

La innovación  
en el sector de  
la construcción



## Industrialisation in Construction- Housing and Residential Buildings

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February 2008



Palacio Euzkalduna  
Sala A3

7 de febrero de 2008  
de 9:50 h. a 16:00h.



## Modern Methods of Construction (MMC)

- *Modern Methods of Construction achieve the following benefits:*
- High levels of prefabrication – fast to install on the project site
- Higher quality by off-site quality control
- Reduced material resources and waste in manufacture and construction
- Low energy use and CO2 reductions
- Economy due to efficiencies in manufacture and economy of scale

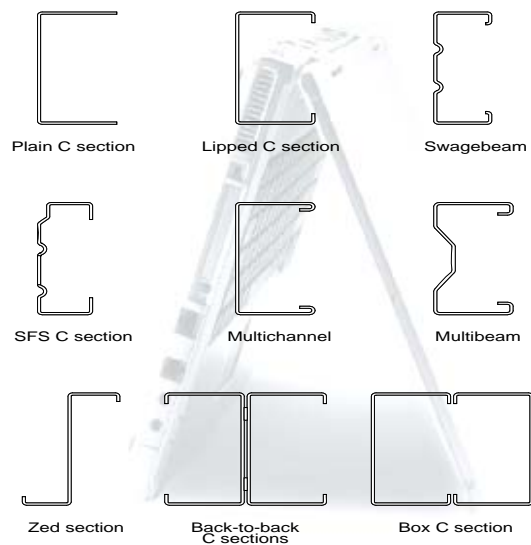


## Light Steel Framing

- Uses cold formed galvanised steel sections to EN10326
- Thickness of 1.2 to 2.4mm
- Steel strength S280 to S390
- Generally, C shape of 65 to 300mm depth
- Elemental construction site (ie 1-D)
- Pre-fabricated wall and floor panels (ie 2-D)
- Framework of modular units (ie 3-D)



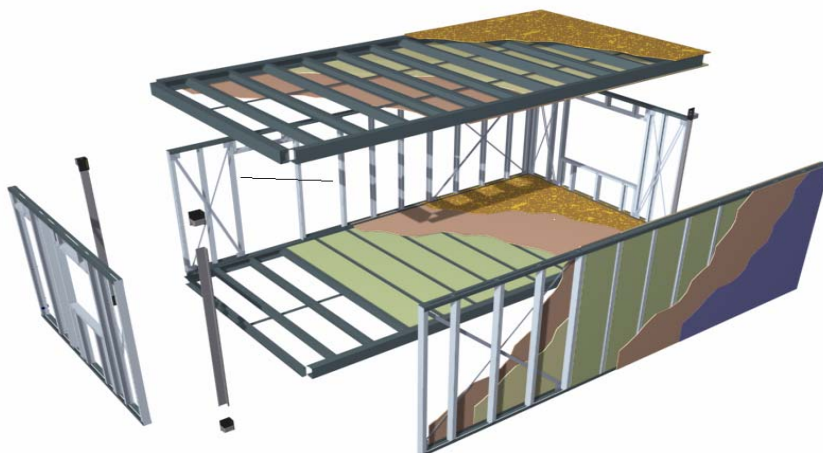
## Types of Light Steel Profiles



### Light Steel Framing used in a House



### Components in a Module



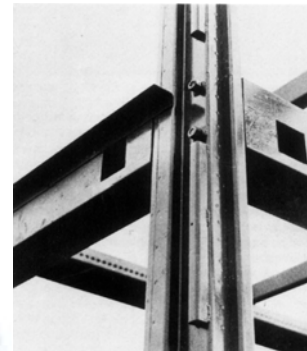
## Modular Construction

- Factory produced volumetric units
- Four sided units have load bearing walls
- Open-sided units have edge beams and corner posts
- Framework composed of light steel frame and some hot rolled steel eg tubes
- Modular sizes limited by transportation (typically up to 4.2m width)

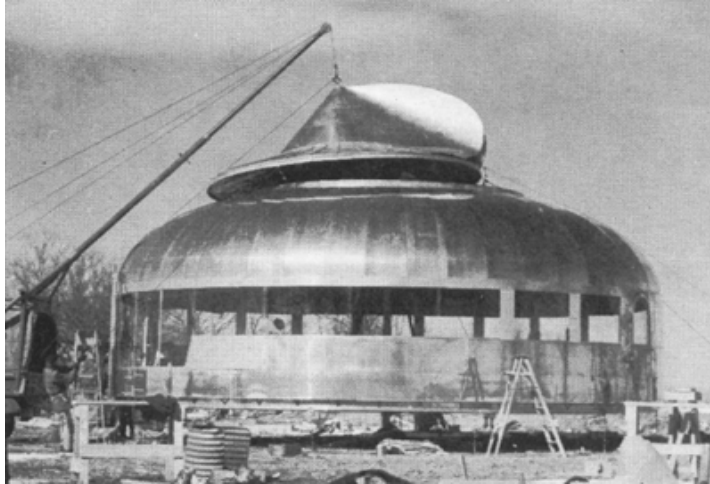


## History of Light Steel Framing

- Early examples of light steel framing by Jean Prouvé in France in the 1940s
- Expansion of the USA and Canada in the 1970s
- First light steel framing projects in Europe in the mid-1980s
- Market share for light steel framing in housing reaches 15% in the USA and Australia
- Important projects in modular construction from 1999 onwards
- Publication of Eurocode 3 -1-3 in 2003 presents design information on light steel structures



Buckminster -Fuller's Diamaxion House , 1944



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9

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*Forms of Construction:  
2-D Panels*



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EUSKAL GOBIERNUA



GOBIERNO VASCO  
GOVERNULU VASCOA

Installation of Light Steel Wall Panel



Braced Light Steel Structure for 4 Storey Building



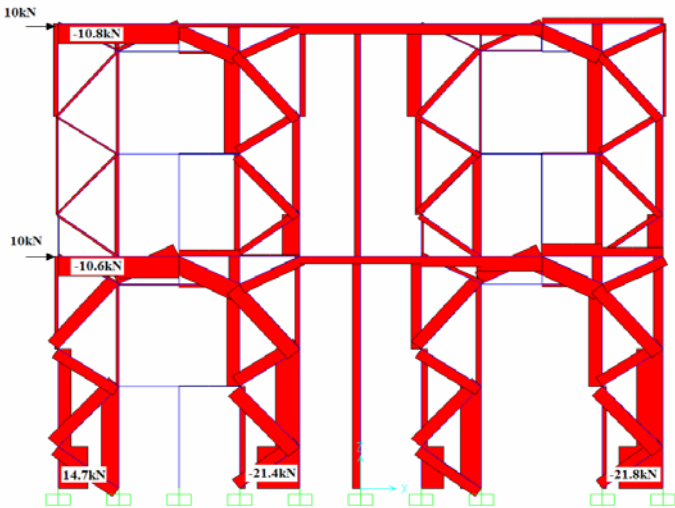


X Bracing for Stability of 6 Storey Building



X Braced panels using Light Steel Framing

Forces in a Typical 2 Storey House due to Wind Action



Light Steel Floor Joists Supported on Z Section over Wall



Pre-fabricated Light Steel Floor Cassette



Pre-fabricated Floor Cassette



Light Steel Roof for Habitable Space



Debut Housing using Light Steel Framing



Apartments using Light Steel Framing, Bristol



Housing using Light Steel Framing



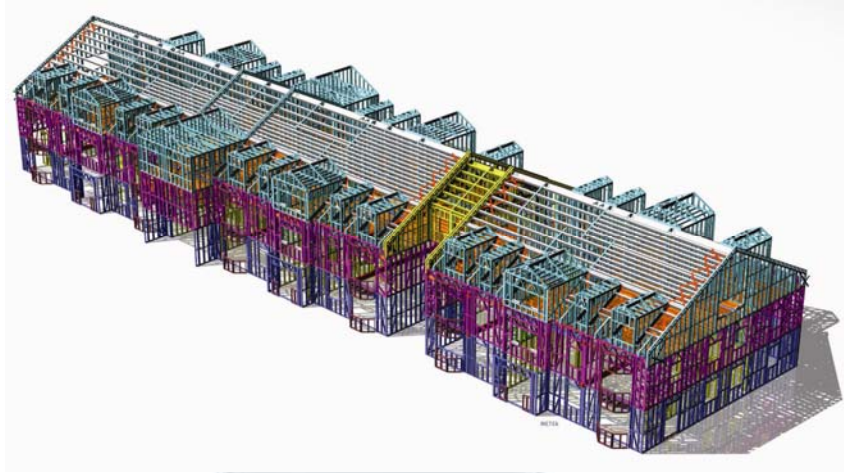
Apartment using Light Steel Framing



Construction of Apartment Building in Light Steel Framing







*X Steel model in light steel framing*



*Completed building in light steel framing, Middlesborough*

Use of Gypsum Anhydrite Screed for Flooring



7 Storey Light Steel Framing, Glasgow





Light Steel Separating Wall – for Acoustic Performance



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*Forms of Construction:  
Modular Construction*



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Modular unit with Integral Corridor



Modular Construction in London



Completed Modular Building with Pre-fabricated Balconies



Modular Construction, Manchester -1000 modules



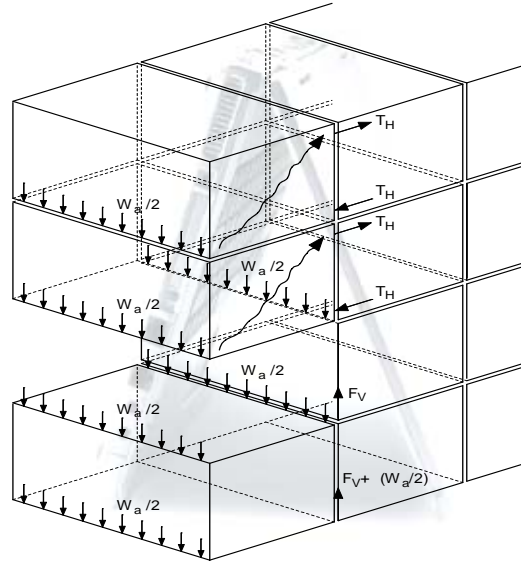




### Fully Modular Building for Social Housing



### Stability of Modules in the Event of Explosion



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*Forms of Construction:  
'Hybrid' modules and panels  
- 2D/3D Construction*



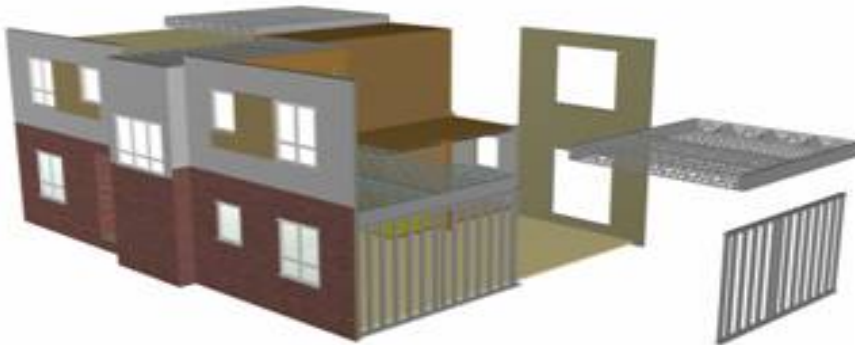
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Modular Stairs and Bathrooms with Large Floor Cassettes



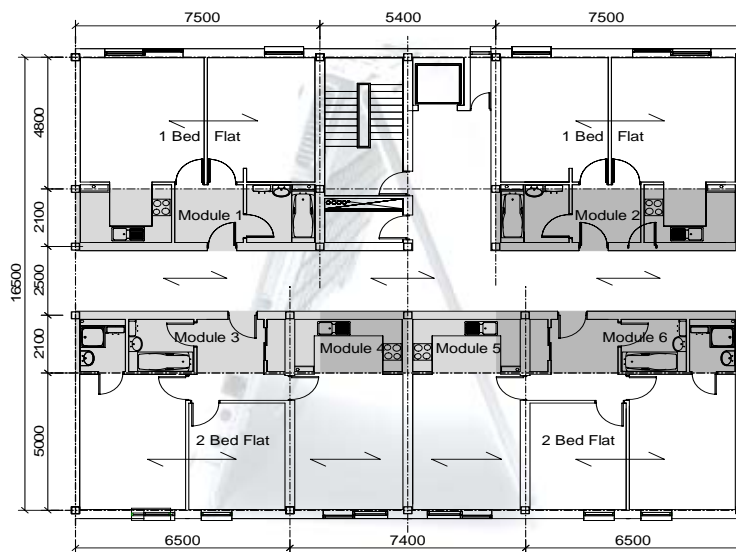
Mixed Use of Modular Bathrooms and Wall Panels



Completed Building using 'Hybrid' Construction, London



Plan Form of Building Showing the Modular Components



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*Forms of Construction:  
'Hybrid' modules supported by a primary  
structure*

*(1-D/3-D Construction)*



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Stability Provided by a Primary Steel Frame





Raines Court, London

### Modules Supported by a Composite Steel Frame





Modular Components Supported by Concrete Podium



Modular Construction for Social Housing in east London





Completed Building with Offices at Ground Floor



Steel 'Exo-Skeleton' with Modules Internally, Manchester



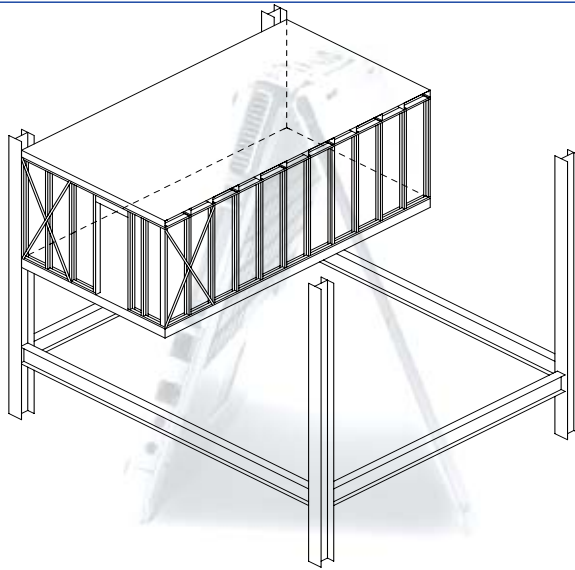
Open House system, Sweden using Square Hollow Section Columns



Completed Building using Open-House, Malmo , Sweden



Modules Supported by Steel Frame



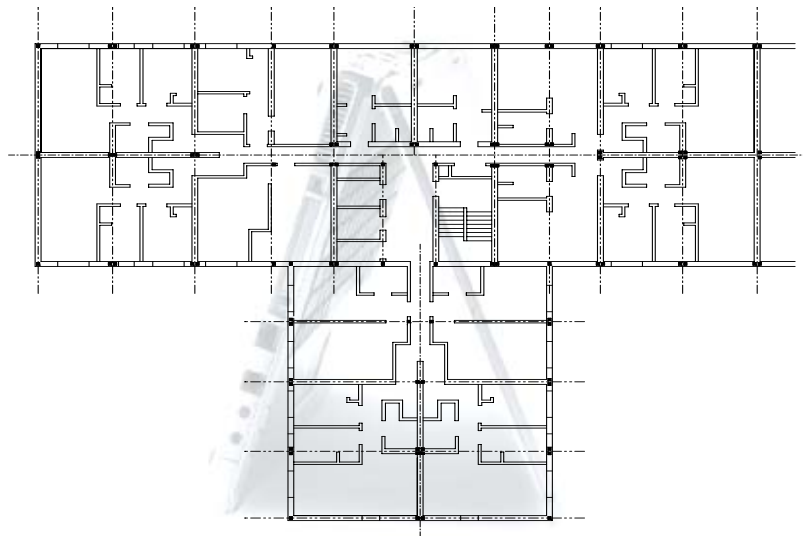
17 Storey Modular Building Stabilised by Concrete Core, London



Completed Modular Building with Concrete Core, London



Plan Form of Building Showing the Modular Components

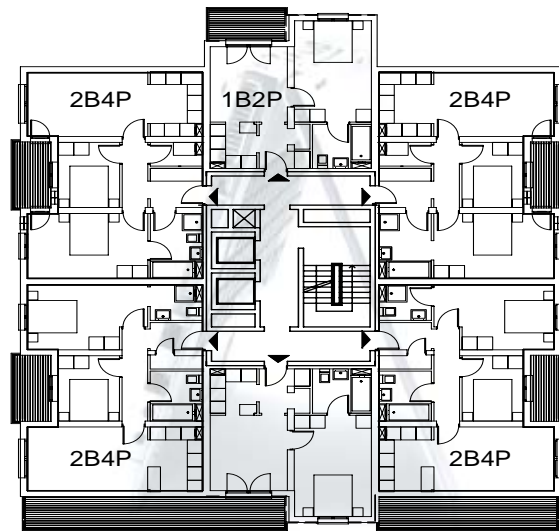




Composite Steel -Concrete Core- Bi-Steel



Plan Form of Building Showing a Core and Modules



Upper Floor

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*Forms of Construction:  
Primary frames and panels  
1D/2D Construction*



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Light Steel Infill Walls to Steel Frame



Light Steel Infill Walls in a Hospital



Light Steel Infill Walls with *Slimdek*



17 Storey Residential Building in *Slimdek*



Demonstration Building, Evreux, France





Structure of Demonstration Building, Evreux



INFRA Plus System using Inverted Slab, Rotterdam



La Fenetre using NFRA Plus System, Rotterdam



SMART House using Tubular Frame and Light Steel Walls, Rotterdam



SMART House using Concealed Tubular Connection



Plus Home, Ruukki, Helsinki



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*Forms of Construction:  
Steel in the Building Envelope*



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ESTADO DE NAVARRA

GOBIERNO VASCO  
GOVERNAMENTO EUSKAL

Large Pre-Fabricated Wall Panel, Lindab, Sweden





Large Pre-Fabricated Wall Panel, Kingspan



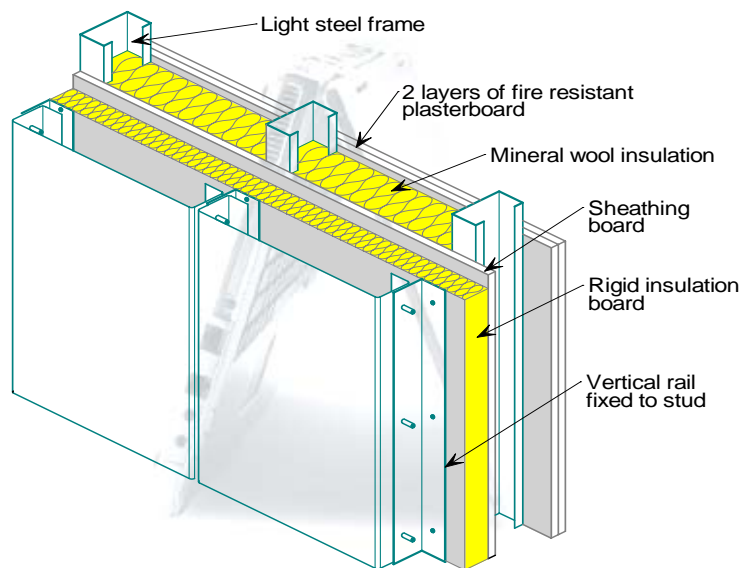
Large Pre-Fabricated Brick Panel



## Large Steel Cladding Panels for a Residential Building



## Insulation in Light Steel Wall Panel - U value <math>< 0.25 \text{ W/m}^2\text{C}</math>



Composite Panel used as Roofing in Housing



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*Sustainability and Economics of  
Industrialised Construction*



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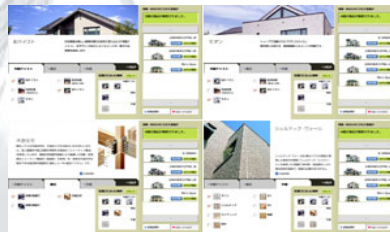
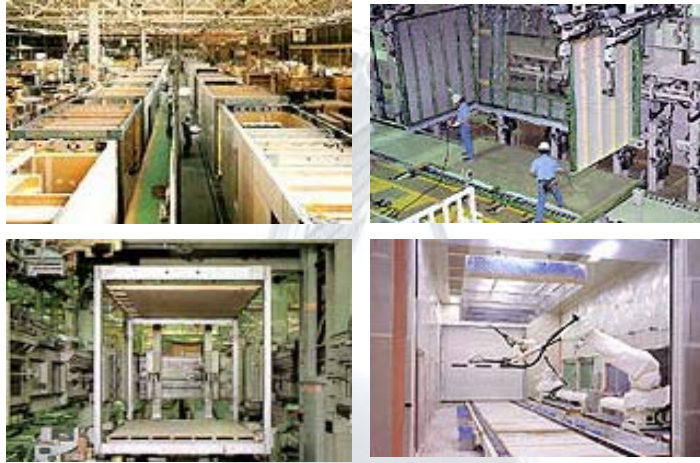
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GOBIERNO VASCO  
DEPARTAMENTO DE ECONOMIA

## Japanese Experience of Modular Construction





## Sustainability Benefits of Industrialised Construction

- Efficient use of materials and higher productivity
- Reduced waste and more re-cycling of wa
- Higher quality and longer life
- Faster construction with less disruption
- Safer construction technology
- Higher skills investment and improvement local economy



## Sustainability Comparisons of Modular Construction with Concrete Frame –Swedish Report SBI 229-2

- Materials use (by weight) reduced by 80%
- Materials from virgin sources reduced by 43%
- Embodied energy in materials reduced by 33%
- Re-cycleability of materials increased by a factor of 9
- Operational energy reduced by 32%
- Transport of materials reduced by 70%
- Furthermore, embodied energy is only 5% of operational energy over a 50 year life



## Key Benefits of Industrialised Construction

- Pre-fabricated components account for 70% of as-built costs
- Labour costs on site are reduced by 75%
- Construction period is reduced by 60%
- Construction risks are minimised
- But , as-built costs are currently 10-15% higher than traditional building
- Speed-related benefits lead to savings of 9%



## Conclusions

- Strong sustainability argument for industrialised methods of construction
- Need to develop strong economic arguments for industrialisation
- Need for standardisation, at least of geometry and interface details
- Need for education on new ways of building using industrialised technologies
- Economy of scale in manufacture will lead to economic benefits but this demands large projects

