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ZEMCH

INTERNATIONAL DESIGN WORKSHOP

COMMUNAL FACILITY DESIGN FOR URBAN REGENERATION

Lecture 7

Antonio Frattari

Department of Civil, Environmental and Mechanical Engineering
Prof., University of Trento, Italy
antonio.frattari@unitn.it

•Full Professor of Building Construction, School of Engineering/Architecture, University of Trento, Italy.
•Full Professor of Wooden Architecture, School of Engineering/Architecture, University of Trento, Italy.
•President of the Degree Committee, School of Civil Engineering, University of Trento, Italy (from 1986 to 1992).
•Chief of Laboratory of Building Design (LPE) of the University of Trento (from 1986).
•Vice-Chancellor at the University of Trento with responsibility for construction projects (from 2004 to 2008).
•Chief of CUnEdI (University Centre for Smart Buildings) of University of Trento (from 2004).
•Rector's Delegate for the relationships with Habitech (Distretto Tecnologico Trentino) (from 2006).
•Rector's Delegate for the relationships with GBC Italia (Green Building Council Italia) (from 2008).

Antonio Frattari was Associated Professor at the University of Roma "La Sapienza" from 1975 to 1986. From 1986 to 2017 he was Full Professor at the Department of Civil, Environmental Engineering at the University of Trento (Italy). From 2017 he is teaching "Wooden Architecture" at the Department of Civil, Environmental Engineering at the University of Trento (Italy). He was chief of the Laboratory of Building Design (LBD) from 1986 to 2017 and chief of the University Centre for Smart Buildings (CUNEDI) from 2004 to 2017 of the University of Trento.

He is member of Zero Erergy Mass Custom Home (ZEMCH), member of the International Association for Housing Science (IAHS), member of the International Council for Monument and Sites (ICOMOS).

The current researches are focused on the buildings for the emergency; on studies in the field of the sustainable building; on the enhancement of the living quality for the senior citizen and people with impairments; on the innovative technologies for the construction of low energy consumption buildings with renewable and natural materials; on conservation and reclamation of wooden buildings.

Main research topics: Emergency Buildings, Design for All, Sustainable Architecture, Passive Building Design, Wooden Buildings, Conservation and Reclamation of Wooden Buildings.
He is author of more than 240 publications as monographies, papers on national and international journals, papers on conference proceedings.

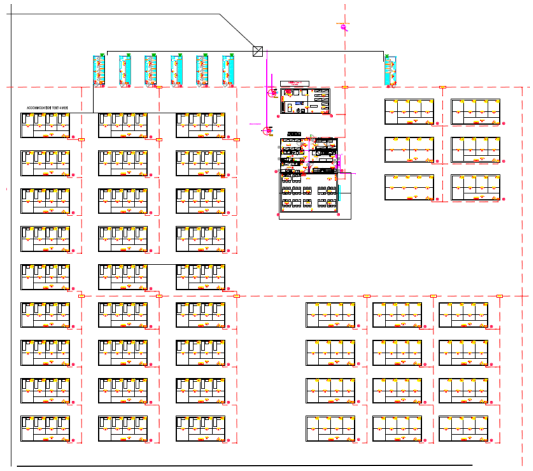
Emergency Architecture in Urban Renovation

One of the first needs of survivors to natural and man-made disasters is a new housing. Refugees and migrants from rural to urban area need construction of new housing too. In these last years, we had several natural disasters like drought, earthquake, flood, storm, as well as wars and humanrelated environmental disasters. According to World Humanitarian Data Trends 2018 by OCHA-UN, these disasters affected more than 95,5 million people in 2017 and forced 18,7 million people to evacuate. From World Humanitarian Data Trends 2018 by OCHA-UN emerges that there was a migration of 68,5 million people. Refugees and urban migration are creating an emergency situation in housing. At the same time, the renovation of districts in our cities often forces us to rethink the urban structure. Integration of new buildings with pre-existents is a problem related to urban renovation during the design phase, because the choices will have a big impact on the future life of the urban space. During the realization of newly designed buildings and new street services, there will be a temporary impact that often affects life for several months or years. In particular, building sites often generate traffic-jam and general changes in daily habits of district inhabitants.

It is very important to reduce building time. A solution proposed from the Laboratory of Building Design (LBD) of the University of Trento (UNITN), directed by Prof. Antonio Frattari is to think at constructive techniques of the "Architecture for the Emergency (A4E)" and develop similar building systems to speed up the time of construction. Researches and projects were carried out at LBD together with national and international research groups financed by Italian and European private and public institutions. Some students took part in different research groups during the years, developing their master thesis focused on specific case study related to general research activities.

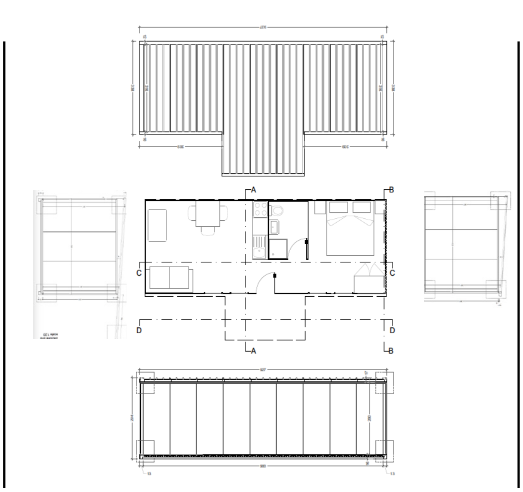
Three categories of buildings can be defined A4E and they are emergency shelters, temporary shelters, and temporary houses. The characteristics of the emergency shelter are very simple. It is easy to erect, low cost and very flexible. However, there is no comfort inside, it is not environmentally sustainable and the use is limited to a few days. Just the time to arrange a camp with temporary shelters. Example of emergency shelters are the tents. We designed a tent camp for 100 people for the UN in a war zone. That was very easy to build, it was built in three days.

Tents after the earthquake in 2017in Italy

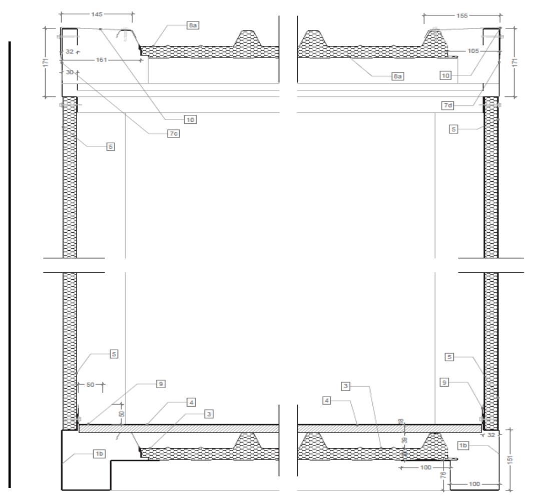


Camp of tents for 100 people

Temporary shelters are a better answer than tents, for what concerns the inner comfort. They need more time for building site setting, especially because of services. The assembly time of a single temporary shelter is longer than a tent, around 6–12 hours. Usually, the constructive solutions are very different, because want to ensure an acceptable comfort level depending on the location. As an example: in central Europe we will have a shelter in sandwich panels with aluminium sheet and polyurethane to reach an acceptable U value, whereas in the Philippines's the wall will be in woven vegetable fibres to ensure natural ventilation. At the University of Trento, we developed the project of temporary shelter with loadbearing sandwich panels in polyurethane and aluminium. The basic version of the temporary shelter has only 18 types of constructive elements.



The layout of the temporary shelter

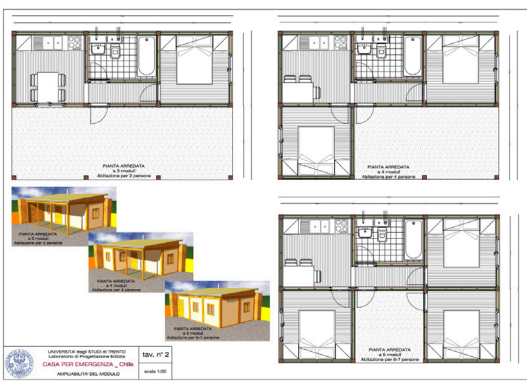


Details of the temporary shelter

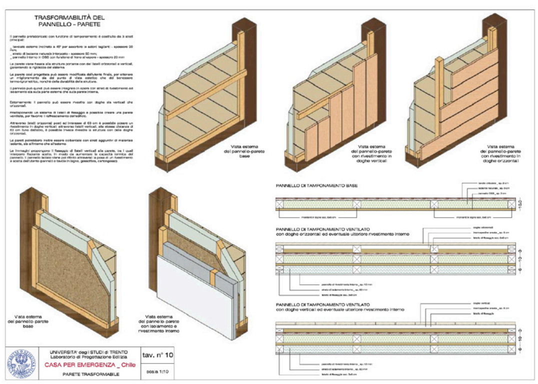
The weight of each element is less than 50 kg, so, it can be handled by hand. We designed the constructive details of the main nodal point. We proposed two typologies with different solutions for the bathroom. In both cases the shelter can be enlarged by 5 or 10 m2 in self-construction. The building system is so easy that one entire unit – with systems and bathroom inside – can be built in 6-7 hours by a team of 5 workers.

v A temporary housing unit needs more or less the same time for erection as a temporary shelter, around 6-12 hours. Usually, it is designed to be assembled and disassembled. It is designed to give a better answer in terms of inner comfort compared to a temporary shelter. After the earthquake
in Chile in 2010, we designed a temporary housing modular expandable unit. The basic unit consists of three modules 2.80x2.80 m2. Combining more basic structural modules (2,80x2,80 m2) it is possible to have three different typologies: for two people 24.00 m2, for four people 31.50 m2 and
for 6 people 39.00 m2.

The structure is based on wooden pillars and beams and the walls are framed wooden panels. Beams and pillars are joined by steel galvanized elements, nuts and bolts. To adapt to different climatic zone of Chile, two different stratifications were designed for the wall panel. The first solution is a panel, thickness 100 mm., with the following stratification from inside to outside: OSB (20 mm), insulation (60 mm), nailed boards (20 mm). The second solution of the wall is thermally reinforced with an insulated inner coating. The stratification from inside to outside is gypsum board(12 mm), insulation (60 mm), OSB (20 mm), insulation (60 mm), nailed boards (20 mm), ventilated interspace and external layer with nailed boards (20 mm).

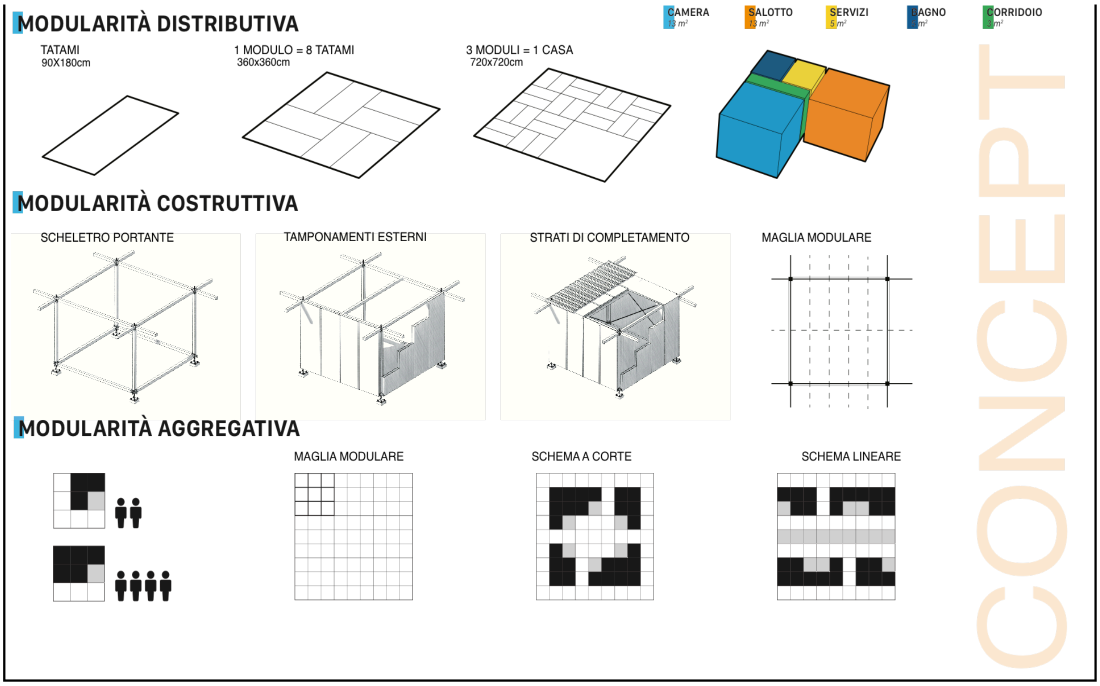


Typologies of the temporary shelter for the earthquake in Chile 2010.



Alternative for the external wall.

Following the idea of modular units with the wooden structure, we developed, with the students1 a flexible constructive system to build prefabricated housing for two and four people respectively 39,00 m2 for two people e 65 m2 for three/ four people. We referred to the modular dimension of the Tatami and we used it as a unit to generate the basic modules



Concept definition for temporary shelter.

We carried out a computer simulation for the analysis of thermal bridges. Fundamental to reduce energy consumption. We paid particular attention to use only nuts and bolts for assembling and disassembling elements.

At the University of Trento, we investigated the opportunity to build temporary housing with CLT panels. We decided to use CLT panels and X-rad connection system to speed up the construction of the module at the building site. The construction with CLT is perfect to resist static and dynamic external actions, this seismic resistance is also important in emergency situations.
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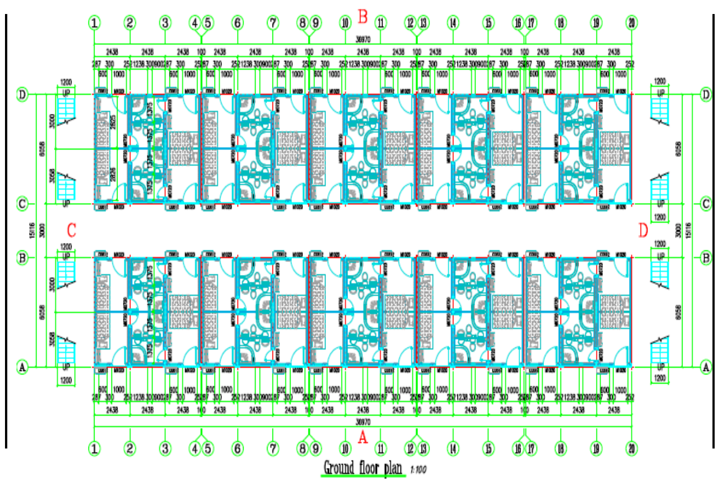
We developed, with the students a three-dimensional module using the same Xrad system. Our target was to reduce construction time, so that more marine-container-dimensioned modular elements can be assembled quickly to build a housing unit at the building site. Concerning sustainability, we paid particular attention to the possibility to manage the house offgrid.
For this reason, we dimensioned a PV system able to answer the need of a family. The housing is equipped by systems that reuse greywater and rainwater. The house is equipped also with autonomous systems to store freshwater, eliminate black water and produce small quantities of electricity. The house can be equipped with a heat pump for thermal comfort in winter and in summer. The reconverted containers are easy to adapt as temporary houses. After a reconversion in factory, containers are ready to reach the destination by train, truck or ship. The utilization is very quick, just the connection of the network because they can be ready inside with the furniture and the services.
Also, in this case we developed a project for 80 people on two floor for a UN camp.


The prototype.

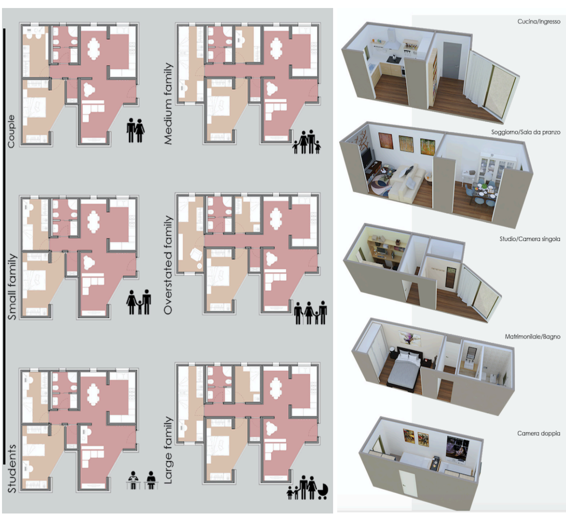


Ground floor of the assembled containers.

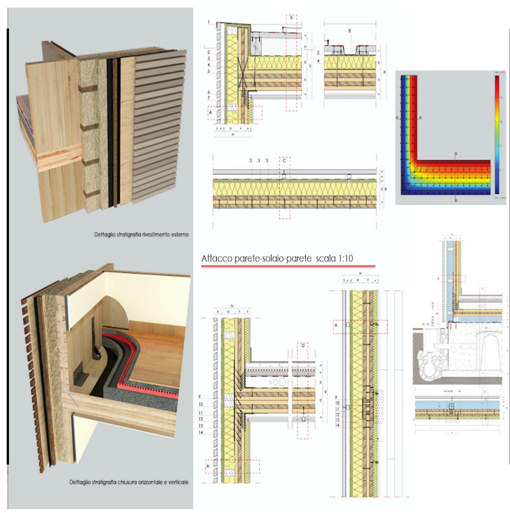
We applied all the constructive concepts developed for the Temporary Housing to the construction of the Permanent Housing, in order to reduce the time in the building site by transferring the majority of the construction activities in the factory including also the inner finishing, the furniture, the systems.
In both cases, there is a high level of prefabrication and an industrialized process drives the production of components. Based on previous experiences, we decided to explore the possibility to build permanent buildings with three-

dimensional elements. We thought that this was the best solution to minimize construction time at the building site, while still conserving the quality.

We started our design process from the max dimension of the three-dimensional element that can be transported by truck. It is 2.5 x 3 x 12 meters as a marine container of 40 feet. For the first project, developed with the students2 we kept the module dimensions to 2,50x 2,78x 9,00, because it was enough to solve the functional needs. The building is built assembling the three-dimensional elements. In the design phase we followed the principles of sustainability that we introduced in our previous project and that we always follow. In particular, we planned to use renewable or recyclable and recycled materials, and to use thermal insulation coherent with the climate local conditions.



Different typologies.



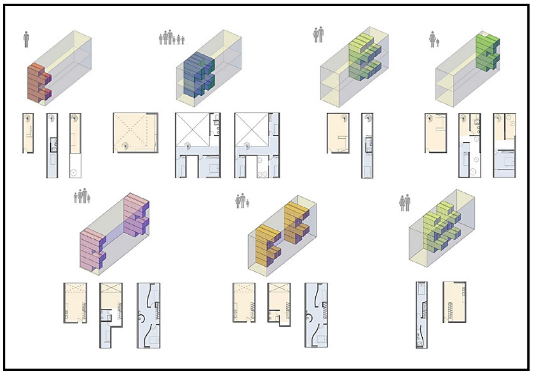
Constructive and thermal solutions.

To reduce energy consumption, we choose to give a strong bioclimatic characterization to the building and integrate it with energy systems that use alternative and clean sources. To improve the quality of energetic efficiency and reach the category of Zero Energy Building, we planned to install building automation systems in the building. Last but not least, we prefigurated an energy interchange between buildings and infrastructures in a smart district.

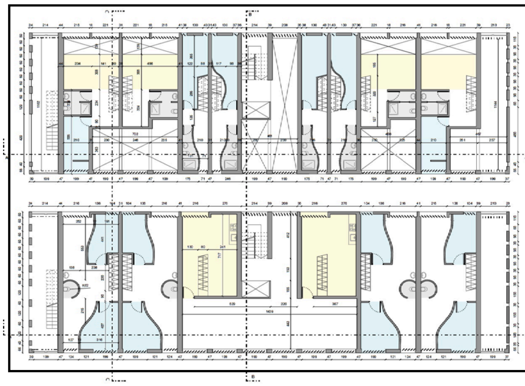
Using the same three-dimensional modules, we tried to develop building in wood 14 floor height developed as master thesis from Silvia Vaona. We are studying some structural elements and of course also the solution related to sustainability.

Another design experience, this time in Cuba island, started from our experience of architecture for the emergency. In this project developed as master thesis from Susanna Horta, we thought to use recycled marine containers 40 feet. Because the use of marine container allows a short construction time, it is affordable. It is possible to give the container a good design quality and also environmental quality because it is recyclable. We studied the details of the container to find a way to modify them, because a marine container 40 feet has strong points. It is transportable, resistant, economical, easy to find, versatile but it has several weaknesses: dimension, thermal insulation, fire-resistance, acoustic insulation. We had to analyze these last weaknesses and design the right solution to allow the new functions. We started the project evaluating how many units were possible to put together and how to connect them and how arrange the inner space organization.

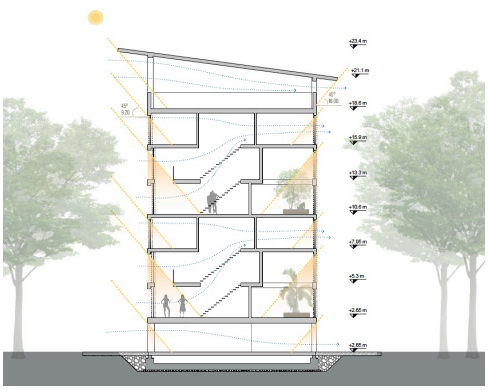
The solution was to articulate the housing units on two floors and interconnect them through horizontal corridors sometimes at double height. Then we studied the single housing units for a different number of occupants. We defined 7 housing typologies. Cuba has very hot and humid climatic conditions. For this reason, we paid particular attention to the bioclimatic condition to exploit the energy coming from the sun and the natural ventilation. We evaluated the sun path and the dominating direction of the fresh winds to orient the building in the best way. The inner organization of the housing units is complementary to the building orientation and allows to exploit in the best way the solar energy. We introduced a "filter zone" at the ground and attic floor to protect the building from the sun and refresh the board of the building with ventilation in summer. We applied similar solutions on the lateral. The natural ventilation in the housing is guaranteed by the double facing and from the particular shape of the indoor partitions. The ground floor and part of the housing on the first floor are totally empty to ensure the natural ventilation. The same for the floor under roof and on the last row of containers to the right and left of the building. Then we studied the details for the structural connection of the containers and for constructive solutions to solve acoustic and thermal weaknesses.



The typologies.



Second and third floor



The cross section.

General view of the building.