Value Benefits of Modular Construction in Building Extensions

APPLICATIONS
ROOF-TOP EXTENSIONS
HOTELS
RESIDENTIAL
COMMERCIAL
HOSPITALS
EDUCATION
TRANSPORTATION

VALUE BENEFITS
LIGHT WEIGHT
SPEED OF INSTALLATION
REDUCED SITE INFRASTRUCTURE
EARLY RETURN ON INVESTMENT
IMPROVED FACILITIES & ACCESS
MINIMUM DISRUPTION
ROBUST CONSTRUCTION
GOOD ACOUSTIC INSULATION
CAN BE RELOCATED

After renovation

Before renovation

Modular Bathroom

SPEED OF INSTALLATION

Extensions to existing buildings using modular units can be constructed in less than 50% of the time required for conventional construction. The modular units can be installed in a few days (typically at a rate of 5–10 per day), and construction of the cladding is 'off the critical path'.

MINIMUM DISRUPTION

In renovation projects, disruption due to site activities is minimal, both in terms of minimising noise and dirt, and in terms of the speed of the process. Connections to the existing building can be made by modifying windows in the façade into doors. Balconies can be attached between the modules, thereby not requiring attachment to the existing façade.

REDUCED SITE INFRASTRUCTURE

The site facilities, storage, equipment and number of workers on-site are much reduced. The construction period is also reduced by over 50%, leading to an equivalent saving in site preliminaries. Costs of waste disposal are reduced to less than 20% of conventional construction.

EARLY RETURN ON INVESTMENT

The return on the investment using modular construction can be increased due to various factors:

- reduced interest charges (due to earlier completion)
- earlier rental (and often increased rental charges)
- less disruption (and temporary relocation costs)
- new or higher quality space (e.g. roof-top apartments)

The economics for a major extension to an existing hotel should take into account the loss of income of the existing facilities, and the income due to early completion. This can amount to 20% of the total cost of the extension work, which is a potential saving in using modular construction relative to site-intensive construction.

RELOCATION

Although not generally in new-build, it may be necessary to consider future relocation and re-use of the modular units in renovation projects. In this case, the asset value of the modules is maintained. Furthermore, it is not necessary to relocate the occupants of the building when modular units are installed, particularly in roof-top extensions.

New balconies and over-cladding, Finland.

Modular Construction in Building Extensions

Modular construction uses pre-engineered modular units which can be stacked and are self supporting. They can be used in new-build or in renovation, by attaching the units to the side of the existing building, or by placing them on the roof to create new living space.

Modular construction using light steel framing has the following attributes:-

SUSTAINABLE CONSTRUCTION

- ✔ Energy efficiency
- ✔ Efficient materials use
- ✔ Minimises waste
- ✔ Can be reused
- ✔ Ease of dismantling
- ✔ Long life product
- ✔ Minimum disruption

RE-THINKING CONSTRUCTION

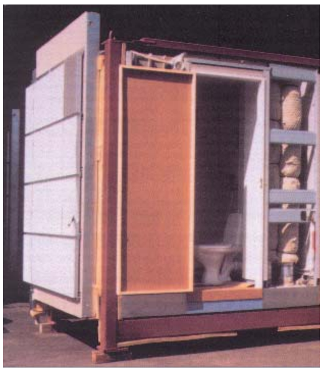
- ✔ Reduced costs
- ✔ Reduced time on site
- ✔ Increased productivity
- ✔ Certainty of budget and time
- ✔ Reduced wastage
- ✔ Safer construction
- ✔ Higher quality

Applications using Modular Construction

Modular construction is used in hotels, residential buildings, fast food outlets, and service stations where the benefits of speed of installation and economy of production scale can lead to major cost savings. The same technology may also be used in building renovation, where existing buildings may be extended horizontally or vertically, by use of modular units, thereby extending the useful life of buildings with the minimum disruption to the occupants.

The structure of the modules is light steel framing, and the units are often fully fitted out and clad in the factory before delivery to site. For building renovation, the modules may comprise new bathrooms, bedrooms, stairs, lifts, balconies and service pods.

The following projects illustrate the use of modular construction to extend buildings to provide high quality space and new facilities. Often, the use of modular units is combined with over-cladding of the existing façade, and as part of a comprehensive refurbishment to improve the buildings' life and function.



Modular bathroom.

Visualisation of the Plymouth building.

Roof top modules being lifted into place.

The University of Plymouth

The developer, Unite, chose modular construction for the roof-top extension of a University building in Plymouth because the 28 study bedrooms could be manufactured and fitted out 'off the critical path' and the installation could be carried out rapidly to meet the tight construction programme.

The light steel framework was designed and manufactured by Corus Framing, and the modules were assembled, fitted out and installed by Unite.

The modules were supported on a steel grillage on the existing flat roof of the 4-storey steel framed building constructed in 1948. The new shallow pitched roof is supported by the modules. Two types of modules were designed: 4-sided modules, and 3-sided modules that could be placed with the open side next to a closed side to minimise the thickness of the wall. Prototype tests were carried out to check the robustness of the modules during lifting and transportation, and to confirm acoustic insulation levels.

The installation of the modules took only 10 days. The building was fully renovated in only six months to meet the University's tight schedule for the new student year.

Modules fitted out at Unite.

Modules located on steel grillage.

Recent Applications using Modular Construction

Roof-top apartments using modular units in Hämeenlinna, Finland.

Pre-fabricated balconies and modular units at Forssa, Finland.

Projects in Finland

The Finnish steel company, Rautaruukki and its subsidiary Rannila Steel have created a production facility for modular bathrooms and toilets that have been used in both renovation and new-build projects in Finland. The short 'weather-window' in the Nordic climate is such that there is an imperative to build quickly in the summer months. By using modular units, the work can be done without displacing the occupants.

There is a large stock of concrete panel buildings in Finland, and a number of projects have been completed in which the buildings have been extended and over-clad to improve their appearance and life, and importantly, to reduce energy bills. New modular units (including a bathroom and sauna) are stacked and attached to the existing façade, and new balconies extend the building line and create high quality living space. The units are clad in steel cassette panels and the joints between them are covered by the same type of cassette panels on-site.

Examples of these projects are shown in Raahe (front cover, main image), and Forssa (above). In Hämeenlinna, a new floor with a pitched roof was added to a 4-storey building.

Project in Denmark

A series of 4- and 8-storey concrete framed buildings was renovated using light steel sub-frames and cladding, and new communal space was created on the existing roof. Modular construction was chosen for the new roof space because the large units could be completed on-site and lifted into place with minimum disruption to the occupants.

The roof-top extension was completed with a fully glazed façade with inclined tubular columns to support the roof. The building was also over-clad using steel panels in bright colours to counterbalance the busy road-side in the Rodovre suburb of Copenhagen.

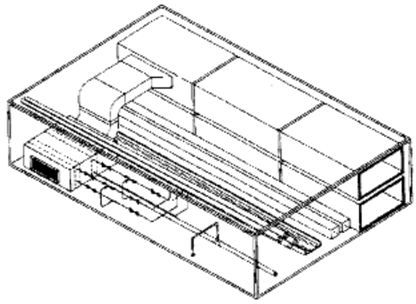
Communal space added to the roof in Rodovre, Copenhagen.

Modular Plant Rooms in NatWest Tower, London

Advanced construction techniques were used by Crown House Engineering for the mechanical and electrical engineering contract to refurbish the 42-storey, 200 m NatWest Tower in the City of London.

Crown House provided expertise and innovative engineering solutions for this major project to increase the speed of construction, while raising standards and controlling costs.

The installation of M&E services in the tower focused on Crown House's 'SuperRack' system. These multi-serviced, prefabricated light steel modules combine pipework, ductwork and cable tray in a single unit. The modules are pre-lagged in factory conditions, removing further work activity from the building site. Service installation periods were reduced by half.



Pre-fabricated services module.

Modular roof-top units being lifted into place.in the Copenhagen project.

Edinburgh University

A detailed design study was carried out on the renovation of a 3-storey student residence at Pollockhalls, Edinburgh University, constructed in 1968. The proposed upgrading consists of new roof-top study bedrooms and new bathrooms attached to the existing rendered masonry façade. The visualisation of the renovated building was carried out by the Department of Architecture of the University.

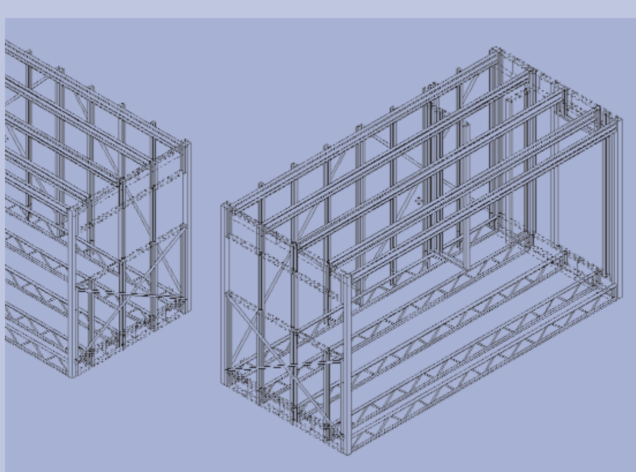
The new bedrooms are designed to be installed on the flat roof and have separate access. The new bathrooms will be constructed in pairs, and installed either side of a fully glazed window to maintain natural lighting. The University has not yet decided to proceed with this scheme, but the decision will be based on the use of the higher quality accommodation, particularly for conferences.

Original view of building.

Proposal showing bathroom pods and new roof extension.

CONSTRUCTION NOTES

Modular units comprise light steel framing which is designed to be sufficiently robust for the conditions existing during transportation and installation. The units are lined internally, and are often fully fitted out in the factory. Cladding can be attached prior to delivery to site, but this process is normally done on site in order to conceal the joints between the units.



Open-sided module.

TRANSPORT AND INSTALLATION

The maximum width of modules that can be transported is 4.2 m, but 3.6 m is the normal width for transport without restriction. The maximum length is up to 12 m depending on the trailer used, but 8 m is more typical. Units of heights up to 3 m can be transported easily.

Lifting of larger modules is carried out with a lifting frame; a lifting beam can be used for smaller modules. The angle of the lifting chains or cables should be such as not to cause excessive horizontal forces on the ceiling members.

MODULE DESIGN

Modules are usually designed with longitudinal edge beams that transfer the forces between the modules. Some modular systems are corner supported, in which case the edge beams, or in some cases, the braced walls, span between the corner posts.

Open-sided modules can be designed to create larger spaces, but in this case the edge beams are relatively deep (up to 450 mm). Lattice joists may also be used to provide space for service integration. The double skin floor and wall construction provides excellent acoustic insulation.

SERVICES

Modular design is most cost-effective when services, such as bathrooms and electrical fitments, are installed in the factory. The pipework is usually placed on the outside of the modules to facilitate vertical connections on site. The corridor between the modules can be used for horizontal service routes along the building.

FOUNDATIONS

Foundations are usually in the form of strip footings for edge supported modules, and pad footings for corner supported modules. In poor ground, the corner supported systems are more efficient with piled foundation. The foundations must be levelled accurately prior to installation of the modules.

CLADDING

All types of cladding may be used. Lightweight cladding may be attached directly to the module units. Brickwork cladding is usually directly supported by the foundation, and is supported laterally by the modules. In this case, the height of the brickwork is limited to 12 m. It is not generally economic for the brickwork to be supported directly by the modules at each floor level. In tall buildings, lightweight cladding is more economic.

Technical Aspects

Structure

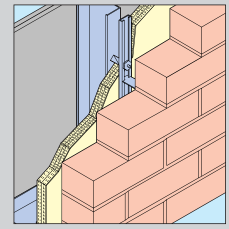
The light steel components are designed to BS 5950-5 and to Eurocode 3 Part 1.3.
Generally, C sections are used of 75–150 mm depth for the walls, and 150–450 mm depth for the floors. The strip steel is specified as S280 or S350 to BS EN 10147 (the numerical value representing the yield strength of the steel in N/mm^2). The steel is galvanized for durability.

Connections

The connections between the light steel elements may be made by screws, bolts, rivets or welds (the last two are only factory processes). The inter-connections between the modules over 4-storeys high must satisfy 'robustness' requirements. The self weight of the units is typically 1.0–1.5 kN/m^2, and holding down connections are only necessary for shear resistance.

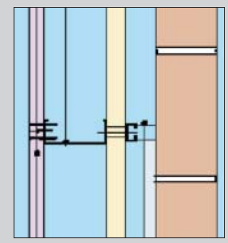
Cladding details

Brickwork may be attached by stainless steel wall ties located in vertical runners that are fastened by screws through the external insulation to the light steel framework. Lightweight cladding is directly supported by the light steel framework and can be attached at the factory.



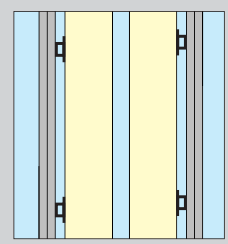
Thermal insulation

The required thermal insulation can be achieved by external insulation, to create a 'warm frame', or by additional insulation placed between the studs. In this second case, the moist air that exists in bathrooms must be ducted out of the space to avoid condensation.



Acoustic insulation

Double skin floors and walls achieve airborne sound reductions of over 60 dB, which can be enhanced by additional insulation placed between the studs. Impact sound reductions are also good, and cement particle boards are often used for their rigidity and acoustic insulation.



SCI PUBLICATIONS

Modular Construction Using Light Steel Framing: An Architects Guide
SCI P272

Case Studies on Modular Steel Framing
SCI P271

Over-Cladding of Existing Buildings using Light Steel
SCI P247

Over-Roofing of Existing Buildings using Light Steel
SCI P246

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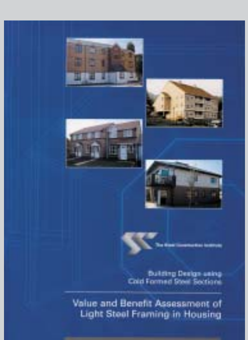

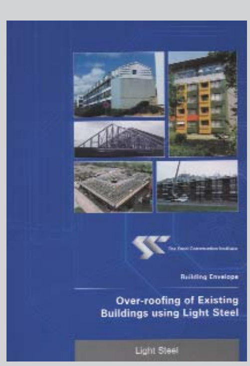

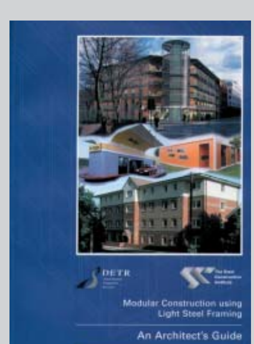

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