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Questions: How to overcome the "White-Savior Industrial Complex" and invert the expertise model that has guided both architectural education and practice? (Fisher). **Projects:** a park in Mexico City (Bilbao), a low-cost housing prototype in Vietnam (Trong Nghia) and a prefab system for emergency struck areas in Italy (Bennicelli Pasqualis). **Pedagogies:** experimentations of social-impact driven US university projects, for new educational methodologies and hybrid models of practice, in Kansas (Criss & Kleinmann), Pennsylvania (Harrison; Michael & Nicholas), Texas (Ali), and South Carolina (Hambright-Belue & Holland). **Contexts and Strategies:** understanding the complexities of social-impact design both under specific socio-economic and political conditions (Brazil: Chagas; South Africa: Bodino) and within the larger framework of a cultural discourse and critique (Melcher).

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THE PLAN Journal (TPJ) intends to disseminate and promote innovative, thought-provoking and relevant research, studies and criticism in architecture and urbanism.

The criteria for selecting contributions will be innovation, clarity of purpose and method, and potential transformational impact on disciplinary fields or the broader socio-cultural context.

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Maurizio Sabini - Editor-in-Chief

THE PLAN JOURNAL
Cube srl
Via del Pratello, 8
40122 Bologna - Italy
Tel.+39. 051.227634
Fax +39. 051.220099
tpj@theplanjournal.com
www.theplanjournal.com

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Temporary Houses for Post-disaster and Social Emergency

Mariagiulia Bennicelli Pasqualis

ABSTRACT - *The research focuses on the theme of the resolution of the problem of the emergency housing in urban and metropolitan areas, and in terms of how to house about ten thousand of people in short times, with comfortable and low cost dwellings, subsequently to a catastrophic event or a social emergency.*
The aim of the research is defining a model of open residential building system, based on the high density and reversibility strategies.
On one hand the research analyses the actions undertaken during the earthquake occurred in L'Aquila on April 2009, focusing on the "mistakes" which were clear since the beginning but only today clear to everyone, and the "merits" of what is an extraordinary operation, never seen before, of building in few months a very large number of dwellings, through a wide repertoire of procedures and technologies.
On the other hand the research analyses the need of creating new temporary dwellings to allow heavy interventions of urban development.
The combinations of these two realities, post-catastrophe and social emergency housing, will create, in time of peace, a supply chain for temporary, reversible and low cost dwellings.

Keywords: temporary houses, post-disaster emergency, social emergency, high density housing, S.A.T.O.R. Project.

The research entitled "Temporary high density dwellings for post-disaster and social emergency" focuses on the resolution of the problem of the

housing emergency in urban and metropolitan centers, and tries to answer the question: “how to temporarily accommodate about ten thousands of people in short times, in a comfortable way and with low-cost building systems, subsequently to a catastrophic or social nature event.”
In fact, in case of natural-disaster events, people must cope with the loss of their houses and belongings, on the one hand, and the dislocation for an undetermined period of time in provisional dwellings, often uncomfortable (such as container units) and/or far from their territories, causing the abandonment of the struck urban centers, thus each own history and memories.
Furthermore, when provisional dwellings are designed as permanent, no specific uses are usually defined for the future; when conceived as temporary, usually is not foreseen any clear specification about their dismantlement. In the latter case, indeed, it is not rare to find cases where these structures – after the emergency purposes use – are still occupied or reused for tourism, even though they don’t fulfil the minimum residential standard, with high costs in terms of environmental sustainability and a waste of money, essentially due to the continuous adaptations. As a key example, in Birmingham, UK, there is a complex of lodgings realised in 1946 after World War II to solve the lack of houses; the government provided the population with 156,600 provisional residential units, designed and produced on the basis of the American prefabricated housing modules (UN-HABITAT/IFRC, 2009). These lodgings were designed to last 10 years, but they are still there and still occupied, after 70 years.

Then, the general objective of the research is to define temporary housing systems to answer to high-density housing emergency, which are able to keep the population in its own territories next to its own houses, where temporariness means the duration of average 3-5 years, as indicated by the estimation of the Civil Protection for the time of reconstruction.
In particular, the research proposes the development of an advanced model of residential, temporary and reversible, low cost, with a “zero impact” on the territory. Such system should be able to welcome thousands of evacuated people, adaptable to different technologies selected on the basis of a dry-assembly repertoire. Finally, the study is aimed to define an open system to continually update and, above all, available to a market as widest as possible.
The starting point of the study is the earthquake which hit L’Aquila on April 6, 2009. The research started analysing the actions undertaken, focusing on the “mistakes” which were clear since the beginning (but clear to everyone as at today), and the “merits” of what it is an extraordinary operation, never seen before, of building a very large number of dwellings in few months through a wide repertoire of procedures and technologies.
Firstly, the main error made was the realisation of permanent and

traditional residential buildings in available areas around L'Aquila urban centre, creating criticalities in terms of traffic congestion, rupture of the social tissue due to the dislocation of the population, difficulties for the local enterprises and economic conditions linked to the real estate market sector. Secondly, the costs of interventions were consequently high, due to the durability of the buildings and the creation of the concrete anti-seismic platforms with consequences for the financing of the reconstruction. Last but not least, the high risk of definitive depopulation of the historical centre of L'Aquila, as the new towns make really hard the return of the inhabitants (mainly students, strangers and young couple) to the former houses.

Therefore, the specific objective of the research is the development of an open residential building system – from the design concept up to a virtual prototype – based on the high-density and reversibility strategy able to offer opportunities for development not only within the emergency post-catastrophe scope, but also within the social housing emergency one, in particular for the production of temporary, reversible, low-cost and comfortable dwellings to house the end-users of the public residential building stock to undergo retrofit operations, which represent one of the main current strategies of urban development.

At the same time, the above-mentioned open system should be adaptable to the requirements of a permanent residence as a strategy for new construction housing interventions characterised by a high degree of reversibility and then durability (Fig.1).

Starting from these two realities – the housing emergency following catastrophes and/or social issues – the design and management strategies are defined to create, in time of "peace", a productive supply-chain aimed to realize a product more and more suitable for the necessities of a temporary and reversible residence and, in this way, checked, which means to limit not as much the mistakes – often unavoidable due to the urgency of interventions – but rather the permanent effects of mistakes on the territory.

In this sense, it is necessary to generate a double innovation for both the procedures and the architectural product basing on the criticalities of the current strategies. This means also to set the basis for a wider and more general consideration, according with the actions to undertake for defining an innovative product and to provide a new regulation (currently missing) related to the temporary housing interventions.

Such necessity can be clarified, for instance, taking the "low-cost" objective, one of the most strategic for the operation sustainability. This is due to the fact that, as mentioned before, high costs create difficulties both during the realisation and decommissioning phase of the building systems. How to create low-cost and comfortable dwellings? Low-cost can be determined through qualitative and quantitative choices, where "qualitative" means the selection of materials and finishes characterised by a smaller durability due to the temporariness of interventions, whilst "quantitative" the rationalisation of the dwelling space in typological and dimensional terms.

Furthermore, the fact that the emergency housing end-users have neither furniture nor wardrobe, allows the contraction of the individual space through the integration of the furniture by the means of a careful meta-design study aimed to guarantee a suitable level of comfort.
Nevertheless, this entails a rationalisation of spaces, which is practicable through the revision of the building standards (in Italy expressed by the DM 1975). This is possible only through the introduction of the already mentioned national discipline for the realisation of temporary residential building systems for emergency scopes. In fact, it is necessary to foreseen simplified procedures to speed up the process and contain costs.
The necessity to operate in the emergency field implicates, in fact, the definition of parameters, which – despite they are present within the ordinary planning – here acquire a strategic importance to answer with urgent actions but at the same time to preserve the territory. Therefore, such parameters require a complex answer dealing with manifold aspects of the design process and a careful procedural planning, besides a careful definition of the architectural product.
From the product realisation process point of view, the idea is to individuate the most efficient answers within the industrialised processes and creating the basis for a direct relationship with the enterprises of the construction sector. In fact, one of the aspects, which characterises more the answer to the housing emergency post-catastrophe, is the contemporariness of multiple interventions. This issue can be tackled only predisposing the widest participation of the building sector enterprises, in order to absorb the necessary production avoiding sudden halt during the building process.

INNOVATION OF THE ARCHITECTURAL PRODUCT AND THE BUILDING PROCESS

Starting from these considerations, the research is aimed to set a verified method constituted by a system of procedures and an architectural product, addressed both to the Civil Protection and the Local Public Administrations – as the bodies primarily involved in the management of emergencies on their territories – as well as to the building sector enterprises – as stakeholders of the development of new productive supply-chain.
From the product perspective, the introduced innovations concern the definition of an advanced model for the realisation of a temporary and reversible residential building system for the housing emergency, which is also able to welcome the know-how of the enterprises of the building sector.
At the same time, it is necessary to proceed to the revision of the whole building process procedures, starting from the identification of the emergency building areas, the definition of procurement procedures for the urbanisation operations, and finally the definition of the design-build

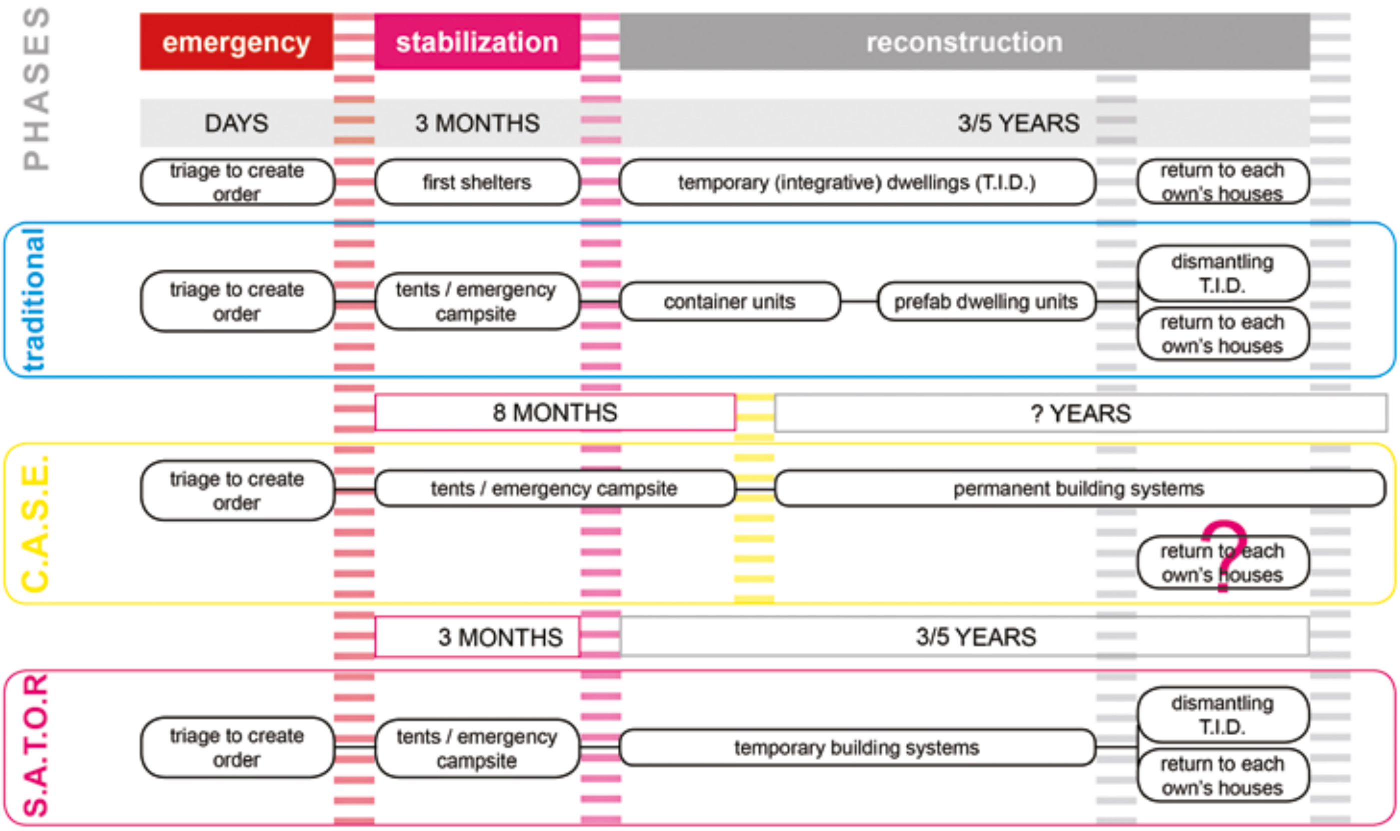


Figure 1. The emergency process: comparison between the different processes defined by the Civil Protection, the Progetto C.A.S.E. and the S.A.T.O.R. Project.

procurement models for the realisation and the following decommissioning of the temporary dwellings.
Instead, it is also necessary to define an intervention referring the still missing building standards for temporary building to discipline the temporary occupation of private areas. In fact, this step could be relevant in order to allow an easier occupation of areas, as in the case of emergencies the occupation of private areas is usually an option, and temporariness would avoid dispossessions.

Furthermore, the analysis of the best practices highlights the need for the institution of a technical structure inside the Civil Protection and linked to the local bodies arranged for the management of the emergency as well as research institutes. This technical structure is aimed to supervise the whole management of the emergency process in times of “peace” – before the event occurs. This assumption means that such systems are not designed for a specific social and geographical context, and therefore it is needed to define building systems able to “accept” the different solutions available on the building market sector and, meantime, “adaptable” to the specific conditions of the emergency context. Thus, a global project as a result, but to adapt according to the local characteristics of the site it must be realized into. The answer to such matters is identified in the project S.A.T.O.R.[1] a temporary organised and reversible housing system, which takes the name from the famous palindrome [2] as a symbol of total reversibility.

The Building Process Innovation

From the procedural perspective, as said, manifold aspects should be redefined.
Some of them are represented by the following issues:

- the emergency areas [3] localisation;
- the timing of the emergency process;
- the procurement procedures for the realisation of the interventions;
- the procurement procedures for the dismantling phase; and
- the definition of the technical specification of the global project as a tool to control the appointment of the building design and realisation during the procurement procedures.

Concerning the timing of the emergency process, the first assumption is to validate the strategy used for L'Aquila, which consists in skipping the container phase to provide the provisional dwellings immediately after the tents camps. Firstly, this allows to saving costs for both the emergency houses and the reconstruction, at the same time. Secondly, former experiences, i.e. the Umbria earthquake, which stroke in 1997, showed how containers were used as "the" provisional dwelling and some of them still last nowadays in those territories.

The innovation introduced in this aspect is, then, to keep this step within a reasonable time, as the Civil Protection guidelines specify that the maximum time to spend in tents should not overpass three months. And this is even more critical depending on the season the events occur: L'Aquila earthquake hit the city in April, during springtime, and this crucially affects the decision process put in place afterwards. In facts, in L'Aquila case, the evacuated population lived in tents for 8 months, during the realisation of the first new housing complexes.
Therefore, how to shorten this time to the suitable one of three months? How to assure a correct evaluation of the design characteristics, of the site areas arrangement? How to correctly and efficiently accomplish the procurement procedures and the building processes in line with this goal? These questions are fundamental, and the answer substantially depends on one main deed to move some of the emergency actions before the disaster events occur, which is subsequent to the definition of the technical structure. Such structure will act as a research body in charge of the global design process of the emergency temporary dwellings, on the one hand, and as a sort of general contractor during the building process, on the other, in order to assure the development of the entire process.

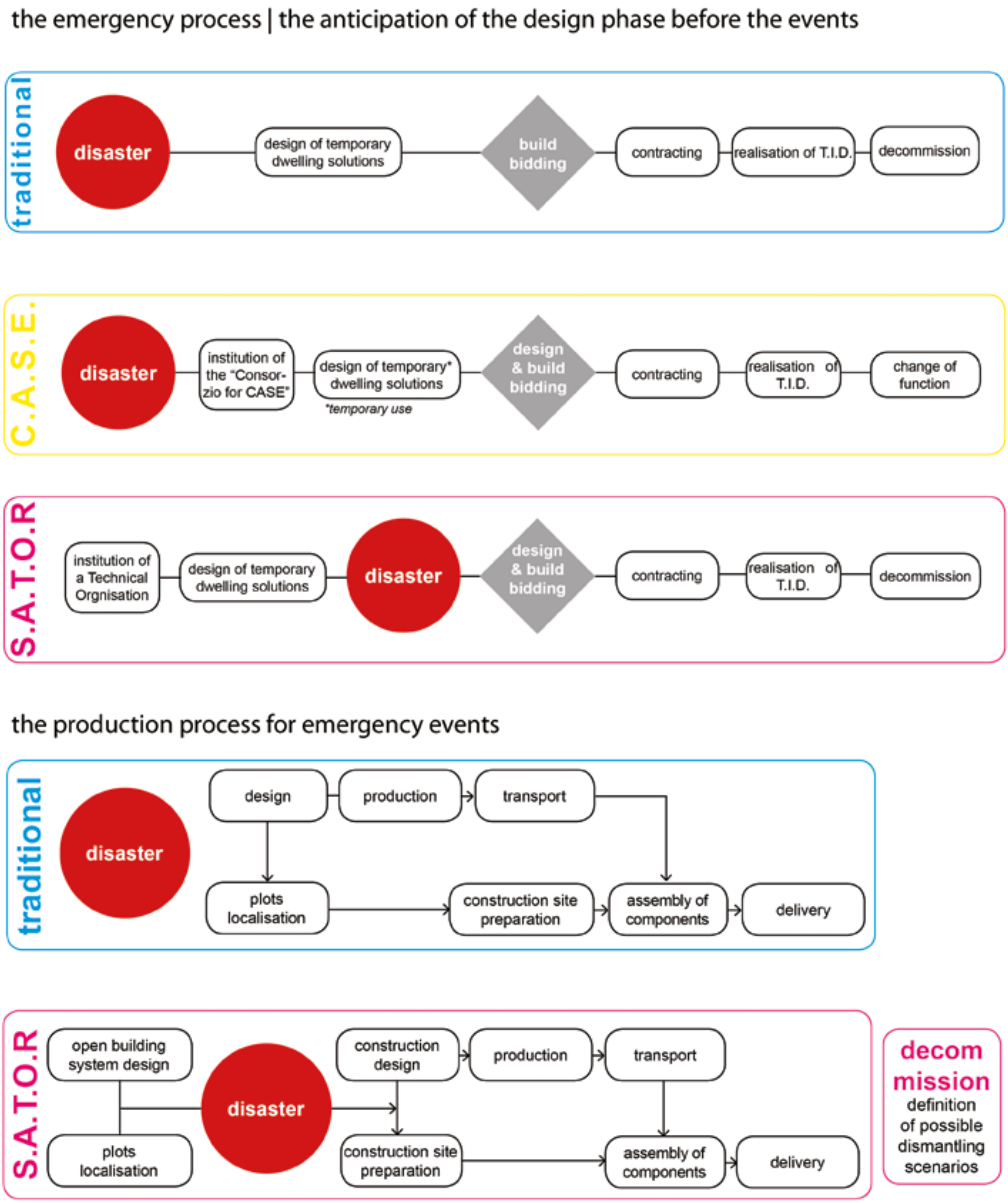


Figure 2. The emergency process: the anticipation of the design process due to the introduction of the Technical Organisation and the effect on the production process of the temporary dwelling solutions. The temporariness quality of the system allows the precise definition of dismantling scenarios.

Through this, it is possible to define the following actions prior the event:

- the design and update of the provisional dwellings and their possible aggregations;
- the emergency areas localisation;

which will allow to immediately start the procurement procedure, on the management side, and the site arrangement and the construction design of the buildings on the production side (Figs. 1, 2).

Regarding the procedural actions, the strategy is to split the procedures into three main categories:

- site areas arrangement and urbanisation;
- foundation systems;
- construction design and realisation of the building systems.

The former two categories will be carried out through the MEAT – Most Economically Advantageous Tender criterion basing on a concept design. The latter, instead, is expected to be fulfilled through the Design-and-Build procedure based on a developed design and with a highly performance-based procurement model. As well as for the former categories, the assignment criterion will be the MEAT one.
The tool, which will assure the respect of the performance indicators, is the Technical Specification document. The Technical Structure would elaborate this document and it illustrates:

1. the specifications related to the Space Units, thus the minimum dimension and the specific performances for the definition of the internal spaces of the dwellings;
2. the description and specifications related to the technical components of the buildings, i.e. horizontal and vertical/internal and external components; doors; windows; etc.
3. the specifications of the tender procedure, thus the definition of the documents participants should submit, and
4. the judging criteria to which the offers would undergo.

The judging criteria are defined to guarantee, among others, the temporariness and the reversibility of the building systems, as those indicators can limit the negative effects of the interventions on the territory and on the reconstruction of the former urban centres.

The Housing System Design

As stated before, the so-called project S.A.T.O.R. represents a high-density, multi-storey and anti-seismic building system, characterised by the contraction of the individual living space and by the rationalisation of the

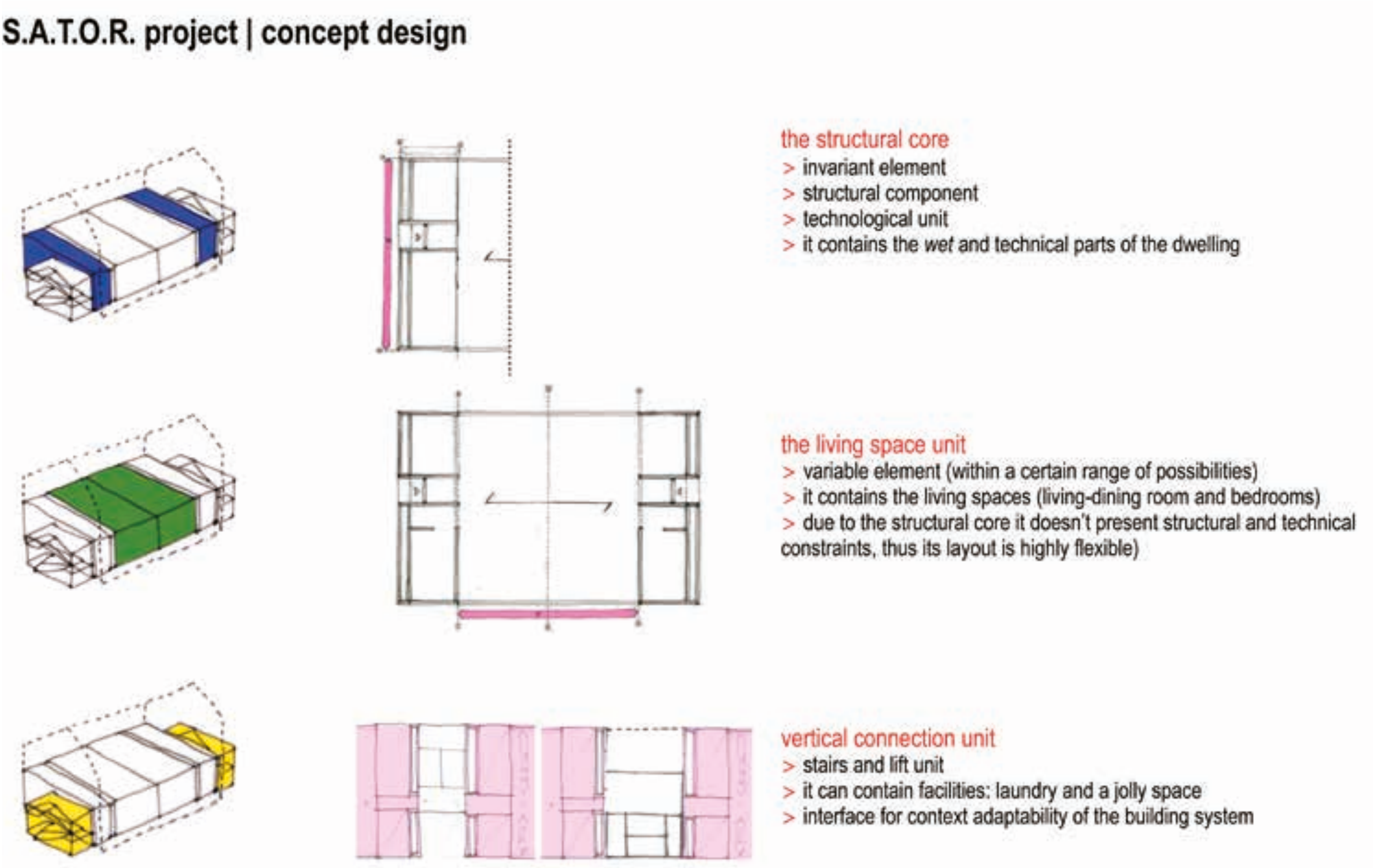


Figure 3. The concept design of the elementary unit of S.A.T.O.R. Project.

fundamental components (i.e. services, supply networks). Such aspects are implicit in the general concept of the high-density residential strategy. Thus, it is possible to state that the high-density strategy is "the" answer in case of middle-great urban centers, to avoid both an excessive dispersion of the emergency districts on the territory, and to reconstitute – also during the emergency – a social tissue. The reasons to adopt this strategy lie on the willing to avoid an increase of the urban functional criticalities (Properzi 2009) and, on the social perspective, the isolation, abandonment and impotence of the residents (Alexander 2011) a low-density approach could procure.

The high-density strategy entails, however, an increase of the complexity of the building site operations, especially in the case of reversible residential systems. Studies and researches conducted on the theme of the post-catastrophe housing emergency usually concern the emergency process management and are based mainly on the low-density strategy and approaches linked to the "container" unit – in typological and technological terms – or in general on the object-ready-to-use. Indeed, this strategy has already shown wide limits of production and quality, introducing several issues inherent to the environmental and functional comfort, on the one side, and to the storage when not in use, on the other.

In fact, looking at the best practices in terms of housing emergency, the "container" strategy is the most frequently adopted. This is evident looking at the manifold examples related to post-catastrophe shelters and student housing buildings. But, as said above, this strategy entails the use of pre-assembled dwelling units – i.e. the container units –, which generally imply (a) technological and (b) typological limits.
On the technological side (a), it double the structure and/or insulation of the "containers"/dwelling units, increasing the use of resources; on the typological (b) one, it entails more than usual to align the dwelling units alongside a shared balcony. If the former one imply the increase of costs, the latter one results in a lack of comfort.
Some examples of this strategy are the student housing systems realised in north Europe and here following indicated:

- the student housing in Amsterdam, realised by Tempohousing;
- the student housing in Le Havre, realised by Studio Cattani Architects, and
- the housing systems for the post-earthquake emergency in Japan realised by Shigeru Ban.

The last one displays a smart way to avoid the doubling of the insulation components, but not that of the structural components, nor the "balcony"-aggregation.
Then, the question is: how to ease the building operations, both for the assembly and dismantling ones, avoiding the "container" or the "cottage" model?
The answer proposed through the S.A.T.O.R. project is an open building system, which is composed of invariant elements (a) and by a complex of variables elements (b).
The (a) invariant elements constituent the "hardware" of the system itself – the technical, structural and technological core; the (b) variables ones, instead, constitute the adaptability of the system to the specific climate, geographical and social contexts.
Such structure realise an "open" system, as it allows changes within a defined range of possibility according to different dwelling sizes; aggregations (e.g. line or gallery); and geometrical characteristics of the site (i.e. altimetry characteristics).

The Typological Design: the Elementary Module

One of the main purposes of the present study is the definition of the "elementary module" conceived basing on the four following elements:

1 - The structural "core"
2 - The living space unit
3 - The vertical connection unit
4 - The envelope system.

These four elements (Fig. 4) constitute the building system and confer the system both the “adaptability” to the specific context of the emergency, and the “functional” and “architectural variability,” as the morphological quality of the emergency compounds is a highly important aspect to tend to, even for emergency temporary buildings.
The structural core (1) is namely the invariant element of the building system, which contains the dwelling services (the entrance and the “wet parts” of the housing unit – i.e. the bathroom and the kitchen). Thus, this element is both the technical and the structural component of the housing unit. Two cores placed at a distance of 7.20m-9.00m one to the other realise the building span. The span between the technical cores identifies the living space units (2), namely the dining and living room and the bedrooms. The living space unit is dimensioned to host two minimum dwelling units, made up of one bedroom, one living and dining room, the kitchen and one bathroom. The range of the dwelling size variation above indicated is 1.80m wide. This distance is the one the building system can admit and it is set in order to implement the dwelling of one more bedroom (Fig. 4).
The second level of dwelling extension is represented by the façade, namely the space between the external wall of the building and the envelope system. This extension-area admits to expand the dwelling both punctually and linearly, through the enlargement respectively of the single space units, on the one side, and the occupation of the all-area to implement the living room, on the other. The punctual extension allows the implementation of the double bedroom with a baby-room space unit and the living room with a small study space unit.

The concept is conceived in order to concentrate the structural and plants constraints in the structural core, thus conferring the maximum variability of the living space units’ internal layout.
All the space units, both those contained in the structural core and the living space ones, have been re-dimensioned through an attentive meta-design study – based on the activities to carry out in them and the minimum equipment of those spaces – in order to rationalize the internal space to preserve the territory and save costs for the reconstruction of the urban centers (Fig. 5, 6, 7).
The vertical connection unit (3) is that part of the building which permits the vertical aggregation of the system and the adaptability to the geometrical characteristics of the site, as it can “assimilate” the horizontal (geometry) and vertical (altimetry) variations of the area. This is possible modifying the shape and the position of this unit in relation to the elementary module. Thanks to this quality of the vertical connection unit, it is possible to achieve variations in the plan geometry of the building system, defining linear or curve simple multi-storey building or more complex aggregations like courtyard buildings; balcony-served buildings and others.

Finally, the envelope system (4.) is the outer part of the building, which confers the adaptability to the climatic conditions of the context and the

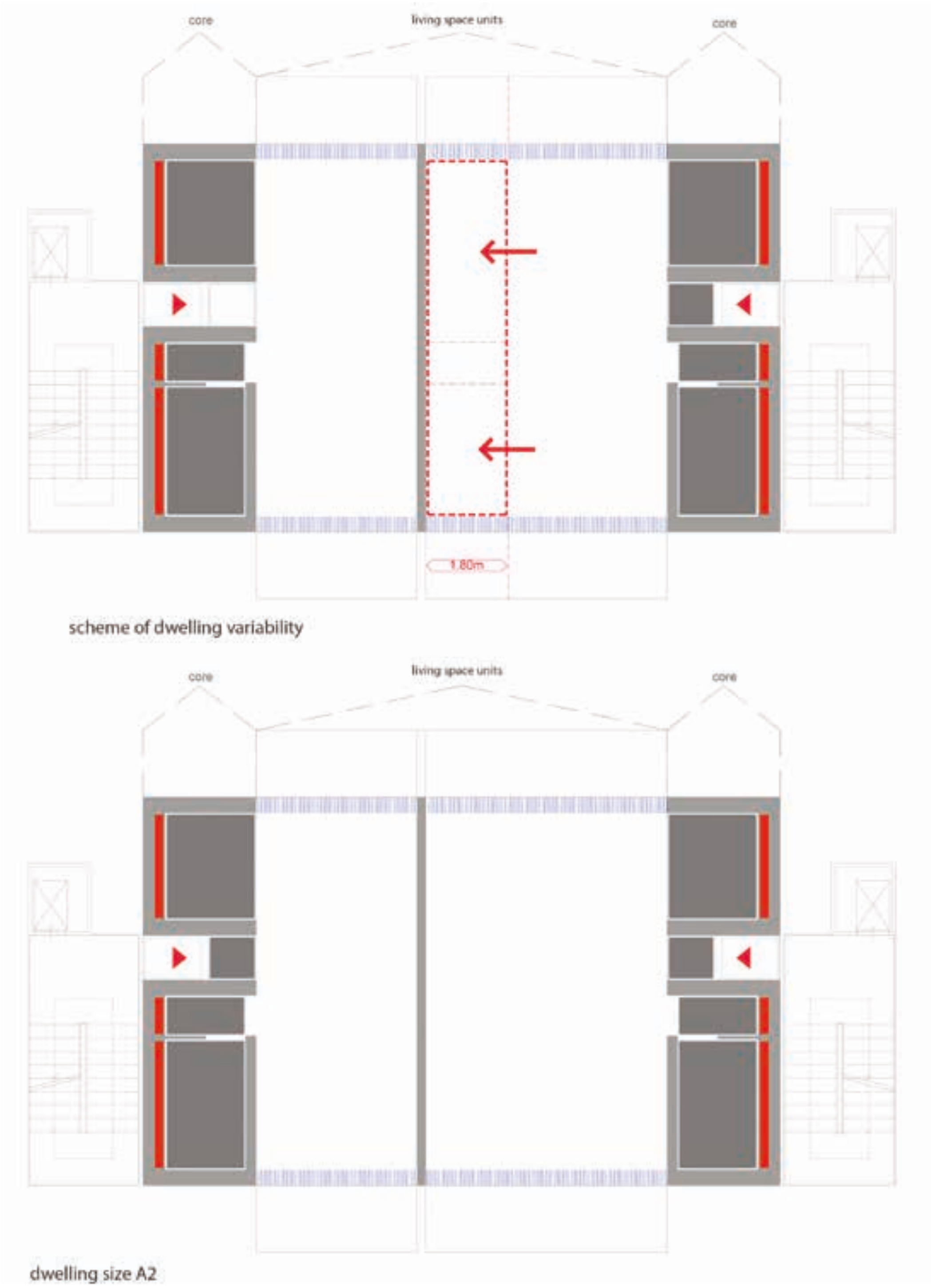


Figure 4a. Scheme of the dwellings variability: the scheme of the dwelling plan extension and the different dwelling size.

building morphological feature, thus the variability and the identity of the emergency quarters, at the same time. In facts, it is conceived as a juxtaposed system to be moved according to different configurations with respect to the building body. The envelope system realises – according to the different requirements – the facade of the building or an inside /

Figure 4b. Scheme of the dwellings variability: the scheme of the dwelling plan extension and the different dwelling size.

external habitable space, both as a place of addition of space units to create the different dwelling size and to guarantee the morphological variability of the system. Such aspect is necessary to avoid the realisation of a multiplicity of districts all equal ones, with the result of a substantial alienation of people who lives in them. The variability is a quality of the building system aimed to create an architectural landscape also in temporary emergency districts (Fig. 8).

The criteria the present study is based on are mainly the following:

1. The comfort of the residential units
2. The temporariness of the building systems
3. The low-cost

The (1) comfort of the residential units is one critical requirement, but firstly it is important to set which level of comfort we should intend. In fact, in the case of temporariness, the comfort assumes a different connotation in comparison with the permanent houses. This assumption is based on the fact that (a) reducing the comfort of the provisional dwellings allows saving money to reinvest into the reconstruction, and (b) it helps people to push for going back to their former houses. Reducing the comfort, thus, entails operating on the environmental requirements, which means the surfaces rationalisation and the selection of proper internal and external finishes. This is applicable only in case of – and thanks to – the temporariness of interventions. Furthermore, low cost is the requirement which makes the temporariness sustainable, thus possible.

The present study, then, operates the rationalisation of the dwelling surfaces through an attentive design process, applying the meta-design principles and through a “trial and error” approach (Bisig, Pfeifer, 2008). The concept design of the elementary module presents a “strip” dwelling organisation, where each strip is related to a specific function. The concept is formulated taking into consideration respectively: the single dwelling layout; the aggregation of dwellings, both horizontally and vertically, and the adaptability of the building systems to the specific context.
Regarding the internal layout, the design process starts with the assessment of each single space unit and the reconsideration of the activities each space unit is allocated to. As stated before, the design process should also consider the minimum furniture needed to equip each space with, considering that emergency end-users do not hold any belongings. Then, the furniture must be provided with the dwelling. This fact offers one more opportunity of reconsidering the internal layout and designing the container elements in order to ease the dwelling unit usability, on the one side, and to save space and then costs, on the other. At the same time, the space unit definition cannot leave the construction and transportation requirements out of consideration. Those requirements, however, should be combined with the ergonomic criteria, thus the usability of spaces.

For example, the design of the bathroom space unit should consider:
(a) the minimum width to comfortably use the bathroom fixtures; (b) the minimum length to put the bathroom fixture in line on the same wall, in order to rationalise the plant system and to correctly use them; (c) the

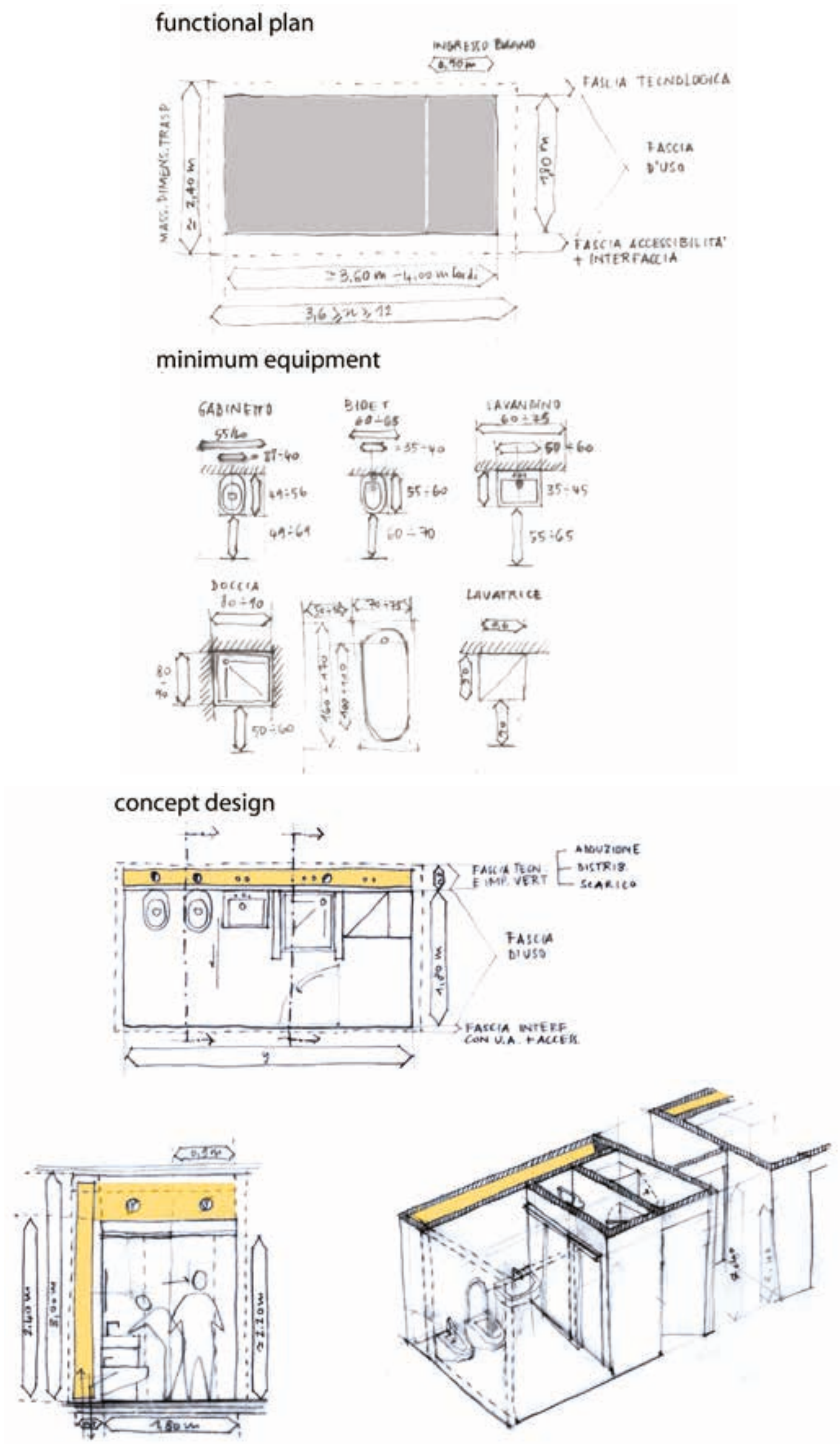


Figure 5. The study for the rationalisation of the dwelling space units: the sketch of the bathroom plan, section and minimum equipment.

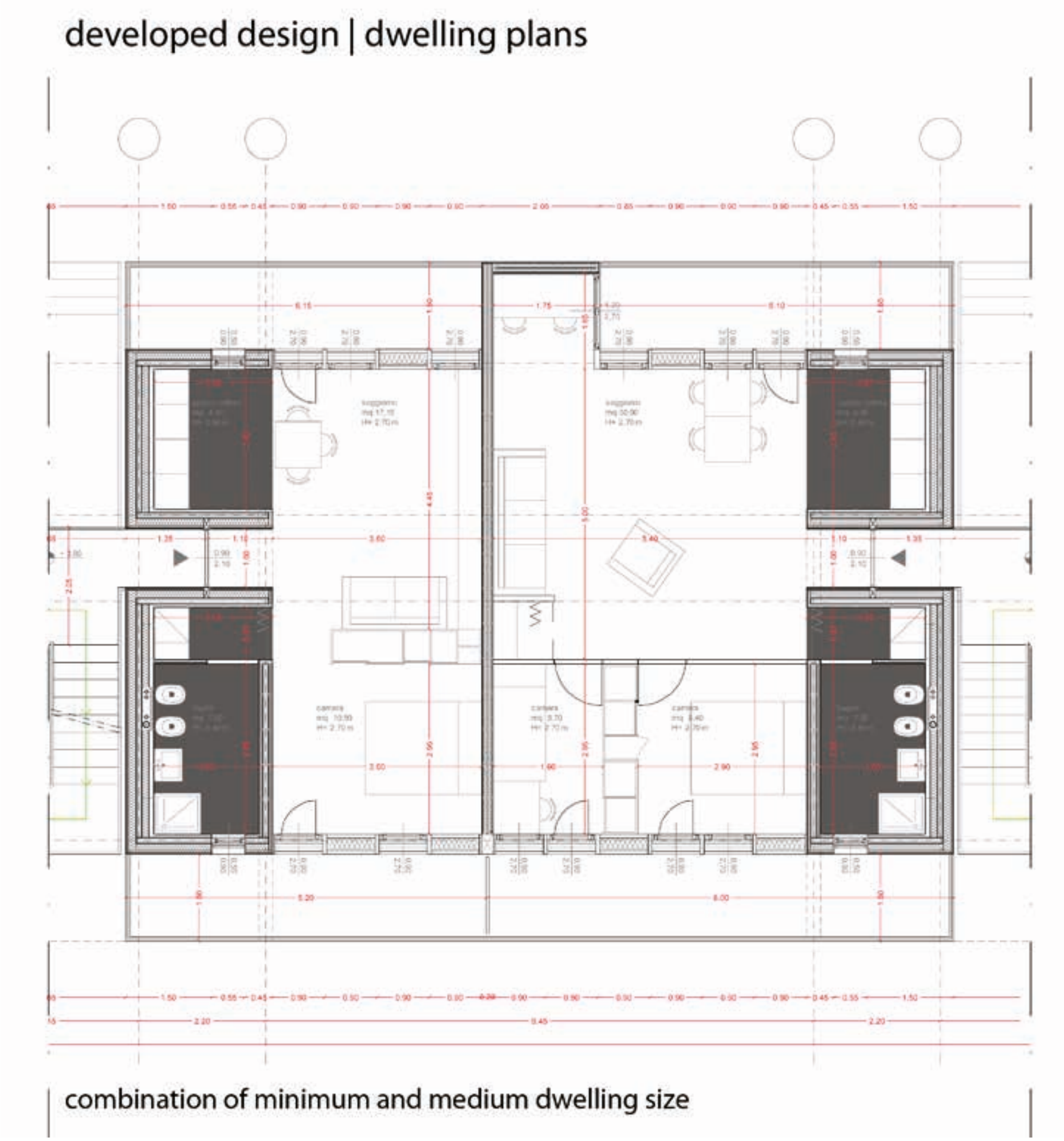
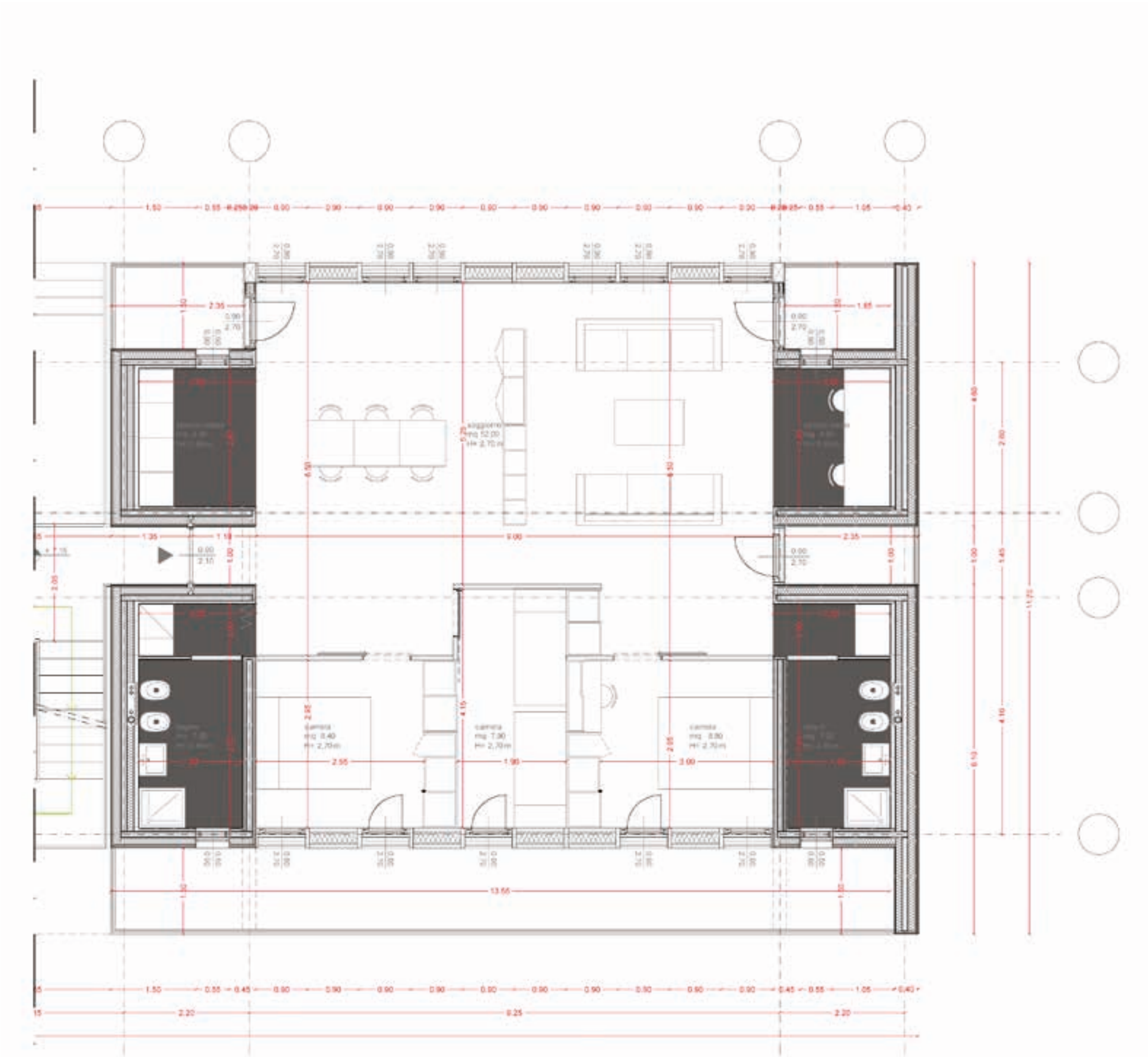


Figure 6a. The virtual prototype: the developed design of the dwelling plans illustrating a range of possible layout variations.

possibility to bring the bathroom unit as a 3D component on site, thus to keep the space unit into the regular transportation measures; (d) the need to combine the bathroom space unit with the kitchen one to keep



the maximum dwelling size

Figure 6b. The virtual prototype: the developed design of the dwelling plans illustrating a range of possible layout variations.

the technological complexity together and free the living space units from structural and technological constraints. All these aspects bring to the definition of a space unit characterised by a dimensional range of a

minimum of 1.8m large (internally), a maximum of 2.4m large (externally) and a maximum of 12m long. The unit space design should, then, comply with those dimensions to reach the requirements above set.
Furthermore, the width gap of 0.60m allows the positioning of the plant system and the definition of the construction model, thus the structural system of the emergency building system.

The same process is applied to all the space units composing the dwelling, taking into consideration the minimum and maximum building span, which should also allow the use of standard components for its realisation. Thus, the dimensional coordination of the elementary module considers the bedrooms minimum internal proportions and the living/dining space layout, on the one side, and the technological dimensional standards to allow the use of standard building components, on the other side.
The result is the possibility to place two minimum dwellings suitable for a couple or for a couple with a child, in the 7.20m building span. Indeed, the 9.00m long span can host a minimum and a medium dwelling, suitable for 3 or 4 people (a double bedroom with a single one) or the biggest dwelling size, suitable for 5/6 people distributed in 3 double bedrooms.
The project S.A.T.O.R. virtual prototype eventually realises the following different dwelling size:

- A1_40: 40sqm for two people (one master bedroom)
- A1_50: 50sqm for two people and a child (one master bedroom + the baby-room space unit)
- A2_56: 56sqm for three people (one master bedroom and a single one)
- A2_59: 59sqm for three people (one master bedroom and a single one + the study space unit)
- A2_64: 64sqm for four people (one master bedroom and a double one)
- A3_100: 100sqm for five people (one master room, a double bedroom and a single one)
- A3_117: 117sqm for six people (one master room and two double bedroom)

These result from the combination of the elementary module and the punctual and linear dwelling extension level.

The Construction and Plant System Design

The construction system is one crucial aspect to define high-density, temporary and reversible building systems.
Thus, the study analyses the different requirements needed to achieve all the above-mentioned building system features.
These requirements, which form the reference indicators for the building enterprises to explicit in the tender briefing, have been defined basing, on

Figure 7. Two internal views of the minimum dwelling size and its possible layout variation through the introduction of a partition furniture.

the one hand, on their “weight” on the environment, and on the other, to guarantee the real temporariness of the building systems.
Due to the temporariness quality of the building systems, the technological choices have fallen in the only field of dry-assembly construction systems,

which guarantee a rapid assembly and dismantling of the system and, through stratified constructive solutions, the reversibility of the system itself.

These indicators are here following synthesised:

- *Portability*, which means that the component should be shaped and assembled in order to be easily transported and moved on site.
- *Impact on the ground*, which depends on the foundation typology and on the foundation material impact.
- *Imprint on the ground,* meaning the tight relationship between the shape and the ground occupation of the building systems. This imprint can be, for example, compact, linear, crooked or fragmented.
- *Construction speed*, which indicates the quality of the building system to be assembled rapidly and with the smallest number of operations. This quality is conferred through a rationalisation and simplification of the building system during the design phase and it acquires a crucial role in emergency situations, being the strategy to both save costs and give a rapid answer to the housing need.
- *Flexibility*, which refers the availability of the building system to adapt itself to the needs of the end-users (once identified) and the context, and to offer a certain range of variability, thus to confer an architectural quality to the emergency districts.
- *Dismission*: this is a fundamental indicator, as it makes the temporariness and the reversibility of the building system real. These qualities, in fact, depend on the attitude to reverse the building operations and derive from an attentive design process and the use of proper technologies and construction systems. Furthermore, the building system should be layered, in order to separate materials basing on their recycling property.
- *Recycle/reuse* indicates that materials and components should be chosen basing on the life-cycle of the building system to realise and on guaranteeing the maximum *availability* to be recycled and/or reused.
- *Anti-seismic*: this indicator, above all in the case of a natural disaster situation, covers a key role, even for the psychological equilibrium of evacuated people. Due to the temporariness strategy, it is possible to expect the building systems to undergo to earthquakes of minor intensity in comparison with long-lasting structures. This doesn't mean to minimise the seismic aspect, but to intervene through specific strategies and technologies, both during the design and realisation process, to guarantee the appropriate resistance of structures in case of earthquake basing on their limited life-cycle.
- *Low-cost*, which indicates the quality of the system of guaranteeing the suitable safety and the maximum of the comfort with the minimum costs of the building systems. This parameter means

Figure 8. Possible external views of the S.A.T.O.R. Project, depending on the shell definition.

to operate: rationalising the dwelling surfaces; simplifying procedures; choosing materials and technologies available to the building market sector able to ease the realisation process. This requirement is critical as it makes the temporariness strategy possible, on the one side, and maximally employ resources into the reconstruction of the urban centres, on the other.

In synthesis, the building systems should be conceived basing on the available technologies and dry-assembly construction models, assuring their total reversibility, once the emergency will end. Finally, to ease the building process, above all during an emergency process, it is important to prefer industrialised processes, minimizing the site operations. This latter requirement is crucial due to the contemporariness of interventions in case of a post-disaster housing emergency.
Then, the S.A.T.O.R. project represents the possible answer to the above-mentioned issues, as it is conceived as an open-system to realise through dry-assembly construction models, among those currently available on the market and to update to the brand-new ones.
Among the construction aspects, the foundation system represents one of the most critical points, as usually, it is the element entailing the heavier impact on the ground, thus the footprint on the environment.

The most part of the samples often presents concrete foundations directly realised on-site. This kind of structures is normally intended to be reused after

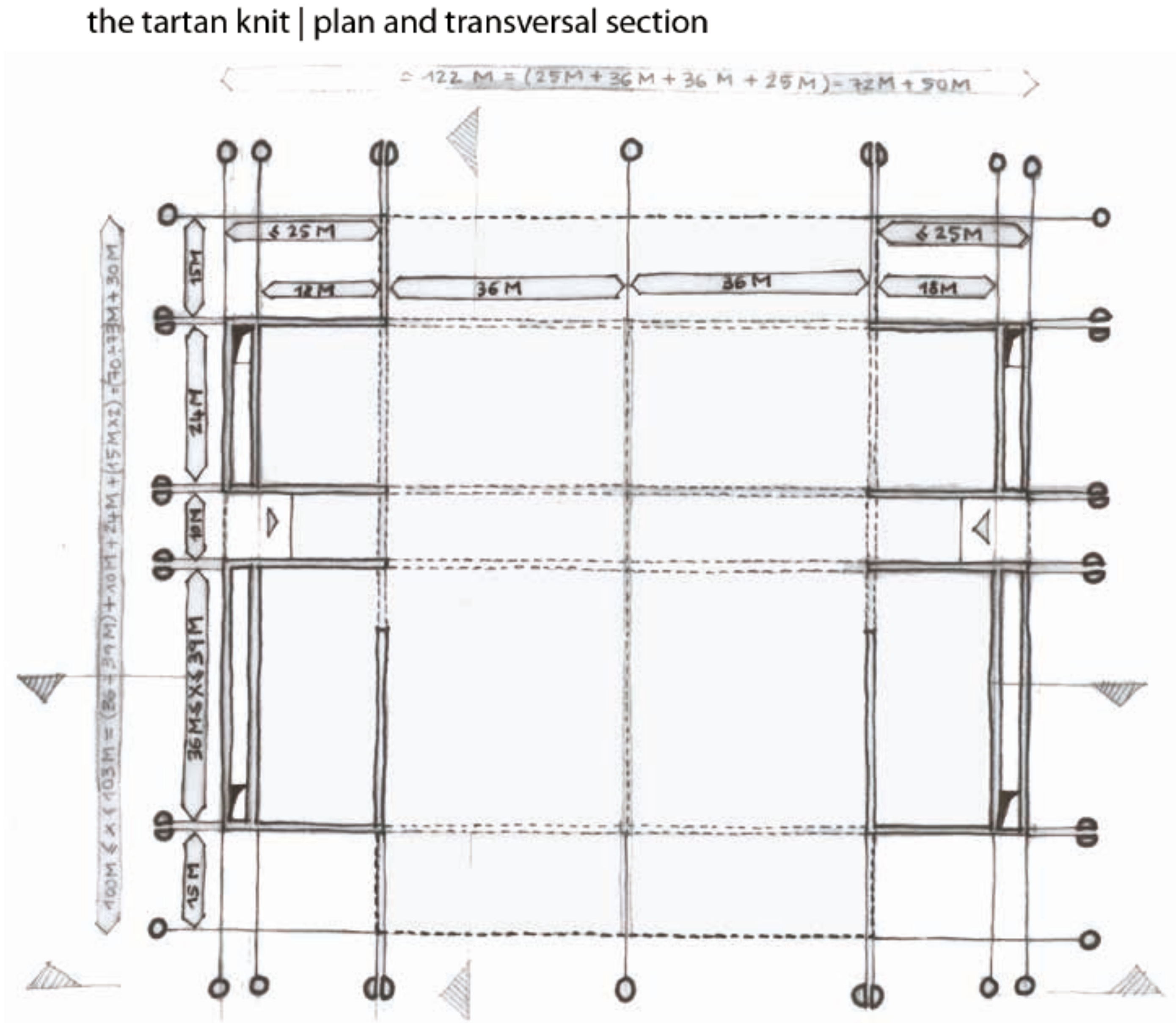


Figure 9a. An early scheme of the tartan knit with the definition of the different dimensional modules for the elementary unit elements.

the emergency, usually without defining a real destination (i.e. platforms for market stands, is one of the most recurring ones) and producing, as a result, the permanent occupation of an area. On the contrary, the present study wants to define temporary and totally reversible systems, which produce a “zero impact” on the environment, thus it designs a specific foundation system completely pre-fabricated and assembled on site.
This is constituted of three classes of the pre-casted beam produced in blocks, depending on the weight – thus the transportability – of each one. Furthermore, it presents an integrated hook system and pre-configured holes, to assemble the beams by the means of metal tie-ropes.

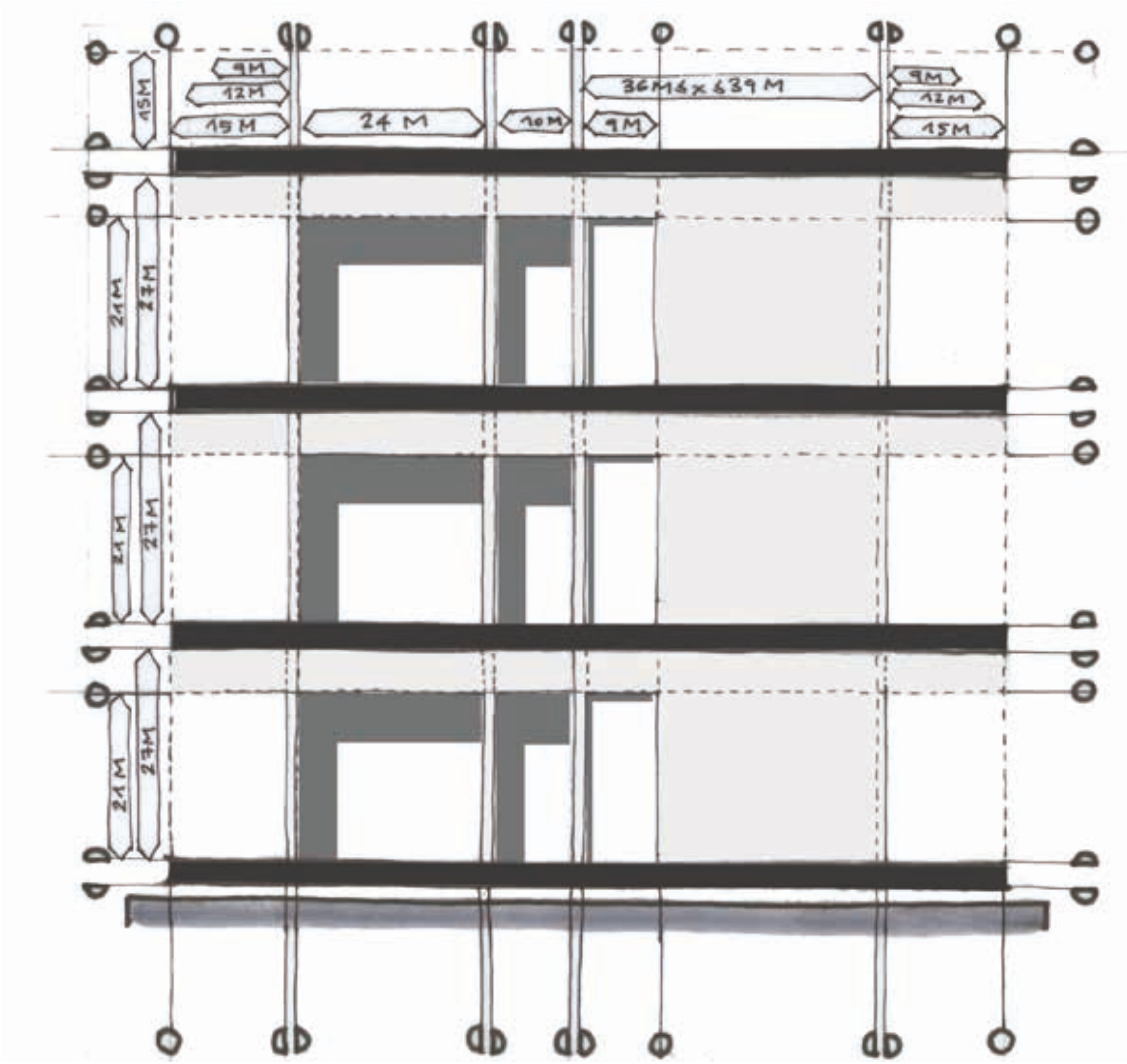


Figure 9b. An early scheme of the tartan knit with the definition of the different dimensional modules for the elementary unit elements.

At the same time, also the elementary module is conceived in different components, each one with its own construction strategies basing on the specific morphological and technological characteristics:

1. The structural "core"
2. The living space unit

The (1.) structural core is a self-standing system, which admits a total prefabrication; thus this component could be transported on-site as a 2D panels to assembly on site, as well as a preassembled 3D volume – in

case also completed with the equipment – depending on the specific convenience in terms of transportation and site conditions.
The (2.) living space unit, instead, is realised with a framed structure supported by the structural core vertical elements.
The dimensional organisation of the elementary module, thus the entire building system, is achieved through a "tartan knit," which allow defining the internal layout of dwellings regardless the available materials and construction technologies to choose during the procurement procedures (Fig. 9).
In facts, the tartan knit puts its axis on the internal and external edge of the structural element, in order to control the internal dimensions of the space units. The flexibility of the system is assured giving to each different component its specific dimensional module basing on the component specialisation. The S.A.T.O.R. project case presents a different dimensional module for the structural core and the living space unit, to fit with the specific space, technological, structural and plants needs.

Regarding the plant systems, they also follow the temporariness strategy, which admits defining specific environmental performances for the emergency dwelling. Literature shows how in the case of a short-term stay – temporariness – it is possible to reduce some of the reference values required for the plant systems design, defining standard fitting with provisional situations.
Concerning the plant systems design, it follows the same requirements defined for the construction system. Thus, they should be conceived in order to allow the total reversibility of plants and recycle/reuse of the single components.

In conclusion, to test the building system, the research provides a virtual prototype with a wood-combined technology system: X-Lam for the structural core and balloon-frame for the living space unit (Fig. 10). Being a virtual prototype, the test was conducted producing a developed design of a 3-storeys housing system, in analogy with those the C.A.S.E. project built in L'Aquila in 2009, to demonstrate that it is possible to realise qualitative residential districts even though in the case of temporary building system for a post-disaster emergency.

CONCLUSIONS

The S.A.T.O.R. project is the development of a clear and slender complex of procedures and tools (the special specification) that make efficient, and therefore effective, any process referable to the resolution of the housing emergency. These tools surely represent the basic conditions to reach the other central objectives: the constructive rapidity which solves, further to an evident saving of times and costs, the lodging of the evacuees in the shortest time possible. To reach this aim the management of the necessary

Figure 10. A sectional perspective of the structure of the S.A.T.O.R. Project virtual prototype illustrating the balloon frame construction system of the living space unit.

procurement procedures and the specific indicators to fulfil have been provided, in order to make the objectives of the Public Administration and the productive sector converge.

The research, nevertheless, leaves some open matters, among which the low-cost and the decommissioning objectives. Currently, the cost esteemed of the turnkey project S.A.T.O.R. stand around 950€/sqm. Such figure represents an interesting objective for what concerns the whole sector of the so-called low-cost building systems.
However, the realization of the objective needs to aim more decidedly to the further contraction of the geometric aspects, specifically on the quantities - height, surfaces, among the others - and contemporarily, on a complex of low-cost finishes, according to the temporariness of the building systems and in correspondence to an acceptable comfort performance for the inhabitants. This means to limit the use of resources reducing the cost

of the provisional dwellings and saving the most of the financing for the reconstruction.

In synthesis, the principal goal is surely reachable with a further examination of the building system design, preferably in collaboration with the productive compartment and through a wide and deep investigation of the building products market.
The concept of decommissioning certainly represents a very critical goal to reach because it is evident that this not only concerns the present study but also the next future of the architectural design culture and of the overall building market sector. Excluding the objective of the building systems dismantlement finalized to its re-assemblage in other place, that would require or a storage strategy or an urgent planning no-practicable for the well-known negative consequences, the present research has intended to frame an adequate repertoire of components and elements that can be destined to the reversibility and recyclability principles of components and materials which compose the building system. At the same time, it is necessary to develop a further and careful evaluation of the material nature, through a comparative system both for a performance, productive and economic assessment of the different opportunities currently offered by the market sector of the building materials and technologies. The present research opts, instead, for the timber-wood technology, as it was the most suitable for the verification of the system.
In conclusion, one of the central points at the base of the present study is primarily to show that through a symbiotic relationship among the authorities in-charge, Universities, Civil Protection, contractors and industrial suppliers within the building sector – along with a careful design activity – it is possible to realize comfortable, sustainable, agreeable interventions of temporary high-density building systems.

Notes

1. Sistemi Abitativi Temporanei Organizzati Reversibili.
2. SATOR AREPO TENET OPERA ROTAS is a palindrome of the early Christian era, namely an inscription legible in all the directions (from right to left and the opposite, as well as from the top to the bottom and vice-versa.
3. With the terms “emergency areas” is here intended the site for the provisional dwellings as defined in the “Metodo Augustus” document (Galanti, 2007), not those areas for the first emergency operations, or those of the tents camps.

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Mariagiulia Bennicelli Pasqualis was born in Genova in 1981. She graduated and got her Ph.D. in the technology of architecture from the Faculty of Architecture in Florence. She has been working in Ipostudio since 2007 and associated partner since 2014. Adjunct professor in building system design at the Department of Architecture DIDA of Florence. In 2014 she turned her PhD thesis in a book published by FrancoAngeli, Milan: "Case temporanee. Strategie innovative per l'emergenza abitativa post-terremoto".
E-mail: mariagiulia.bennicelli@gmail.com.

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