversal skills, and context-specific design capacities. The educational strategy was structured to ensure the progressive acquisition of knowledge, moving from theoretical understanding to analytical practice and ultimately to creative synthesis. This pedagogical progression was articulated in four sequential and interconnected phases: (1) Theoretical instruction; (2) Practical and analytical sessions; (3) Immersive design workshops; and (4) Digital prototyping and presentation.

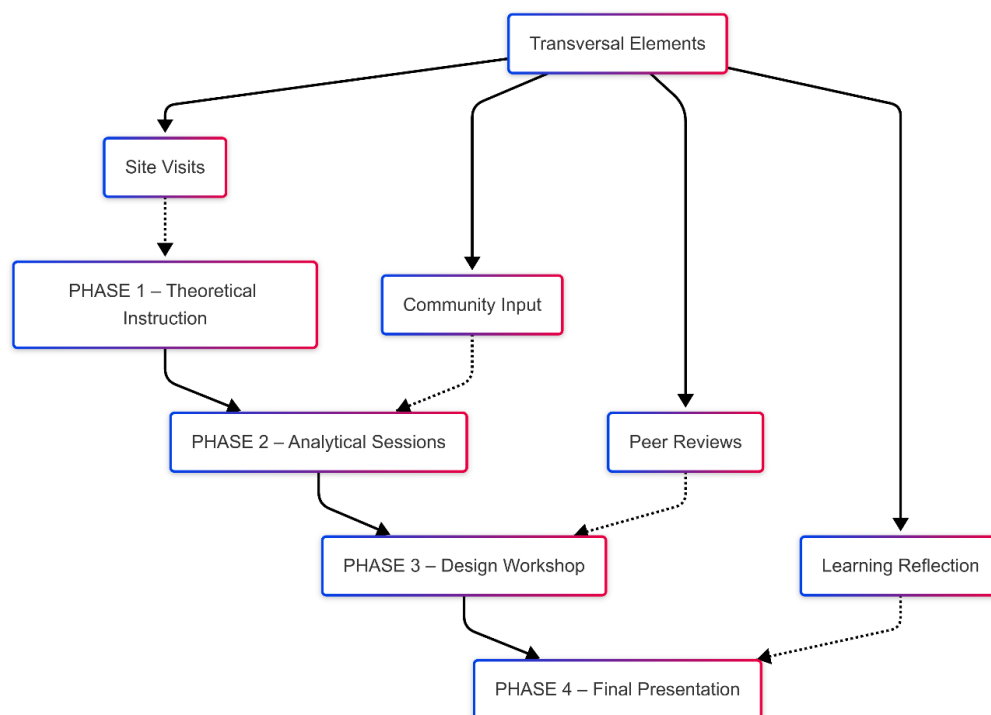


Figure 1. *AISS|24 Methodological Framework: A Design-Based, Learner-Centered Pedagogical Model for Sustainable Heritage Recovery*

Participants

Participants were recruited through a public call issued by the Order of Engineers of the Province of Catania and the Department of Civil Engineering and Architecture of the University of Catania. The Summer School was open to professional engineers registered with the Catania Order, master's students in the final years of civil/building engineering and related programmes, and recent graduates (within one year); if places

12. Güneş M. Avinç, "Design-Build Projects in Architecture Education and Experimental Structures as a Pedagogical Approach," *Journal of Engineering Science and Technology Review* 17, no. 4 (2024): 228-239.

remained, members of other professional Orders and students from other universities could also be admitted. The call required an application form and curriculum and invited candidates to indicate their first and second choice for the thematic area in which they must be involved (building reuse and new functions; structural diagnostics and seismic upgrading; energy retrofitting and renewables/energy communities; accessibility and green mobility; hydrogeological risk mitigation), which were later used to form balanced interdisciplinary groups. Applications were assessed by the Scientific Committee, primarily in chronological order and, for students and recent graduates, with priority to first-time participants. Thirty-one participants completed all activities and the final survey; the cohort comprised professional engineers, advanced students and recent graduates with previous experience in architectural/structural design and construction technology. Participation was voluntary, and all participants gave informed consent for the anonymised use of their data and project materials for research and dissemination purposes.

Theoretical Instruction

The first phase consisted of a curated series of lectures designed to provide participants with the cultural, environmental, and technical foundations necessary to engage with the case study. These lectures were interdisciplinary, covering a range of topics such as the historical evolution of Aeolian settlements, the morphological and ecological features of the Filicudi landscape, typological characteristics of vernacular architecture, principles of passive environmental design, and the seismic vulnerabilities of traditional construction. Technical instruction included the application of digital tools for environmental simulation and structural assessment, integrating BIM-based modeling, climate analysis, and energy performance evaluation.

Rather than operating in isolation, the lectures functioned as conceptual frameworks to be challenged, deepened, and operationalized during the subsequent phases. Emphasis was placed on positioning traditional knowledge systems in dialogue with contemporary sustainability and resilience paradigms, inviting critical reflection and reinterpretation.

Practical and Analytical Sessions

The second phase enabled participants to translate theoretical inputs into operational knowledge through hands-on exercises and analytical exploration. These sessions included on-site and desk-based activities such as morphological and typological surveys, site mapping, solar path and microclimate analysis, material behavior studies, and the use of parametric modeling tools. Conducted at the University of Catania and during the early stages of field engagement, these activities served to ground participants in the specificities of the site and to build a shared methodological toolkit.

Particular attention was given to the integration of digital technologies, facilitated by the involvement of ETALab (Enabling Technologies for Architecture Laboratory). Demonstrations and exercises in digital scanning and rapid prototyping tools provided a bridge between analog heritage systems and computational design approaches.

Experiential Learning Module: Field-based Design Studio in Zucco Grande

The third and central phase of the methodology was the immersive interdisciplinary design workshop conducted in the abandoned village of Zucco Grande on Filicudi Island. This site was chosen based on multiple selection criteria: its architectural and environmental value, its morphological complexity, and its capacity to stimulate design thinking around themes of isolation, decay, and resilience. The village's partial ruination and difficult access rendered it a setting for experiential learning and critical experimentation.

Participants were organized into seven interdisciplinary working groups, each assigned a thematic challenge related to the broader goal of sustainable heritage recovery. These themes included architectural adaptation and reuse, energy self-sufficiency, resource management, passive thermal comfort, sustainable mobility, seismic risk mitigation, and structural consolidation. Design challenges were framed within a shared master plan vision, which encouraged inter-group coordination, mutual feedback loops, and spatial coherence across different interventions.

Each group's workflow followed an iterative logic: site analysis, conceptual framing, design development, peer review, and prototype refinement. Tutors and mentors from architecture, engineering, and environmental disciplines provided ongoing supervision and critical dialogue, ensuring both technical feasibility and design sensitivity.

There are several design-build or heritage studios within global academic institutions including Rural Studio (Auburn University, USA), the worldwide European dbXchange Network, the CIRC-ARCH /Crafting Circularity (Antwerp University, BE) or Officina (IUAV University, IT). Specific applications of "learning by doing" in architectural topics are analyzed by Güneş¹³ where the pavilions produced by students in different Universities between 2010 and 2022 were researched and evaluated. The integration of design-build projects and experimental structures within the architectural education curriculum has been demonstrated to engender active student participation, foster the development of creative thinking skills, and facilitate the exploration of significant issues such as sustainability, recycling, innovative and advanced construction techniques.¹⁴

This approach has been adopted in AISS|24 with, in addition, the integration of parametric design, rapid prototyping, and active heritage learning in a context of seismic and climatic vulnerability. Unlike traditional preservation-focused models, AISS|24 positions students not as observers but as co-producers of resilient solutions with real territorial and pedagogical impact.

13. Sardar S. Shareef, Hozan L. Rauf, and Ejeng B. Ukabi, "Reconsidering Teaching Construction in Architectural Education," *Journal of Philology and Educational Sciences* 3, no. 1 (2024): 43-57.

14. David A. Kolb, *Experiential Learning: Experience as the Source of Learning and Development* (New Jersey: FT Press, 2014).

Digital Prototyping and Final Presentation

The fourth phase focused on the material and communicative translation of the design proposals. Using a range of analog and digital tools, including physical modeling, parametric scripting, and rendering techniques, participants refined their proposals into project narratives suitable for public dissemination. Special attention was paid to the integration of sustainability indicators—such as energy performance, material circularity, and environmental impact—as evaluative criteria for the proposals.

This phase culminated in a final public event at the University of Catania, during which each team presented their design to a multidisciplinary audience. The event was conceived not only as a conclusion, but as a platform for collective learning and trans-scalar reflection, reinforcing the participatory and transformative goals of the program.

Assessment of Design Proposals

The seven design proposals developed by the interdisciplinary groups were evaluated during the final public review by a panel consisting of the School's teaching staff and invited external experts from academia and professional practice. To ensure comparability across projects, a set of shared assessment criteria aligned with the intended learning outcomes and the objectives of the AISS|24 was adopted: (1) understanding and interpretation of the local context (heritage values, landscape and environmental constraints); (2) integration of sustainability dimensions (energy performance, seismic safety, accessibility and social use) in a coherent design concept; (3) feasibility and reversibility of the proposed interventions with respect to the fragile setting; (4) quality of interdisciplinary collaboration (e.g., explicit contribution of different disciplines to the proposal); and (5) clarity of representation and communication (drawings, models, diagrams, and oral presentation). Each proposal was discussed and assessed against these criteria; feedback was then used as a basis for revising and refining the projects and for the critical reflection activities reported in the Results and Discussion section.

Evaluation of Learning Outcomes

To evaluate the educational impact of AISS|24, an anonymous post-programme questionnaire was designed and administered online during the final day of activities. The survey comprised three sections: (i) background information (study programme, year, previous experience with heritage and sustainable design), (ii) eighteen closed-ended items on perceived learning outcomes and quality of the educational experience, and (iii) three open-ended questions inviting critical reflection on strengths, weaknesses and suggestions for improvement. Closed-ended items were formulated as statements (e.g., "The Summer School improved my ability to integrate sustainability considerations into heritage projects") and rated on a 5-points Likert scale from 1 ("strongly disagree") to 5 ("strongly agree").

Responses to closed-ended items were analysed using descriptive statistics such as frequencies and percentages, focusing on indicators related to interdisciplinarity,

integration of sustainability and heritage, effectiveness of the four-phase structure and perceived usefulness of digital tools. Open-ended responses were examined through an inductive thematic analysis: two authors independently coded the comments, grouped them into recurring themes (e.g., perceived added value of on-site immersion, workload and timing, suggestions on logistics), and resolved discrepancies through discussion until consensus was reached.

Educational Foundations of the AISS|24 Pedagogical Model

The pedagogical model adopted by AISS|24 is grounded in constructivist and experiential learning theories, emphasizing the role of learners as active participants in the co-construction of knowledge. It draws inspiration from Kolb's experiential learning cycle,¹⁵ in which concrete experience, reflective observation, abstract conceptualization, and active experimentation form a cyclical and integrated process. Furthermore, the collaborative and situated dimension of the program aligns with Wenger's theory of communities of practice, where learning emerges through social interaction within a shared domain of interest. The real-world complexity of the design challenges presented in AISS|24 reflects Schön's concept of the "reflective practitioner",¹⁶ fostering the development of professional judgment through action and critical reflection. The structure of AISS|24 echoes the principles of design-based research (DBR,¹⁷) in which pedagogical innovation is tested, refined, and assessed in iterative cycles within authentic contexts. In this scenario, we stimulate the students to be able to move from siloed disciplinary thinking to actively navigating "wicked problems" in interdisciplinary teams within transdisciplinary learning environments, according to similar experiences like Anchor framework,¹⁸ which conceptualises universities as civic anchors that co-create solutions with local communities through project-based, real-world challenges.

Aeolian Islands and Aeolian Houses

The Aeolian Islands are a very suitable case study for several reasons. The most important of these is the remoteness of the location, which is offset by the strong relationship between architecture and landscape. Secondly, there is the presence of cultural and natural excellences, which are of interest to tourists.

The Aeolian Archipelago is located off the northern coast of Sicily, at a distance of just over 12 nautical miles from the Cape of Milazzo. It comprises seven large inhabited islands and numerous rocky outcrops. The largest of the "Seven Sisters"

15. Donald A. Schön, *The Reflective Practitioner: How Professionals Think in Action* (Londra: Routledge, 2017).

16. Sasha Barab, and Kurt Squire, "Design-Based Research: Putting a Stake in the Ground," *Journal of the Learning Sciences* 13, no. 1 (2004): 1-14.

17. Avinç, "Design-Build Projects in Architecture Education and Experimental Structures as a Pedagogical Approach," 2024, 228-239.

18. Calayde Davey, "The ANCHOR Framework," in *Proceedings from the International Research Symposium on Problem-Based Learning (IRSPBL)* (2025).

(as the locals call them) is Lipari, which has played the role of the archipelago's capital since time immemorial, despite Salina Island's larger economic presence (Figure 2). The islands have a documented history dating back to prehistoric times. They have experienced both prosperous and depressed periods throughout history, such as the free kingdom of the Eolian people in the 6th century BC, the surrender to the Roman fleet of Consul Aurelio Cotta during the Punic Wars (252 B.C.), and the colonization by Lord Ruggero D'Altavilla the Norman, as well as the sack by the Saracen pirate Ariadeno, known as Barbarossa, in 1544,¹⁹ The Aeolian Islands were recently rediscovered by the public thanks to the famous 1949 film *Stromboli*, starring Ingrid Bergman and directed by Roberto Rossellini. The archipelago's value has also been recognised by UNESCO, which added the islands to its World Heritage List in 2000.



Figure 2. *The Aeolian Archipelago and its Built Environment: (a) Location at the National Scale; (b) Location at the Regional Scale; (c) Typical Example of Aeolian Vernacular Architecture*

Filicudi lies in the western arm of the Aeolian Islands. Although Stromboli is closer to the Sicilian coast, Filicudi and nearby Alicudi are more isolated because they lie far off the Milazzo-Lipari-Naples route, which was once frequented by merchant ships and is now popular with tourists. Nevertheless, Filicudi boasts the

19. Moses I. Finley, Denis Mack Smith, Christopher Duggan, and G. Codignola, *Breve storia della Sicilia* (Bari: Laterza, 1992).

longest history: a prosperous community that traded obsidian lived on the small hill of Cape Graziano from the Neolithic to the Bronze Age²⁰ (Figure 3).



Figure 3. *The Archeological Site of Cape Graziano: A Village of Bronze Age (from 2300 B.C. to 1300 B.C.)*

The relationship between the inhabitants and the natural environment has created a stunning landscape, the result of hard work on the land. Thanks to its isolation, Filicudi Island has managed to preserve its rural landscape more effectively. It has now become a popular destination for naturalists from all over the world, having been declared a protected nature reserve in 1997.

Filicudi is "the Island of Ferns", or perhaps "of the Phoenicians". It is certainly a suggestive island of the Aeolian Archipelago with six eruptive centres: the Fili di Sciacca, the Zucco Grande, the Fossa delle Felci, the Monte Torrione, the Montagnola and the Capo Graziano. The coast is dotted with numerous caves and lava cavities, the best known of which is the Grotta del Bue Marino, once a breeding of reproduction of the Monk Seal, now extinct. Today, the island of Filicudi, about 9.5 km² and with a maximum elevation of 774 m a.s.l., is characterized by a series of scattered districts that have formed along the winding axes of the mule trails created to serve the terracing system, very peculiarity of the island.

One of the centres worth visiting is Zucco Grande, a village in the north-east of Filicudi. Zucco Grande is an abandoned village. To reach it, you must walk two kilometres along a footpath, leaving the inhabited part of the island behind.

The village was once home to 300 people, and their houses, now in ruins, are surrounded by vegetation. The site is indicated on 19th century cadastral maps (Figure

20. M. C. Martinelli, *Aeolian Islands Filicudi in the Bronze Age* (Palermo: Sicily Department of Cultural Heritage and Sicilian Identity, 2015).

4). The streets, now covered in ferns and volcanic lava, are evidence of Filicudi's geological history and recall the antiquity of this place, which emerged from the volcanic archipelago almost 600,000 years ago. It is said that the most beautiful women on the island lived in this village. The elders remember musical processions by groups of men who wanted to impress the renowned Zucco Grande maidens. Nearby is Filicudi's only water source: Vallone Fontana. Today, it has dwindled to a single stream, yet the area's vegetation remains among the lushest on the island.

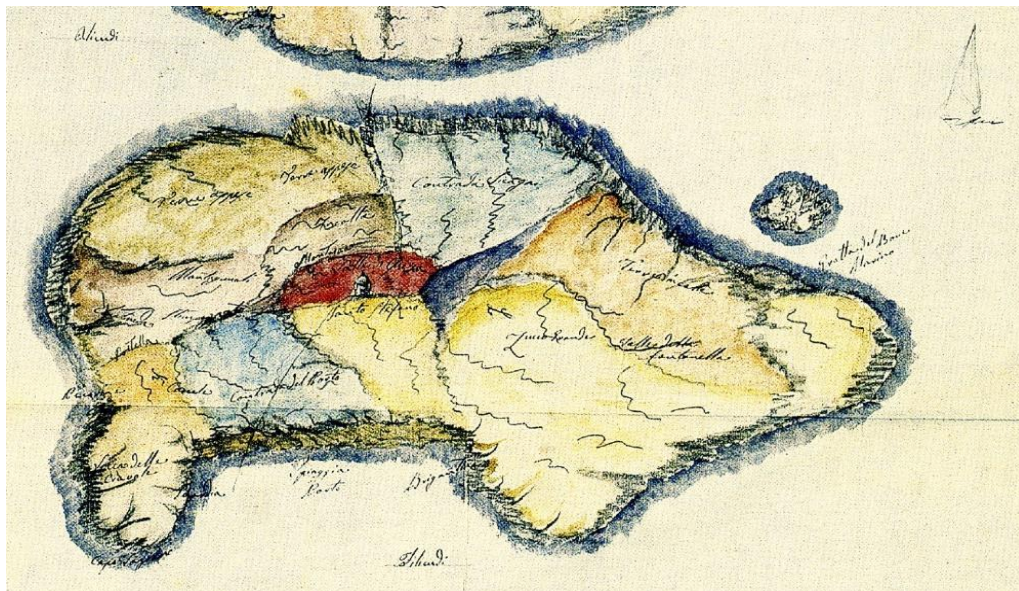


Figure 4. *The Island of Filicudi in a 19th Map: Underlined in Red the “Zucco Grande” Village*

Aeolian Islands Summer School

The Aeolian Islands Summer School forms part of a program of ongoing training activities organised in collaboration between the Catania Engineering Council and the University of Catania. It consists of an intensive, innovative teaching course, usually held in September. Each year, a specific focus is chosen and developed by mixed working groups under the supervision of a multidisciplinary teaching staff. The school's goal is to develop knowledge, skills and competences in the field of innovation.

The Summer School aims to develop skills and competencies that are useful in everyday professional life. The course provides a comprehensive experience, covering everything from concept sketching to defining executive details. The organization began in 2019 with the first edition held in the city of Catania. Since 2022, the school has been hosted on the island of Filicudi, focusing on the promotion of Aeolian architecture. From that date onwards, it has been known as the "Aeolian Islands Summer School".

The 2022 edition of the Summer School was entitled "Sismo-energy requalification of historical buildings". It focused on the design features of refurbishment works for traditional buildings, with the aim of improving energy efficiency and seismic resilience

through an integrated design approach. The Aeolian houses were a perfect case study for this purpose because they can be considered ante-litteram sustainable buildings and have withstood several earthquakes over the years.²¹ Taking into account the specific requirements of the area, the refurbishment design incorporated innovative solutions for tourist accommodation, such as short-term rentals, holiday homes, and home restaurants.

The careful analysis of the characteristics of Aeolian architecture, even in its ruined state, guided the workshop participants, who were divided into six working groups. Many of the solutions presented by the working groups were based on Aeolian building practices and the distributional specificities of traditional architecture. The revival of the traditional bagghiu, complete with pergola and wooden features, was a recurring theme in all the proposals (Figure 5). The working groups tried to reconcile compliance with conservation rules, improvement of the buildings' seismic response, current comfort standards and the need to reduce energy and water consumption within the strict regulatory framework of the area in question,²² with varied outcomes and not without some difficulty.



Figure 5. *A Typical Aeolian House: We Can See the Bagghiu and its Pergola in Reed Mat*

The Summer School 2023, titled "Building Digital Technologies for Sustainable Architectural Units", focuses on innovative technologies most suitable for temporary micro-architecture in fragile contexts. The following considerations led to its creation.

21. Alessandro Lo Faro, Angelo Monteleone, Gianluca Rodonò, and Vincenzo Sapienza, "The Seismic-Energetic Refurbishment of Vernacular Architecture: An Application to Aeolian Island (Italy)," in *10th Euro-American Congress on Construction Pathology, Rehabilitation Technology and Heritage Management (Rehabend 2024)*, a cura di Círculo Rojo, 1501-1508 (2024).

22. Ibid.

The enhancement of building heritage is an important opportunity for territorial development. Although it is mandatory to imagine new ways to create more space, adapt existing buildings to new uses and standards, or provide new functions and facilities in the area, it is also important to consider new ways to achieve this. To this end, it is crucial to develop expertise in advanced design methodologies for innovative, lightweight building components formed from recycled and recyclable materials assembled using dry technologies. These methodologies allow for new types of intervention involving reversible and removable additions to existing buildings. Furthermore, the scope has been broadened from architecture to landscape, taking into account innovative solutions for new constructions.

The island of Filicudi has two tourist ports, two archaeological sites and several ruined buildings. There are therefore many places where actions to valorize the local cultural heritage or improve the tourist reception can be planned, using mobile, temporary and new architectural units.²³ To this end, lightweight, sustainable and reversible building technologies are essential, as they help to keep the building site clear and reduce invasiveness.

Participants were asked to design two pavilions for tourist reception in port areas, two pavilions for showcasing prehistoric finds at archaeological sites, and two traditional Aeolian house extensions to serve as information points. The designs were created using corrugated cardboard and wood. The high performance possible with these materials, even in the AEC sector, was demonstrated in a recently completed research project²⁴ and an ongoing one.²⁵ The University of Catania has played a central role in both projects. Using less invasive building technologies may help to meet the need for respect and preservation of the local architecture thanks to their reversibility.

The Summer School 2023 will focus on the following goals:

- Design approach for small-scale architecture.
- Checking that the landscape is suitable.
- Using digital tools for architecture.
- Using parametric models.
- Use of the rapid prototyping tools.

The working groups had been addressed towards the use of some innovative building technologies, such as:

- ACHICART: it is based on alveolar precast panels that are made by corrugated cardboard; these panels are used for the building's outer walls and also for the structure that holds up the building; this technology has already been tested for use in a small experimental building called Test-Box.²⁶

23. Next Generation UE, *PNRR Isole verdi* (Ministero dell'Ambiente e della Sicurezza Energetica).

24. Early Warning System for Cultural Heritage, *EWAS Project*.

25. Archicart, *Archicart Lifehouse Project*.

26. Dario L. Distefano, Gianluca Rodonò, and Vincenzo Sapienza, "Le nuove frontiere dell'architettura di cartone," *Il progetto sostenibile* 38 (2016): 112-119.

- ICARO: it is the acronym of Innovative Cardboard ARchitectual Object and it is based on a precast mixed panel that combines wood and corrugated cardboard. These two materials work well together thanks to a sort of pre-stress. Icaro technology has already been tested by building a small experimental pavilion in a Sicilian archaeological area.²⁷
- LAYERS: the fundamental premise of this technology is the decomposition of the architectural object into a series of layers, which may be either vertical or horizontal. These layers can be constructed from wood and assembled with either a mutual gap or in direct contact. This technology is primarily concerned with the fabrication of objects with organic shapes.

In the development of the design activities, a digital workflow was assumed in the various phases of the process: from the survey of the areas to the rapid prototyping of physical models. This phase was facilitated by the collaboration of the ETALab, a facility of the University of Catania.²⁸ The proposed methodology was found to be highly suitable for the building technologies that had been adopted, and it was also found to be in line with the digital transition to which the AEC sector was moving towards.²⁹

The Aeolian Island Summer School 2024 (AISS|24)

Educational Framework for Sustainable Heritage Design

The AISS|24 was conceived as an interdisciplinary educational initiative aimed at exploring innovative strategies for the integrated recovery of traditional buildings in Mediterranean contexts, with a particular emphasis on fostering sustainable tourism hospitality. Bringing together academics, professionals, and students from diverse fields such as architecture, civil engineering, transportation, and environmental sustainability, the program promoted a collaborative learning environment where theoretical knowledge and practical experience converged.

Organized by the University of Catania in collaboration with the Order of Engineers of the Province of Catania and supported by local authorities, the Summer School focused on the historic village of Zucco Grande, located on the island of Filicudi, as its primary case study. This site, rich in cultural heritage yet marked by abandonment and decline, offered a setting in which to explore the challenges and opportunities associated with the revitalization of traditional Mediterranean architecture.

The pedagogical approach adopted by AISS|24 was structured to blend academic instruction with immersive fieldwork, enabling participants to develop context-

27. Vincenzo Sapienza, Gianluca Rodonò, Angelo Monteleone, and Simona Calvagna, "ICARO—Innovative Cardboard Architecture Object: Sustainable Building Technology for Multipurpose Micro-Architecture," *Sustainability* 14, no. 23 (2022): 16099.

28. Enabling Technologies for Architecture Laboratory (ETALab).

29. Vittoria Bonini, Paolo Galelli, and Alessio Minetto, *Tomorrow is Reloading: Il ruolo del digitale nel progetto della città contemporanea*. (Genova: Genova University Press, 2022); Microsoft, and RIBA. *Digital Transformation in Architecture*.

sensitive design solutions grounded in direct observation and experiential learning. The program followed a blended learning model integrating lectures, site surveys, workshops, and collaborative project development.

The educational goals of the initiative included fostering interdisciplinary cooperation in the resolution of complex architectural and environmental problems; advancing the application of passive design principles and renewable energy technologies to enhance the sustainability of historic buildings; investigating new solutions for improving accessibility and mobility in geographically isolated but culturally significant areas; and formulating design methodologies for the structural consolidation of vernacular buildings, with specific attention to seismic safety and the conservation of original materials.

Program and Activities

Running from September 13 to October 12, 2024, the Summer School was designed to provide participants with a comprehensive understanding of sustainable strategies for the integrated recovery of traditional Mediterranean buildings, using the abandoned village of Zucco Grande on the island of Filicudi as a real-world case study.

The program officially began on September 13 with the Inaugural Day hosted at the headquarters of the Order of Engineers of the Province of Catania. This opening session introduced participants to the objectives, methodologies, and thematic priorities of AISS|24, highlighting the central focus on sustainability, cultural heritage preservation, and community-centered design. A series of lectures followed, addressing key topics such as traditional Mediterranean architecture, sustainable tourism development, passive design techniques, energy efficiency, and the seismic vulnerabilities of historic buildings. At the end of the session, participants were divided into seven interdisciplinary working groups, each tasked with developing a design proposal tailored to specific challenges and opportunities identified within the Zucco Grande site.

On September 18, participants attended a Keynote Lecture held at the Ex Chiesa di Santa Caterina d'Alessandria in Lipari. The event featured renowned experts in architecture and environmental sustainability who presented on a variety of subjects, including bioclimatic design, strategies for regenerating abandoned villages, the potential of renewable energy communities in remote territories, and the historical evolution of coastal settlements in the Mediterranean.

From September 19 to 22, participants traveled to Filicudi to carry out an intensive fieldwork phase on site at Zucco Grande (Figure 6). This immersive segment of the program enabled students to gain a direct understanding of the architectural, environmental, and socio-cultural dimensions of the location. During this phase, they conducted architectural surveys to document existing structures and evaluate building techniques and material conditions; carried out environmental assessments to analyze microclimatic behavior, resource availability, and landscape constraints; examined accessibility challenges imposed by the island's rugged topography; and engaged with local stakeholders to collect oral histories and perspectives on the significance and future potential of the village. These activities

served as the foundation for the subsequent development of design solutions grounded in real-world conditions.

After returning to Catania on September 23, participants entered the final stage of the project development phase, which lasted until October 4. During this period, the working groups refined their concepts and advanced their proposals into more comprehensive and integrated design solutions, incorporating feedback from academic mentors. The resulting projects addressed several interconnected themes. These included reconciling the conservation of traditional forms with modern sustainability objectives through the use of passive strategies and local materials; incorporating renewable energy technologies such as photovoltaic systems and rainwater harvesting combined with passive cooling techniques to reduce energy dependence; developing innovative strategies to improve accessibility while minimizing environmental impact through the design of pedestrian paths and sustainable transport solutions; proposing structural reinforcement and seismic retrofitting techniques that respected the conservation requirements of historic architecture; and envisioning community-centered public spaces that could strengthen local identity, enhance the tourism offering, and support economic revitalization.

The Summer School culminated on October 12 with the Final Presentation and Exhibition held at the University of Catania. This concluding event offered a formal opportunity for each group to present their work to an audience of academics, professionals, local stakeholders, and public administrators. Through drawings, models, and multimedia presentations, participants articulated the challenges they encountered and the design solutions they developed over the course of the program. Beyond celebrating the achievements of the working groups, the event fostered valuable dialogue among different stakeholders, encouraging wider reflection on sustainable heritage recovery and underscoring the importance of interdisciplinary collaboration in addressing the multifaceted challenges of fragile contexts.



Figure 6. *Participants in Zucco Grande, Filicudi*

Results and Discussion

Design and Prototyping

Working in seven interdisciplinary groups, participants tackled a range of issues including energy optimization, structural reinforcement, sustainable mobility solutions, and heritage conservation strategies. Each group developed a detailed proposal that not only addressed the specific challenges of Zucco Grande but also explored the broader implications of sustainable development in Mediterranean contexts.

The following sections of this paper outline the structure of the Summer School, describe the key activities and workshops conducted, and present the outcomes of the group projects, which collectively demonstrate a range of innovative approaches to sustainable heritage recovery.

It must be clarified that all sustainability metrics presented in the following sections, such as energy savings or emission reductions, are predicted indicators

derived from simulations and design calculations, not empirical measurements of built interventions.

Taking into account the complexity of the project, the various groups were involved in addressing the different issues in an integrated multidisciplinary design process starting from an initial master plan (Figure 7), in which the work of each group was directly linked to the emerging requirements and the results obtained in the development phase of the other groups, aimed at identifying potential problems and conflicts throughout the design phase. It is important to highlight that the design process was iterative. Several proposals underwent significant revisions based on feasibility critiques and inter-group feedback. For instance, initial mobility plans were deemed overly invasive, requiring a shift to lighter, modular infrastructure. Similarly, early concepts for the "Albergo Diffuso" required simplification to meet the constraints of the existing ruins and resource availability, highlighting a common challenge in balancing ambitious revitalization with practical conservation.



Figure 7. *Zucco Grande Project Master Plan*

The first two groups worked on the project of recovery and functional revitalization of the existing through design proposals aimed at transforming the old buildings and the traces of the ruins into spaces dedicated to tourist reception. The third and fourth groups, taking inspiration from the previous design proposals and the renewed needs in terms of comfort and energy demand, worked on the energy requalification project of the old buildings and on the study of strategies for the production of sustainable energy, but also the management of resources in Zucco Grande. The fifth group was engaged in the accessibility project to the site chosen as a case study, with the aim of also renewing the mobility system of the island. The last two groups finally addressed the issue of seismic risk mitigation and structural consolidation.

Group Volcano – "L'innesto"

The Vulcano team explored the concept of architectural grafting (the graft) as a strategy to merge contemporary interventions with the existing historical fabric of Zucco Grande. The primary objective was to create a dialogue between past and present, promoting architectural continuity while introducing new functions that could revitalize the abandoned settlement. This approach was selected as an alternative to conservative restoration or demolition with reconstruction, allowing the valorization of the urban context through a new identity linked between past and future (Figure 8).



Figure 8. *Rendered View and Main Elevation of the Work of the Vulcano Group*

Key interventions included the use of platform frame structures made of sustainable materials such as heat-treated wood and locally sourced stone, ensuring minimal environmental impact and strong contextual integration. These modular and lightweight structures were designed to be reversible and adaptable, allowing for future modifications without compromising the integrity of the original architecture. The project emphasized the creation of common spaces that could serve both residents and visitors, promoting social interaction and community involvement. Courtyards, shaded terraces and outdoor gathering areas have been strategically incorporated to enhance usability and enhance the spatial experience, while respecting the environmental sensitivity of the site.

Group Filicudi – "Albergo diffuso"

The Filicudi team focused on the adaptive reuse of existing buildings and traces to develop a model of "Albergo Diffuso" that supports sustainable tourism while preserving the cultural identity of Zucco Grande. The project involved the reconstruction of the old collapsed volumes and the transformation of the scattered historical structures into interconnected hospitality spaces that could attract visitors and at the same time promote local economic growth. Starting from the refurbishment of the old oven, a new kitchen was designed in compliance with current regulatory standards. Since the south-west part of the buildings has two elevations above ground, the ground floor was dedicated to tourist-receptive activities, while the rooms on the first floor were reserved for the exclusive use of the host. All the new functions were integrated into the traditional layout of the village. For the reconstruction of the old volumes on the ground floor, traditional materials and techniques were re-proposed, while for the total reconstruction of the area adjacent to the oven area, the second floor of the host's residence, the room that will serve as a guest room and the independent block containing the toilets and the administrative office, Steko wooden blocks were used, subsequently covered in wooden boards treated with the Shou Sugi Ban technique, a solution that aesthetically dialogues with the pre-existing structure and at the same time improves the weather resistance of the covering itself (Figure 9).

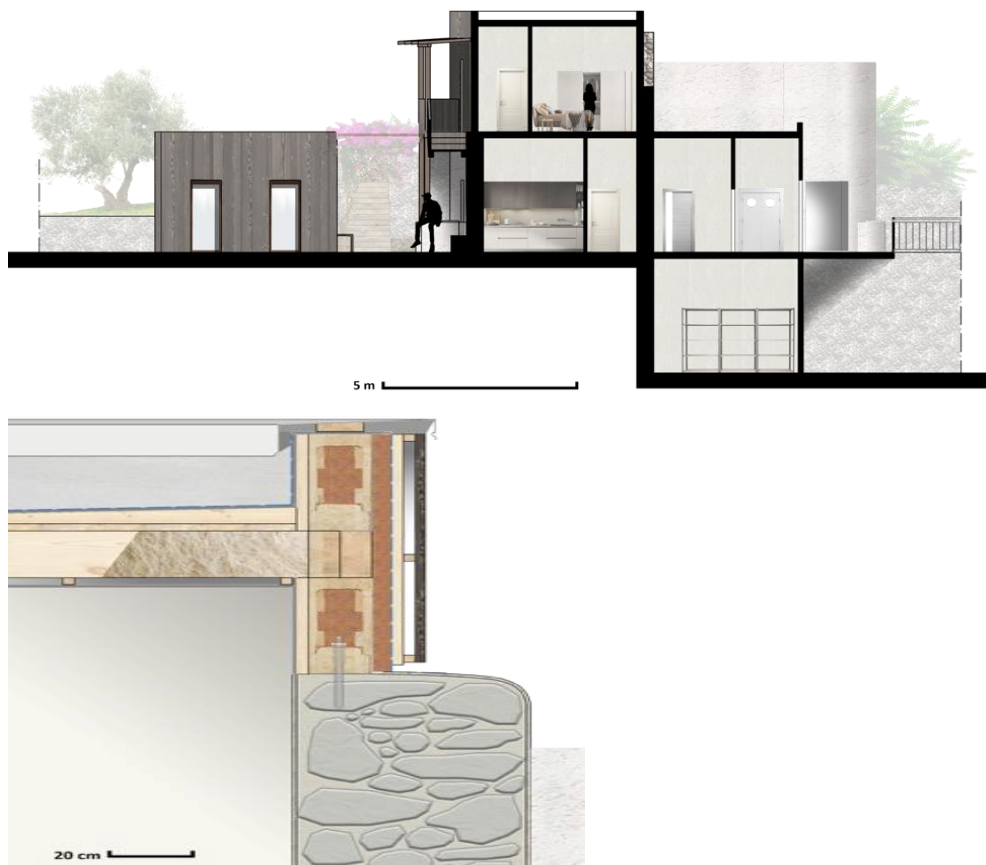


Figure 9. Section and Construction Detail of the Work of the Filicudi Group

Particular attention was paid to the enhancement of the existing water management systems, including the restoration of the rainwater collection tanks, reflecting the Aeolian architectural tradition of resource-conscious design. The project also promoted local gastronomy and cultural heritage by incorporating spaces for cooking classes, local produce markets and community events. By revitalizing abandoned buildings and activating common spaces, the project aimed to create a model of sustainable tourism rooted in the local culture and traditions of Filicudi.

The project preserved and reactivated existing rainwater cisterns. Design projections estimated 18,000-liter seasonal capacity, which simulations indicated could meet 60–70% of domestic non-potable water use during high tourist season, potentially reducing dependency on imported water by an estimated 40%.

Group Lipari – "Continuum"

The Lipari team developed a proposal for a visitor hub and first contact tourist center that would serve as an entry point to Zucco Grande, enhancing the experience of both residents and tourists. The project aimed to create a seamless transition between the historic village and the surrounding natural landscape, while promoting environmentally responsible tourism. The project included a reception area, an information center, and local craft shops, all arranged around an open plaza that could serve as a gathering space for visitors and the local community. In order to obtain spaces dedicated to the new functions starting from the restoration of the pre-existing volumes, the reconstruction of the collapsed parts on the first floor was planned with new masonry covers, whose finish allows to differentiate the new blocks from the pre-existing parts (Figure 10).



Figure 10. *Main View of the Work of the Lipari Group*

The architectural approach emphasized passive design strategies, such as natural ventilation, solar shading, and the use of green roofs, to improve energy efficiency and reduce the ecological footprint. A network of pedestrian paths has also been introduced to improve connectivity within the site, encouraging slow mobility and fostering deeper engagement with the local landscape. By integrating tourism services with community spaces, the project has reinforced the idea of a continuum between cultural heritage, nature and contemporary life.

Group Salina – "Zucco Green"

The Salina team pursued the challenge of energy self-sufficiency by proposing strategies for sustainable energy production and resource management within Zucco Grande. In this case, the group was directed to design strategies and interventions aimed at energy efficiency of buildings and sustainability. The primary objective was to create a model for an energy resilient village that could operate independently, minimizing its environmental impact (Figure 11).

Simulations indicated that the project incorporated expanded cork panels for thermal insulation, reducing the U-value of external walls by approximately 60% compared to the existing stone masonry. The photovoltaic system was dimensioned to meet at least 85% of the expected energy demand based on simulated annual solar gain. These interventions aim to lower operational energy consumption below 40 kWh/m²·year, consistent with NZEB criteria in Mediterranean zones.

The integration of photovoltaic panels and multi-split heat pumps enabled renewable energy generation and efficient climate control, while passive cooling strategies – such as shading devices and cross-ventilation – further reduced energy consumption. Water management was also a focus, with the implementation of rainwater collection systems and greywater recycling to promote the circular use of resources. A community energy hub was proposed as a central hub for monitoring energy flows, encouraging the creation of a renewable energy cooperative that could support local residents and future visitors.



Figure 11. Integration of Photovoltaic Panels in Buildings and Energy Results of the Work of the Salina Group

Group Stromboli – "Mobilità Sostenibile & Accessibilità"

The Stromboli team addressed the critical issue of mobility and accessibility, aiming to improve transportation options within Zucco Grande while preserving the ecological integrity of the island. The project aimed to improve connectivity for both residents and tourists, particularly in areas that are currently difficult to access due to the rugged terrain. One of the group's key proposals was the development of an electric sea-bus network, designed to provide zero-emission transportation between Zucco Grande and other parts of Filicudi. Modular floating pontoons constructed from recycled materials were introduced to create three seasonal landing places, to facilitate safe and flexible mooring points. A solar-powered inclined panoramic elevator was proposed to connect the coastal area with the village at a higher altitude, offering an accessible and environmentally friendly alternative to traditional routes. An intermodal connection system based on a rack monorail was designed to connect the village to the internal vehicular routes of the island, as well as facilitate the transport of tourists and luggage (Figure 12).

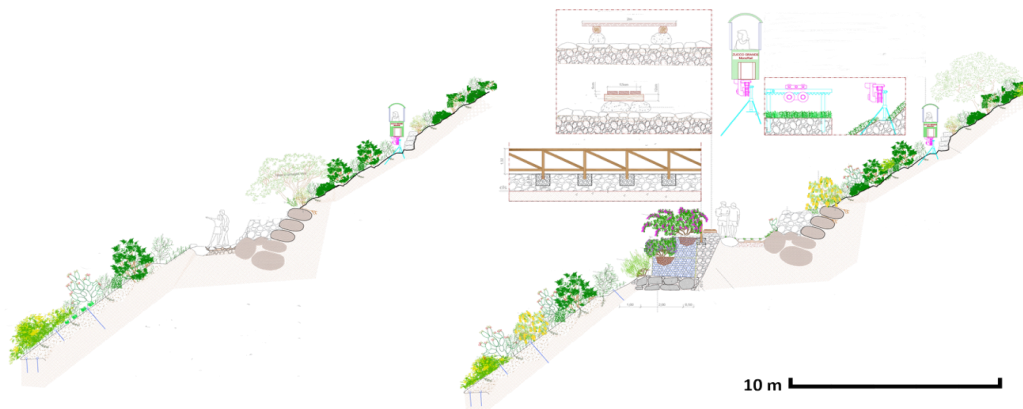


Figure 12. *Pedestrian Link Design Sections and Monorail Scheme. Work of the Stromboli Group*

The project has also integrated on-demand micro-mobility options both on land and inshore, including car sharing of electric vehicles and e-bikes, but also hydrofoil e-bikes and surf scooters, enabling flexible last-mile transport solutions tailored to the needs of both residents and tourists, also aimed at an immersive experience. The proposed electric sea-bus and inclined elevator were projected to reduce CO₂ emissions by over 90% compared to current diesel-based access modes. The use of solar energy for mobility infrastructure further enhances the site's transition to zero-emissions mobility.

Group Alicudi – "Recupero Strutturale"

The Alicudi team focused on the structural consolidation of the existing buildings of Zucco Grande, with a focus on seismic risk mitigation, while maintaining their historical authenticity (Figure 13). Recognizing the vulnerability of traditional masonry

structures in seismic areas, the team explored minimally invasive techniques compatible with heritage conservation standards.

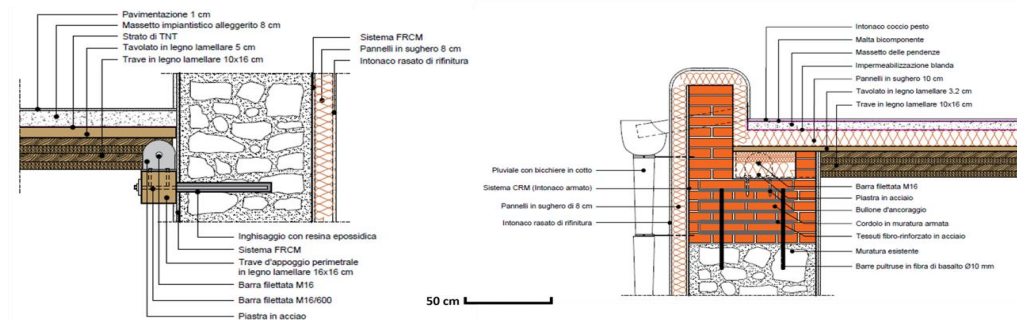


Figure 13. *Improvement Interventions: Floor-Wall Connection and Roof-Wall Connection. Work of the Alicudi Group*

The project adopted the "Where It Was – How It Was" approach, using original materials found on site to reconstruct collapsed portions and repair damaged elements. Structural reinforcements instead included the consolidation of the masonry with injections of binding mixtures and using the FRCM system, the construction of reinforced masonry curbs on top of the load-bearing facings, and the reconstruction of the old floors according to the checks required by current regulations. To ensure long-term safety, the team proposed the installation of a seismic monitoring system capable of tracking the structural health of the buildings over time. This approach not only improved the structural integrity of Zucco Grande, but also respected the cultural and historical value inherent in its architectural heritage.

Group Panarea – "Adeguamento Sismico & Conservazione"

The Panarea team focused on achieving seismic retrofitting while preserving the architectural character of the traditional buildings of Zucco Grande (Figure 14). The project aimed to balance the need for structural safety with the principles of reversibility and minimal intervention, ensuring that the proposed techniques could be adapted or removed in the future without damaging the original fabric. Key interventions included the application of Reinforced Composite Mortar (CRM) to improve the strength and ductility of the masonry, reinforcement by hooping of the masonry openings to prevent collapse during seismic events and the strategic use of steel tie rods to improve overall stability. For the horizontal structures, the team proposed the reconstruction of the floors using traditional techniques, combined with modern reinforcement strategies to improve load distribution and prevent deformation. A key focus of the project was the use of highly sustainable materials and low-impact construction methods, in line with the wider objectives of environmental sustainability and heritage conservation. By prioritizing safety without compromising aesthetic and historical integrity, the project has provided a replicable model for seismic retrofitting in contexts of historical interest.

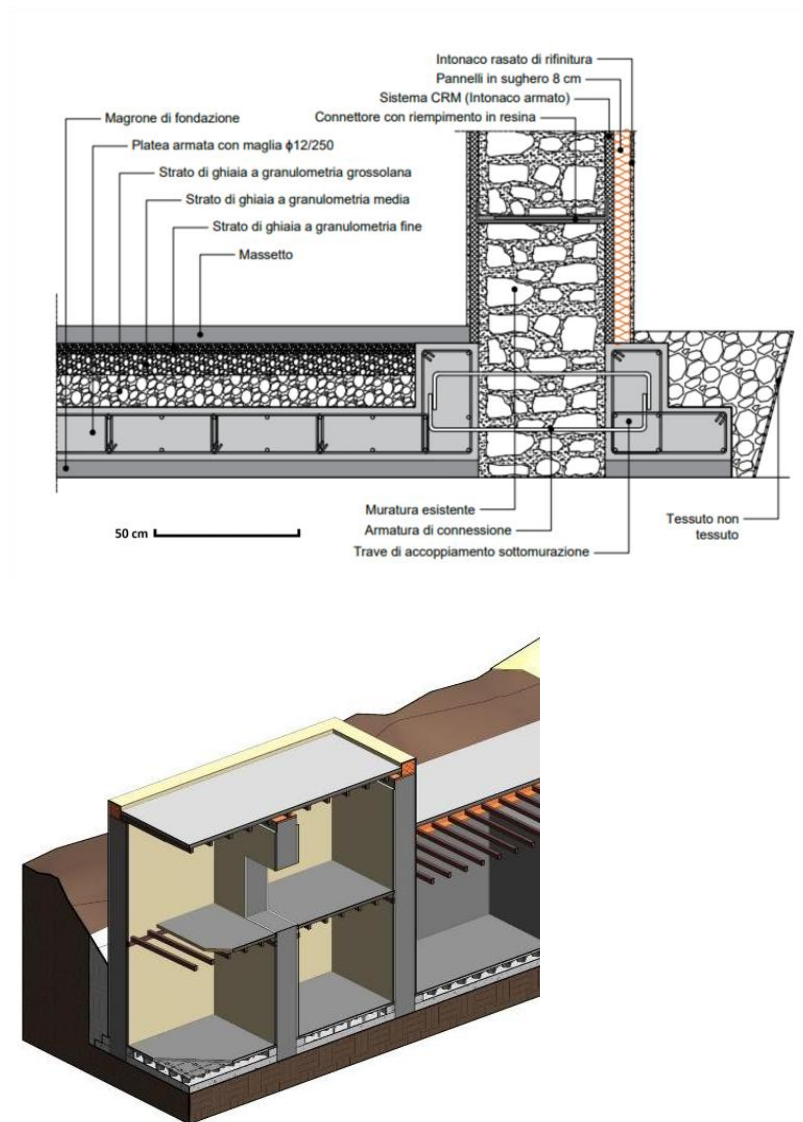


Figure 14. *Improvement Interventions on Foundations. Work of the Panarea Group*

Comparative Analysis of Design Approaches

Table 1 summarizes the design focus, strategies, technologies, and sustainability contributions of the seven interdisciplinary groups involved in AISS|24. While Table 1 summarizes the distinct outcomes, a comparative analysis reveals shared challenges and divergent strategies.

This is most evident in the two groups addressed to the structural reinforcement. Group Alicudi adopted a stringent "Where It Was, How It Was" philosophy, prioritizing material authenticity and minimal intervention using FRCM systems (Figure 13). In contrast, Group Panarea focused more on reversibility and compatibility, utilizing CRM systems and steel tie rods (Figure 14), which offer robust seismic retrofitting while being philosophically distinct from Alicudi's strict conservation approach.

Table 1. *Comparative Summary of the Design Proposals Developed During the AISS|24 Summer School*

Group	Design Theme	Main Objectives	Technologies and Materials	Heritage Conservation Approach	Sustainability Contributions
Vulcano	Architectural Grafting	Merge new functions with historical ruins through reversible additions	Platform-frame, local stone, heat-treated wood	Reversible modular structures; contextual integration	Low-impact reuse; passive comfort; social activation
Filicudi	Albergo Diffuso	Adaptive reuse for scattered hospitality model	Steko blocks, wooden boards (Shou Sugi Ban), traditional masonry	Recovery of collapsed volumes; architectural typology reuse	Rainwater collection; circular resource use; socio-economic regeneration
Lipari	Visitor Hub and Cultural Continuum	Create a tourism and community hub as a threshold between heritage and nature	Green roofs, natural ventilation, shading systems	Visual/functional continuity with original settlement	Passive cooling; slow mobility; multifunctional public space
Salina	Energy Self-Sufficiency	Retrofit buildings for energy efficiency and resilience	Expanded cork insulation, PV panels, multi-split systems, water recycling	Hidden integration of systems in existing fabric	Energy autonomy; circular water use; creation of energy hub
Stromboli	Sustainable Mobility and Accessibility	Improve inclusive access and intermodal transport to the village	Electric sea-bus, floating pontoons, inclined solar elevator, monorail	Infrastructure inserted without disturbing existing layout	Zero-emissions transport; access for all; flexible seasonal infrastructure
Alicudi	Structural Consolidation	Seismic retrofitting and material repair using low-impact methods	FRCM systems, grout injections, reinforced masonry curbs	"Where it was, how it was"; use of local materials	Enhanced safety; monitoring systems; authenticity preservation
Panarea	Seismic Retrofitting and Material Preservation	Minimize visual and structural invasiveness during seismic adaptation	CRM systems, steel tie rods, traditional floor reconstructions	Reversibility; minimal intervention philosophy	Resilience; use of low-impact and traditional-compatible techniques

A similar comparison emerges among the architectural reuse proposals. Group Vulcano ("L'innesto") proposed a high-contrast "grafting" of modern, reversible platform-frames onto the ruins (Figure 8). Group Filicudi ("Albergo Diffuso") opted for a hybrid approach, blending traditional reconstruction (re-proposing old techniques) with modern systems like Steko blocks for new additions (Figure 9). Group Lipari ("Continuum"), however, prioritized passive design and landscape integration (Figure 10), using the existing volumes as a basis for a visitor hub rather than a residential model.

Learning Impact: Survey Results and Reflections

According to the post-program survey ($n = 31$), 91% of participants agreed or strongly agreed that they had improved their ability to integrate sustainability in heritage design. 85% reported that the collaborative environment helped develop new interdisciplinary skills. The use of digital tools, such as parametric modeling and energy simulation, was rated as "very effective" by 78% of respondents.

"Designing in Zucco Grande taught me how to balance technological innovation with cultural sensitivity. It was not just a studio—it was a real-world challenge." – Participant, Building Engineering and Architecture master student.

Challenges and Limitations

The AISS|24 experience highlighted several tensions and constraints that qualify the results presented above. A recurrent issue concerned the relationship between conservation and energy retrofitting: in many proposals, participants had to balance the desire to improve thermal performance and reduce operational energy use with the need to preserve the material authenticity and visual integrity of masonry envelopes and roofs. Prioritising reversible and minimally invasive interventions often meant accepting lower theoretical energy savings than more intrusive alternatives, illustrating the trade-offs that practitioners face in protected heritage contexts.

Feasibility also emerged as a significant limitation. While the projects were grounded in regulatory frameworks and informed by preliminary sizing and simulations, economic and governance aspects could only be explored at a preliminary level within the limited timeframe of the Summer School. Some of the more ambitious mobility and infrastructural solutions (e.g., funicular systems, rack monorails, extensive floating pontoons), as well as the proposed energy community and water management schemes, would require detailed cost-benefit analyses, environmental impact assessments and management models before implementation. The proposals should therefore be read as advanced, research-informed scenarios intended to stimulate dialogue with institutions and communities, rather than as implementable masterplans.

At the process level, inter-group coordination and the balance between competing objectives proved challenging. Aligning assumptions on service levels and phasing across seven groups progressing at different speeds led to overlapping or conflicting interventions that had to be renegotiated and adjusted in the final stages. Participants also reported difficulties in reconciling energy performance, seismic safety, accessibility, landscape integration and social use under time pressure and with heterogeneous familiarity with simulation tools and regulations. These tensions, while limiting the degree of optimisation achieved in each proposal, formed a central part of the intended learning experience.

Compared with the 2022 and 2023 editions, which operated at the scale of individual buildings or small micro-architectures, the 2024 programme adopted a settlement-scale perspective. This broadened the educational value in terms of cross-scalar and interdisciplinary reasoning but also intensified logistical complexity and cognitive load for participants. The present study therefore captures a single intensive cycle of design-based experimentation in a complex setting and should be

complemented in future research by longitudinal follow-up across multiple editions and by more detailed feasibility studies on selected pilot interventions.

Beyond Zucco Grande: Towards a Transferable Model

The design and pedagogical framework developed during AISS|24 can serve as a prototype for other fragile, depopulated or climate-sensitive contexts across the Mediterranean and beyond. When compared to similar international workshops, such as the UNESCO "Living Heritage" initiatives or design-build studios in rural Japan (e.g., Kengo Kuma's workshops), the AISS|24 model places a unique emphasis on integrated technological systems rather than focusing solely on vernacular construction or craft. While many international programs prioritize traditional materials, the Zucco Grande projects demonstrate a hybrid model that weds high-tech simulation (NZEB, CO₂ reduction) with heritage conservation. Its replicability stems from its modular educational structure, the use of scalable technologies (e.g., Steko blocks, CRM/FRCM reinforcement), and a transdisciplinary process that bridges research, practice, and community engagement.

Future applications may include island communities in the Cyclades, North African coastal settlements, or post-disaster rural heritage sites where integrated sustainability and cultural resilience are urgently needed.

Conclusion

The AISS|24 reaffirmed the value of interdisciplinary, design-based educational programs as instruments for addressing the ecological, socio-cultural, and spatial challenges facing heritage landscapes in marginal territories. Grounded in a learner-centered methodology that integrated theoretical instruction, field investigation, and collaborative design, the program provided a dynamic framework for testing innovative approaches to sustainable heritage recovery. The abandoned village of Zucco Grande on Filicudi Island served not only as a case study but as an immersive laboratory where participants were invited to reinterpret vernacular architecture as a living, adaptable system.

The outcomes of AISS|24 demonstrated that traditional Mediterranean settlements can be reimagined through contemporary design strategies that prioritize sustainability, resilience, and cultural continuity. The proposals developed by the seven interdisciplinary working groups articulated a coherent and multilayered vision for the village's revitalization. These ranged from passive and active strategies for energy autonomy, to lightweight and reversible architectural grafts, to inclusive mobility infrastructures and hospitality models rooted in the identity of place—such as the reinterpretation of the *albergo diffuso*. The integration of advanced technologies, including photovoltaic arrays, CRM and FRCM reinforcement systems, Steko blocks, and parametric prototyping, was balanced with a respectful engagement with local materials, construction traditions, and landscape character.

The integration of measurable sustainability indicators within the design proposals—ranging from operational energy use to embodied material impact and

mobility emissions—demonstrates the feasibility of aligning heritage preservation with technical standards for ecological transition, as defined by CAM, EPBD, and the New European Bauhaus principles.

AISS|24 transcended the boundaries between academic training, applied research, and territorial engagement, positioning design as both a method of inquiry and a tool for regeneration. The program fostered a temporary but intense learning community, where students, researchers, and professionals could explore the intersections of technical innovation, cultural heritage, and environmental ethics. The active learning model proved effective not only in building technical and analytical capacities, but also in cultivating critical reflection, intercultural exchange, and community-oriented design thinking.

In conclusion, the AISS|24 program serves as a replicable and scalable model for sustainable regeneration in fragile contexts. By framing heritage not as a static asset but as a living system open to adaptation, the initiative contributes to the evolving discourse on architectural education as a catalyst for ecological transition. It aligns with the objectives of the New European Bauhaus and UNESCO's Historic Urban Landscape approach, underscoring the potential of education rooted in place, driven by research, and guided by sustainability.

To strengthen its impact, future editions of AISS will pursue the development of pilot implementation strategies in collaboration with municipalities, cultural heritage institutions, and funding agencies. Selected design proposals may be refined through research grants or tested through temporary installations, opening a pathway from conceptual design to built experimentation. The program will incorporate longitudinal assessment tools—such as alumni tracking, competency mapping, and post-occupancy evaluations—to monitor both professional development and real-world outcomes. Moreover, future sessions will explore enhanced integration of digital twins, open-source design repositories, and participatory planning methodologies to foster broader community engagement. These developments aim to position the AISS model as a reference framework for academic institutions and regional planning bodies engaged in the ecological transition of vulnerable heritage territories.

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