MANUBUILD demonstration building in Madrid – From concept to reality

Fuster, Almudena; Iglesias, Ana & Boudjabeur, Samir

*Housing Innovation Department.*
*EMVS, Madrid*
*Spain*

*Corus RD&T*
*UK*

**ABSTRACT**

The ManuBuild Open Building Manufacturing System, a co-funded 6th Framework integrated project - is a sustainable building approach that is non-material specific and holistically incorporates Design, Business Models, Manufacturing Methods and Technologies and ICT Support as well as Training and Education. This system enables construction to act as a flexible, agile, value-driven and knowledge based industry and most of all to be highly customer-centric, efficient and competitive.

ManuBuild was created in response to a need to address challenges in the industry in terms of sustainability, modern methods of construction, greater control over process and marrying good architectural practice with offsite construction. These ambitious targets were very much in line with the Municipal Housing and Land Authority (Empresa Municipal De la Vivienda y Suelo de Madrid - EMVS) vision and engagement in fostering sustainable and innovative development, focused on end user needs. EMVS is showing how these challenges have been addressed as well as proving, testing and validating the concepts of ManuBuild through the creation of a building which is delivered as a commercial development and currently under construction in Southwest Madrid.

In this paper, the authors will mainly focus on the demonstration building development. The 25 renting apartments of one and two bedrooms for young people, which forms part of a social housing development for EMVS, are distributed in one block, including an underground semiautomatic car park with 115 parking spaces. The demonstration emphasis is on architectural flexibility of apartment layouts during construction and the life cycle of the building and on using off site manufacturing to reduce site assembly time and to increase the quality of the build.

The process adopted in designing and constructing the building through off site manufacturing will form the main body of this paper.

**Keywords:** ManuBuild, sustainability, social housing, architectural flexibility, off site manufacturing.
OVERVIEW OF MANUBUILD – THE DEMONSTRATIONS

ManuBuild - Open Building Manufacturing- is a European industry-led collaborative research project on Industrialised Construction, part-funded by the EU, under the 6th Framework Programme, involving 22 partners from 8 countries across Europe. The project ambitious targets are very much in line with the Municipal Housing and Land Authority (Empresa Municipal de la Vivienda y Suelo de Madrid - EMVS) vision and engagement in fostering sustainable and innovative development.

End users, private & public developers- such as EMVS-, contractors, suppliers, research institutes, software companies and research & training organisations are represented at the project consortium.

The main objective of the ManuBuild System is to produce uplifting, sustainable and cost-effective customer-oriented buildings, through radical integration and industrialisation of the design, production and delivery processes, as well as greater involvement of the customer. The goals are:

• Shift from traditional craft based to manufactured construction
• Promote the open sourced components
• Adopt advanced manufacturing methods
• Integrate ICT to aid open building manufactured construction

The system addresses the whole building process from design to completion, through a completely new business model, benefiting from manufacturing methods & technologies and advanced information communications & technologies. From the design point of view, the aim is to develop and introduce concepts, methodologies and new products for open building manufacturing, offering customer choice, design for manufacture and construction flexibility. The integrated manufactured solutions encompass new methods and technologies that enable the delivery of value-added, innovative and optimised technologies for both on-site and off-site open building manufacturing. This allows radically increased productivity, improved health and safety, and reduced construction time and costs. ICT infrastructure and tools support open building manufacturing, allowing building designs to be configured by the various stakeholders involved, along with seamless information management and delivery. The results are a holistic business and organisational models to deliver performance based, customer centric, whole-life, value-driven solutions tailored to suit open building manufacturing creating more efficient and better targeted services to the market.

Finally, the wider uptake of ManuBuild concepts is supported by a developed framework for European human capacity underpinned by a proactive and innovative approach to training and education. This includes new academic courses and flexible, accessible training and education material for the industry.
The viability of the ManuBuild vision is being proved on a number of commercial environments of real construction projects: two in the UK (low rise housing and a medium rise apartment), one in Sweden (a medium priced four storey 16 apartment building) and one in Spain (a social housing development), where new technologies applied across the whole lifecycle of the building -from design to services - and new ways to address customer/end-user needs such as design for living, design for openness and customization are being demonstrated. These developments, built to ManuBuild principles, provide examples of how the construction industry, its customers and supply chain can move the industry from a mainly craft production and closed way of working, towards the vision of an open system building manufacturing approach.

EMVS is showing how these challenges have been addressed through the erection of a building, delivered as a commercial development and currently under construction in Southwest Madrid, Spain. The demonstration emphasises architectural flexibility of apartment layouts during the whole life cycle and use of off-site manufacturing to reduce site assembly time and to increase the quality of the build.

MANUBUILD SPANISH DEMONSTRATION: EXPLAINING THE PROCESS

The Spanish demonstration building development is currently under construction in southwest Madrid, a newly developed urban area. The 25 renting apartments of one and two bedrooms for young people form part of a social housing development for EMVS. The dwellings are located in a medium rise block, including an underground semiautomatic car park with 115 parking spaces. The emphasis is on architectural flexibility of layouts and on using off-site manufacturing to reduce site assembly time and to increase the quality of the build.

The two competitions

The EMVS called two international architectural contests in March and November of 2006 for the ManuBuild Demonstrator. Both competitions were based on 5 points of ManuBuild Philosophy: End User Involvement, Open Building, Activity Space Approach, Design for Flexibility and Design for Manufacturing.
The invited teams were familiar with industrialisation, technical innovation, sustainability, especially with energy efficiency and environmental adaptation. Thanks to the two competitions, the EMVS obtained 15 different architectural proposals of European well-known practices, for the same plot, same climate and conditions in Southwest Madrid, which illustrated different solutions for the Manubuild demonstrator.

The aim of the first competition was to set the scene for the 2nd restricted call - which included as a starting point the results of the first one. The winner of the second competition would be the Spanish team of architects to design and build the 25 public housing units at the “Ensanche de Carabanchel”. The proposals satisfied the real estate program & sustainable common practice of the EMVS, as well as the objectives of Manubuild outlined below:

- Use of Off-site components such us quick and easy assembled modules, compatible & exchangeable elements, standard connexions, easy to move parts, universal assembly methods and dimensional coordination
- Dwelling flexibility such us possibility of layout reconfiguration to allow adaptation to occupants evolution & needs, easiness for the finishes & installations renovation and future maintenance.
- User’s participation, such us design & configuration oriented to the client, future changes at low costs

Regarding sustainability, the incorporation of energy efficiency criteria, renewable energies, bioclimatic design, proper use of the land, construction systems that reduce waste and increase the life-cycle of the building and dwelling, environmental friendly materials (recycled, recyclable, healthy) was compulsory.

The proposals needed to address as well the positive enforcement of the image of the industrialised systems & buildings through conscious design for the end user, & manufacturing, spatial innovation and contemporary formal image.

**First Competition March 2006**

The first competition was launched in March 2006 and the aim was to obtain proposals of high quality on flexible layouts typology, within the Mediterranean scope and implementation of industrialized, opened and sustainable constructive systems. The end user should also be at the centre of the process.

Twelve European teams from different countries were invited to this restricted competition and 9 entries submitted:

- CTROL [Space] HOUSING Piercy Conner Architects (Uk)
- 6769FR Amin Taha Architects (Uk)
All the proposals provided different and challenging ideas for the Manubuild Madrid Demonstration, focussed on industrialisation of the construction process, use of off-site components and modules, flexible layouts adaptable through time to the changing end users needs and adaptation to the cultural and climate conditions of Madrid.

CTRL [Space] HOUSING, from Piercy Conner Architects (UK), was awarded first prize. The proposal focused on the pragmatic and the sensual and looked for the common factor of flexible, sustainable and industrialised homes through a greater degree of control and increased responsiveness, to enable the end-user more choice and diversity; technologically to facilitate leaner, more efficient fabrication and construction; or environmentally, to allow a building to be effective in varying climates and situations. The aim was to create flexible, sustainable industrialised homes that can be manipulated, adapted and controlled throughout their lifecycle. They proposed light industrial buildings as good examples of controllable and controlled elements, proving flexible, sustainable and durable, adding sensual qualities that most people look for in a home such as warmth, tactility and smaller scale detail, designing a dwelling which was not only pragmatic and efficient but also sensually interesting and responsive. Ctrl [space] proposed contemporary homes that were experientially rich and customisable despite being modular and economical (Manubuild T2.2, 2007)
The 6769FR proposal, from Amin Taha Architects (UK), won the second prize. Their approach was driven by the Manubuild raison d’être for ‘open-manufacturing’. The team looked at the existing products in the market place throughout Europe and drawn out the strategy based on Open-Plan structural volume, Standard system components but material flexibility, Inhabitant desire & flexibility, Flat stacked transportation, Structural sandwich panel walls & floors, Pre-wired walls and Fully prefabricated, plumbed and wired bathroom, wc & kitchen units. To anchor the development within Madrid and this site specifically, the external sun-screen device were used as one of the principle design generators. The perforated metal brise-soleil screens highlighted the intended domesticity of the programme, while maintaining the aspirations for components that can be mass produced and prefabricated off site.

The third awarded proposal SKY GARDEN, from Feilden Clegg Bradley (UK), explored three conceptual ideas critical to successful high density urban living. The scheme was developed around the use of stacked prefabricated shipping containers, with houses and gardens at all levels, and natural cooling by ventilation combined with thermal mass. The result: a living, breathing building.

The spaces held between the stacked Verbus modules blocks were used as allotments/gardens available for use to the inhabitants of the two adjacent levels. Six sky
gardens were provided vertically throughout the building. The sky gardens offered safe environments for inhabitants to interact.

By spacing the modules vertically, air was allowed to flow between the units where unfired clay was used as a thermal store to aid cooling day and night throughout the summer, performing as a Breathing wind tower.

![Image of sky garden](image.png)

**Figure 6: SKY GARDEN, from Feilden Clegg Bradley (UK)**

**Second Competition November 2006**

The objective of the second restricted call for ideas was to obtain design proposals with a high degree of spatial and technical quality for a middle rise housing development at the “Ensanche de Carabanchel” area, as a “demonstration project” to showcase the results of the R+D European project ManuBuild.

The proposals submitted needed to be sustainable and fulfill both the real estate development programme of the EMVS and the objectives of the ManuBuild project, and in particular with regards to the flexibility of the dwellings and the degree of industrialisation attained. Regarding the flexibility of the dwellings, the objective was to be able to reconfigure the residential units, adapting the dwelling to the nature of the family unit, taking into account the potential changes that can occur as it evolves in time, as well as lengthen the life of the building in general while reducing the future maintenance tasks. Therefore the criteria used to assess flexibility were the level of involvement of the users in their residences, the need or not of specialized help, the different solutions/options available for each type of residence, the possibility of reconfigure the floor plan of the units, and the capacity of the building to be updated through time to new technologies, renewing finishes and services, life cycle and maintenance. The teams were asked for the full development and design of one residential unit to showcase the possible configurations and variations offered (floor plan, level plan, façade, etc.) as well as the degree of intervention of the future user.

The objective was to build “residences for people”, in which the future users feel the dwelling as a “home” rather than a “house”. The ManuBuild approach to design of the dwellings, based on the activities they will sustain, was to be taken into account.

The teams were asked to include a rational for the degree of manufacturing involved as well as the percentage of innovation attained (as compared with a traditional/conventional residential building). The quality of the final image and the formal and spatial aspects of the proposal were essential in order to dispel the negative image of industrialized building of past periods. The architectural team needed also to submit a
proposal for collaboration with the ManuBuild project in order to be appraised of the results of the research being currently conducted and to be able to incorporate the results of said research into the building (processes, systems or products).

Sustainability was an essential part of the proposal, therefore the projects needed to incorporate energy-efficient criteria, renewable energy sources, bioclimatic design, the appropriate use of land, building systems that minimize waste generation and improve maintenance tasks and the buildings and units' useful life cycles, the use of environmentally friendly materials (recycled, recyclable, healthy). Eight Spanish teams were invited to this restricted competition and 6 entries submitted:

- 3³ (TRES AL CUBO) César Ruiz-Larrea Cangas – 1sr prize
- BOX Ortiz y León Arquitectos – 2nd prize
- HACER PATENTE Antonio Fernández Alba – 3rd prize ex-aequo
- JARDÍN DE AIRE Pich-Aguilera Equipo de Arquitectura – 3rd prize ex-aequo
- PRET-A-PORTER Fresno-Casas Arquitectos
- TODAY (31+19) AUJA Arquitectos, Urbanistas e Ingenieros Asociados

The evaluation report listed the technical advantages and disadvantages of the 6 proposals submitted, based on the competition criteria:

The proposal 3³ (TRES AL CUBO) from César Ruiz-Larrea & Associates won the first prize. The team proposed innovative systems regarding off-site, sustainability and energy efficiency, such as a smart industrialised façade with Pv & Thermal panels. Standardisation was addressed as well as a flexible layout, good geometrical variation & mass-customisation. The contemporary design of both dwelling and building was of high quality and the use of structural & spatial grid of 3x3 a good example of dimensional coordination. The project and challenges addressed represented a good opportunity to collaborate with Manubuild team.

Figure 7: 3³ (TRES AL CUBO) Ruiz-Larrea & Associates (Sp)

The BOX of Ortiz y León Architects won the 2nd prize. They proposed the use of shipping containers, a Variety of suppliers, accessible services for maintenance, good end user choice and good off-site vs on-site balance.
HACER PATENTE from Antonio Fernández Alba, - a flexible proposal with all the services grouped on the North façade- shared the 3rd prize ex-aequio with JARDÍN DE AIRE from Pich-Aguilera architects team, a contemporary formal proposal with good level of buildability and open for standarisation.

**WINNING DESIGN: DESCRIPTION AND PHILOSOPHY**

The wining design for the Manubuild Spanish demonstration building -currently under construction- emphasised on architectural flexibility of layouts and on using off-site manufacturing, as the competition brief required.

Ruiz Larrea & Associates were selected in January 2007 to developed the design, detailed project and be in charge of the construction.

The proposal – as said- focused on industrialisation and open building, through modularisation and optimisation of the space and building systems , linked to the energy performance of the dwelling and the end user participation. The main objectives proposed were as follows:

- **Structure Industrialisation and open building components**
  The structure proposed is a three dimensional steel grid 3mx3mx3m, completely manufactured off-site and erected on site, as well as the façade, which also works as a customisable energy shield. All the parts and components – including the moveable partitions- will be from open catalogues to allow interchangeability.
• Services industrialisation
All the services will be brought on site as an off-site service core. Kitchen and bathrooms will be grouped and a technical floor will allow flexibility of changes. A water recycling system will be installed in the service modules.

• Typological flexibility
The proposed dwelling is made of 3 spatial areas: living space, 2 bioclimatic modules that help to improve the internal conditions, and a service area, where kitchen and bathrooms are located. This allows 3 different types of dwellings based on the same layout typology: a single user studio, a 2 bedroom apartment for young couples or students and a 3 bedroom apartment for families. The layouts are completely reconfigurable.

• Energy industrialisation
The dwellings have two different bioclimatic industrialised spaces: a south facing gallery to capture the sun and heat in winter and a shadowed space facing north with vegetation and humidity to ensure a reduction of summer conditions.
CONSTRUCTION PHASE

The construction phase started in early 2009 after a public bid among different contractors. The Spanish demonstration - a 25 renting apartments of one and two bedrooms for young people- forms part of a social housing development for EMVS. The dwellings are located in a medium rise block of 5 floors, including an underground semiautomatic car park with 115 parking spaces. Even if the winner proposal has been adapted to real market and plot conditions, the emphasis still is on architectural flexibility of layouts, off-site manufacturing to reduce site assembly time and to increase the quality of the build and end-user involvement, all linked to sustainability and building performance.

The building will be completed by early June 2010 and showcase the integration of different technologies- manufactured structures of concrete & steel-, off-site components and materials- such as bathroom pods-, total flexibility of the dwellings layouts, the implementation of a totally manufactured off-site solar & PV panels façade as well as the integration of an off-site semiautomatic car parking.
ACKNOWLEDGEMENTS

We would like to thank all the teams involved in the two competitions for their challenging proposals and hard work, the Manubuild partners that provided support and trust the development of the demonstrator, all the Ruiz Larrea team for their engagement, the EMVS staff for their support since 2002, the European officer in charge Mr. Cristophe Lesniak and specially the Dragados site manager Jose Luis García, his assistant and team for their compromise. It has been and still is a challenge and an integrated effort.

BIBLIOGRAPHY

- Several authors, Manufacturing the Open House, 15 architecturally rich and flexible proposals, Manubuild Project collection, February 2009, ISBN-13: 978-84-935719-7-9
- Several authors, First Competition brief, March 2006, Unpublished
- Several authors, First Competition brief, March 2006, Unpublished
- Several authors, Manubuild Reports, Deliverable T2.2, Mediterranean typology, 2007, Unpublished