Introduction

Some key-paradigms emerge in the contemporary construction scenario, in the present society distinguished by the immateriality of human work, from the absence of capital weight and from the real time exchange of information at the speed of light.

“To be big and imposing is becoming an handicap and it is not an advantage anymore. For capitalists who would exchange with pleasure their big office buildings with a hot air balloon, the aerostatic lift is the most cost-effective and the most wished of the benefits […]” [Bauman, 2002].

The lightweight, adaptability and reversibility paradigms are becoming more established in architecture and introducing or re-introducing in the construction sector weight and material reduction criteria; adaptability and flexibility capabilities according to changing circumstances or uses; assembly and disassembly capacity for the reintroduction in the productive cycle itself (recycling) or to plan a new functionality (reuse). These issues are in accordance with contemporary social tendencies and cultural changes which are characterised by high levels of job flexibility and mobility. A new nomadism seems to mark contemporary society, “liquid modernity” in which nothing is anymore definite, durable, solid, and instead all appears as transitory, modifiable [Bauman, 2002]. People are on the move for work, study, or entertainment, for necessity or for choice. Journeys and mobility are now global trends, and there are many migration flows of different lengths of time all across the world. Particularly metropolis are ever more exposed to migration flows generating housing problems and precariousness, in the outskirts too. The housing supply, in many European countries, has become a big problem: in Italy, there is a more difficult situation then the one registered in the 80’s and 90’s. Primary housing supply in 2005 is approximately in the region of 300.000 and 500.000 dwellings (in 1991 housing supply was of 173,000 dwellings) [CRESME data]. Besides, there is a great demand not only by weak social strata, but also by old people, students, singles, and regular immigrants with their family (2,5 million residence permits until 2004). The situation of the gypsy camps is constantly creating more problems in the periphery of Milan. So new and old gypsies, with different housing demands, both in need not of permanent, unchangeable, everlasting, heavy architectural structures, but lightweight, adaptable and reversible homes as a result of an open and error friendly approach. A sustainable development ethic presupposes a planning attitude oriented towards social, economic and environmental issues. Currently the building sector is causing the widest environmental impact because of the exploitation of non-renewable raw material, in addition to land use, and energy consumption throughout the life cycle of the building product, make it a must to implement concrete strategies to improve the economic and environmental efficacy and efficiency of the sector. Lightweight adaptability and reversibility criteria in housing construction can allow for sustainable strategies at the three social, economic and environmental levels.
Adaptable in Off-site construction Modern Methods of construction

The off-site construction and Modern Methods of constructions (MMC) offer great capacity in support of lightweight, adaptable and reversible buildings, in achieving social, economic and environmental issues for a sustainable development. Off-site construction is a term used to describe the spectrum of applications where buildings, structures or parts thereof are manufactured and assembled in a different location from the building site prior to installation in their final position. Recently off-site construction, and MMC, are providing interesting outcomes and benefits to sustainability issues: Energy conservation; Waste reduction; Pollution control; Kyoto Protocol, due to materials being easier to control in a factory environment. Some of the most important benefits of factory manufacturing are: superior quality and less defects; more Health & Safety benefits; a faster construction result in savings on on-site management and on-site activities. Off-site construction is based on the manufacturing of lightweight components which are then assembled through dry construction methods. The reduction of weight elements allows low carbon emission construction. Factory manufacturing allows greater predictability of completion, greater predictability of cost. Finally off-site construction may be a key to achieving more agile, adaptable buildings in harmony with principles of sustainability. As well factory manufacturing enables product “design for assembly and disassembly”. An emerging theory suggests that the interface between technical systems should allow the replacement of one system with another performing the same function. Interface with other elements, relatively simple construction processes allow open, flexible and adaptable space and deconstruction rather than demolition so allowing reuse and recycling for a sustainable whole life costing approach. Alternatives to traditional building methods will not always be appropriate, but they could be used cost-effectively for different residential use, far more than it is currently done. In effect all off-site construction is a mix of off-site manufacturing and on site installation and completion. Just as most traditional construction today may incorporate significant elements of off-site manufacture. The difference is a matter of degree. Whether the main elements of the building are formed off site, or in situ really determines the extent to which it can be classified as a “Modern Method of Construction”. The Term was recently adopted by the Housing Corporation and the ODPM as a collective description for both off-site-based construction technologies and innovative on-site technologies based on balloon frame system. The term MMC applies to all different material types: wood, cold formed steel, steel, precast concrete. There are different forms of MMC: Stick build construction; Panellised Construction; Volumetric construction; Hybrid construction [Ross, 2005]. MMC show great benefits in high density housing, such as meeting affordable housing targets, immediate availability of buildings, high level of buildings customization (not standardisation), high level of flexibility, adaptability and assembly/disassembly capacity. The most important problem with MMC is the cost issue. People think it is more expensive because simplistic cost analyses show it to be more expensive and because many of the savings are hidden. Time and quality savings may not actually bring benefits anyway. So the thing is: “Are we prepared to pay for quality and future environmental benefits?”. Lightweight or heavy construction?

There is a relative great diffusion of Modern methods of construction in residential house building, especially in USA and Japan, and recently in some European countries, particularly in northern Europe (Sweden, Germany and UK). But in European Mediterranean countries and especially in Italy there is a greater resistance to MMC diffusion and a scarce diffusion of lightweight, adaptability and reversibility in buildings. Historically USA buildings were based on balloon frame, so there is a great diffusion of lightweight and adaptable buildings, and many mobile homes, following housing mobility demand and American nomadic way of life. In Japan the cost-effective and streamlined production progress allow sophistication of the Japanese prefab factory. Instead European prefabrication experiences in housing were usually associated with concepts of precarious, low quality and unreliable homes. In Europe there is a greater and more consolidated use of MMC particularly in Scandinavia, Germany and recently the UK saw the building of many interesting and innovative multi storey residential buildings using MMC. In these buildings one can find an appreciable mix and
balance between all benefits of MMC and architectural quality, high-levels of repairability, adaptability, personalization, and lower environmental impact in the whole life cycle.

In France, Spain and especially in Italy MMC application is really rare or almost negligible. An interesting application of MMC is being achieved in Spain with an important development of *stick build system* in CFS single family housing, and this kind of construction is acquiring a large share of the residential market. The limited popularity of this construction method in Spain, a country economically, socially and culturally similar to Italy, represents an important example that suggests positive perspectives to the application of these methods even in Italy. In Italy infact the use of construction methods which include lightweight, adaptability and reversibility features are not largely accepted. Italy (and in part Spain and France) is traditionally anchored to heavy construction, with brick and block masonry built in. In Spain the relevant push to MMC has arrived from the manufacturing firms and this allowed to overcome the initial distrust from the building sector operators. The great distrust in Italy has many reasons: the strong bond with traditional construction methods; the diffidence to innovations, especially in housing, and the general refusal of prefabricated construction systems, but also due to the lacking knowledge of technological and environmental MMC performances. Certainly MMC and off-site construction cannot be indiscriminately adopted for every kind of construction and in every situation but they can meet many housing targets in relation to the benefits of these construction methods in achieving a balance between all levels of sustainability. MMC may also give a more qualitative alternative to low quality buildings and constructions in Italy, particularly buildings built before 1977 (marked by fixed and unchangeable typological solution, scarce flexibility, and ineffectiveness of construction techniques employed), projections for Italy foresee investments in the range of 70% of the total value of the construction market [ENEA, 2004].

**What in support of adaptable and sustainable residential building in Italy?**

The specific objective of the current research is to understand how methods of construction oriented towards lightweight, adaptability and constructive reversibility, in a sustainable development ethic, could find application and a greater penetration in house building sector in Italy and particularly in the metropolitan area of Milan. To achieve this, it is important, above all, to understand which are the possibilities of the productive industrial system, how much it is possible to convert existing manufacturers (semi-manufactured structures factories for containers and box) and which are the motivations to move investors. Although currently in Italy there aren’t projects involving the above-mentioned methods of construction, the research is looking into the productive market which could potentially be oriented towards the application of these methods. We are researching the potentialities of italian market in the productive sector for steel, wood, box and emergencies containers, according to investigated data analysis, quantity and importance of the actual productive market, it appears that the sector could be qualified and oriented towards products that could allow the application of modern methods of construction. Moreover Italy has some considerable precedents, for example in steel production, and especially of Cold Formed Steel which date back to the 70’s. The CFS, together with semi-manufactured precasts in wood and concrete, are some of the most used elements in the Modern Methods of Construction. Today a substantial part of the italian iron and steel production is represented by CFS categories, wich however are used only as secondary elements (for example roof framing and internal partitions), while the structural use is limited and applied only to commercial and industrial buildings. Only 10% of the single-floor constructions in Italy is carried out in CFS (72% in France, 83% in UK) [Ermolli, 2006]. In Italy in buildings, over two storeys high, the structural use of CFS is particularly dependent on regulations for the dimensioning of thin sections is provided in pairing with elements that can guarantee higher values of inertia. But interesting signals of vitality are forthcoming from the manufacturing factories. For example, in France, in a cultural and social context similar to the Italian one, there were some cases of conversion of the box and container manufacturing market towards the production of prefabricated modules with higher quality exterior finishes and comfort. Within this research we are trying to involve Italian manufacturers (mostly from the region of Lombardy) of prefabricated modules and CFS into the implementation of their production. Aiming to sustainable and adaptable buildings that have the in-built ability to adjust to changing circumstances and technologies, without excessive waste and conflict. They are functionally “agile”.
demonstrating accommodation capacity far in excess of tightly integrated and functionally determined buildings.

**Adaptable housing: from a “temporary use for necessity” to a “temporary use by choice”**

This article presents a summary of work carried out in the field of design for adaptability and application of reversible methods of construction in the building sector, at the Politecnico di Milano – Building Environment Sciences and Technology Department. This research delves in the field of off-site construction and innovative construction techniques in emergency installations and more long term housing, for which a greater penetration is desirable in the building sector. Particularly the article focuses the attention on the job developed in the didactics, and particularly at tertiary level of education of teaching activity and also in the research activities, e.g. a research entitled “Over the emergency”, co-financed by the Italian Ministry for Education, University and Research, 2000-2002 (national coordinator prof. Franco Donato, title of the national research “Technologies of intervention for the innovation of emergency installations” - operational Unity in Milan, Director prof. Andrea Campioli. Our Research Unit has focused its attention on questions relating to the flexibility and adaptability of constructions in relation to changes in the use and evolution of housing requirements, proposing light type construction systems as suitable techniques to meet these needs for transformation. From this research we have developed further ideas about the temporary housing, that go beyond emergency requirements and suggesting new potentialities and perspectives for light-oriented, adaptable-oriented and reversible-oriented construction methods: we believe that from the emergency housing these new construction methods can take new housing spaces, more in conformity with durability and maintenance, beginning from the most provisional houses to the more durable ones. In this context our research group has also applied the new construction methods during several degrees’ thesis particularly on the university residential house building (pod houses) and in the renovation of an existing historical building (agricultural ability) expressing the technical and formal potentiality in the new building and in all the buildings renovation. The PhD thesis I’m working on is developed within this framework. The energy and environmental crisis of the 70’s have pushed Italy to reorganize only the provisional habitat themes to some functional sectors: tourism, the building sites, emergency housing. The industry showed interest in this sector, without reaching great qualitative results and without great innovations in the typology of proposed solutions. It’s important, before everything else, to point out that in this productive sector, the container is the most widely used typology. It deals with “turnkey” construction systems, conceived to set up short and temporary installations, easily dismantled and whose cells are easily reusable in new installations. Therefore the container is the solution mostly employed in emergency situations. But the containers’ supply for emergency uses still represents a marginal and discontinuous production activity, that a factory cannot consider as its principal production line. There is however a potential market for prefabricated structures for living quarters and offices, which are characterised by their transportability, easy to assemble and disassemble, economically convenient, able to satisfy application requirements for temporary spaces, in different sectors such as tourism, military camps and working sites, refugee communities or gypsy groups. This is the productive sector that, when required, provides the modules for emergency situations. Provided that a specific production sector for emergency situations doesn’t exist, but that there is a more generic production set up for temporary and provisional structures, based on the employment of the non specialized container, the objective of my study is to identify the producers that could be interested in the application of alternative structures which are different from the containers, and which could be adaptable not only to emergency situations but also in general to the wider range of temporary situations. Then it is also necessary to understand how the construction system can adapt to this productive structure. The success of the container is due to the simplicity in its assembly, whereby any metalwork company can assemble it in a short span of time. The problem with containers used as live-in units is instead related to the interior finishes that need a craftsmanship intervention.
Within this context, it is possible to identify some manufacturers of modules or parts that can potentially become producers of prefabricated housing systems at different levels of time frames, in relationship to the emerging targets from the current dynamics. It is useful to underline a scale of different levels going from a “temporary use for necessity” to a “temporary use by choice”. On the one hand the “temporary use for necessity” responds to an urgent need of protection and safety, following natural disasters or war emergencies, humanitarian aid and sanitary situations, having the tendency therefore to provide at times also immediate answers to the detriment of the quality in the production process.

On the other hand, a new temporary dimension can be found in the scenario of current constructions: it represents a more sophisticated and elegant temporary solution, able to answer to new needs of housing and working nomadism. As a watershed between the two ways of temporary solutions is the adaptability of the structures that is their ability to resolve the different environmental requirements and climatic situations, thanks to practicality of the modules of the system and to ease to modify it. Adaptability represents therefore a prerogative that a living space has when from a “temporary use for necessity” space it passes to a “temporary use by choice” unit. In the container-based temporary construction system, adaptability is often sacrificed to the transport requirements and installation facilities and therefore it results at the minimum level possible, while it tends to increase when is changes to a “temporary use by choice” unit.

In structures with higher levels of durability the basic module of the container (e.g. in the residential units built with the volumetric methods) is integrated with components that increase insulation, acoustic, and comfort performances, and with detailed finishing design that personalises the interior environ and plan customization. The integration with additional lightweight elements such as textile membranes or flexible panels allows a greater expressive dynamism and an adaptability to different uses. The use of lightweight material and the dry mounting of all the components, the choice of reversible junctions for the assembly and disassembly offer in this type of construction great opportunities to implement flexible and adaptable spaces that constitute a paradigm that directs the building towards the ethics of sustainable development and which is in a position to express the need for personalisation and change in time of the human being in his housing requirements.

References