

Vision
Modular
Structures
Design Guide



VISION
Modular Structures

BM
barrett mahony

Benefits of Design Using Volumetric Modules

Prefabrication of buildings by off – site manufacture (OSM) as a form of construction is increasing as the potential benefits in terms of faster construction, improved quality and reduced waste are realised. The benefits of a finite cost and a potential programme reduction of up to 50% in build time are gaining attention.

The principles of volumetric modules allow a significant part of a building to be completed off site, and delivered when foundations / structure are at a suitable stage. The building work then proceeds at the rate of erection achievable by the modular system. Most OSM projects involve a significant proportion of site work in the construction of foundations to transfer structures ranging from 10% to 40% commonly of the overall works.

Volumetric or modular construction systems are manufactured from a series of 2D wall, floor and ceiling elements assembled into load bearing modules and stacked on site. Once interconnected the modules form a diaphragm structure equivalent to more traditional construction methods. These units can be fully fitted out internally with doors, and services in place, kitchens and bathrooms fitted prior to delivery to site.

These modules are best suited to apartments, key worker accommodation, hotel units and student residences. The modules can be constructed with corridors included which improve the speed of construction and reduces the overall number of units.

The factory process may involve 20 stages to maintain the continuity in production with many of the processes involving traditional construction methods. This work is all

completed indoors in factory conditions with all the required materials to hand. As a result the process is less affected by skills shortage than traditional construction as permanent, long term jobs are on offer with continuity of work for personnel as opposed to often temporary transient workforces employed on traditional sites.

Completed modules are weather protected and delivered to site or stored for just in time delivery. Safety records tend to be very good on the modular site as the number of workers on site is significantly reduced and the workers on site are involved in a more limited number of situations due to the repetitive nature of the modular construction.

The reduced programme effects, material delivery and storage make the volumetric construction method very suitable to developments where disruption may be a problem such as adding to an existing hotel, providing key workers accommodation at various developments including hotels, prisons etc.

When the modular elements are erected many of the finishes are then applied both internally in corridors and to the external façade. This ensures that the modular construction is not evident in the final building. The finishes internally, aesthetics externally and feel of the building may be of a higher quality but will not be identifiable otherwise from traditional construction. The maintainability and durability of the building will exceed many other forms of construction particularly in the area of shrinkage.

The following pages outline the design and detailing considerations specific to the Vision Modular Structures Volumetric system.



DESIGN USING VISION MODULAR STRUCTURES VOLUMETRIC MODULES

INTRODUCTION

The **Vision Modular Structures** volumetric module (VMSVM) is constructed with a concrete floor, structural walls and a steel trussed roof. The modules are designed for stacking vertically with the transfer of loads through the structural walls. VMSVM modules are very suitable to cellular construction but also offer significant flexibility in terms of shape and internal openings between modules.

Modules are manufactured from a series of 2D elements including floor, ceiling and a variety of walls depending on the complexity of the module. The modules vary in shape from simple rectangular elements to quite complex irregular shapes with splayed corners and stepping of the walls on plan. The walls are the primary load bearing elements of the structure and are therefore designed to bear on the walls of the modules below. The walls are constructed with structural box sections allowing current developments of 16 storeys with potential for higher.

The ceiling is constructed with a lightweight truss incorporating the service zone and designed to support loads during erection, manufacture and finally service loadings in the permanent condition. The floor is constructed from reinforced concrete and is structurally independent of the ceiling in the lower module providing excellent acoustic



Lifting Module On Site

performance. The standard structural walls offer 120 minutes fire resistance.

The Vision Modular Structures volumetric modules are constructed and fitted out in the factory at Ringaskiddy, County Cork in Ireland. The modules are loaded onto trailers and transported around Ireland and the UK by road and sea. All elements are watertight and finished to a very high standard before transporting resulting in minimal work on site to connect services and complete finishes.

Module Construction in Factory

Vision develops a close working relationship with the design team at an early stage of a project as it is essential to coordinate all elements of the manufacturing process. Modular construction generally requires early design freeze and this is aided by rapid resolution of any design issues. Project milestones are identified early on in the development stage of the project in order to identify the manufacturing and delivery dates.

This document, as an aid to Architects, sets out the basic principles of design using the VMSVM and addresses the opportunities for reasonable levels of standardisation. This includes the module dimensions, cladding details, balconies and general construction suitable for planning and construction stages.



Key Benefits

- Reduced construction time – approximately 3 apartments erected each day
- Reduced costs
- Factory quality construction and finishes
- Reduced waste and environmental impact

Development Benefits

- **Speed**
 - Design – specialised in-house knowledge speeds up design stage
 - Construction – Factory built with all materials preordered, available and no down time due to weather.
- **Safety**
 - Reduced number of workers on site
 - Workers have reduced number of tasks and hazards
 - System building allows detailed analysis of risks at each stage
- **Regulations**
 - British and Irish Standard Compliance
 - British and Irish Building Regulations Compliant
 - SDS Compliance when required
 - ECO homes standards when required
 - Building Insurance Compliant
- **Materials**
 - Concrete floors
 - Variety of cladding materials possible, stone, brick, render, timber, metal
 - Robust construction
 - Flexibility in layout

End User Benefits

- **Quality**
 - Quality of finish from factory construction
 - Solid concrete floors
 - Exceptional sound rating



Cores and Modules under Construction at Rockbrook

STABILITY

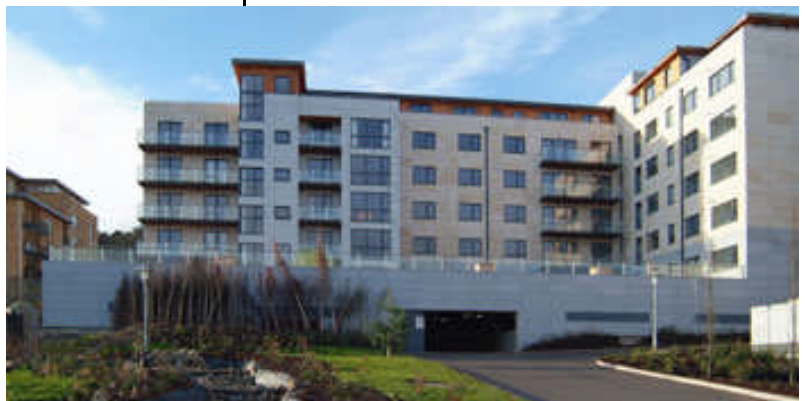
The stability of the Vision Structural Volumetric Modular building is generally achieved by the use of a concrete or steel core. In this way the stability is similar to most medium height buildings. The concrete floors are connected together between modules to create a diaphragm at each floor allowing horizontal building loads to be transferred back to the core.

Structural cores may not be required for low rise buildings with the modular walls providing racking strength for stability. This is dependent on the building layout, wall openings and the number of modules in each direction and is reviewed on a project specific basis.

THE STRUCTURAL GRID

The support structure is generally a conventional design in steel or concrete and may allow significant flexibility in terms of layout. Structural grids may be coordinated with the modules for efficiency, but in most structures the

Completed Vision Modular Building





requirements for flexibility will not permit this. Structural grids of up to 10m x 10m have been achieved over retail units with ten storeys of modules above. In some developments the modules are set back from the edge of the support structure to allow for support for balconies or external space at this level. A number of developments have been completed with modules supported directly over car parking with the module layout not relating to the car park grid.

Where the module support is not directly off the foundations, a slab is always constructed to provide a working platform and deal with secondary structural effects.

THERMAL PERFORMANCE

The VMSVM Building System can be designed to have elemental U-values for its walls, floors and roof varying from 0.27W/m²K to 0.12 W/m²K. The external elements of the system are designed to meet both the UK and IRL Building Regulations requirements under Approved Document L and Part L respectively. The system was also assessed for thermal bridging during the BRE Certification assessment and meets the requirement of Part L for thermal bridging.

AIRTIGHTNESS

Approved Document L1 A for new dwellings and the new DEAP energy calculation software in Ireland for BER Certificates requires type testing to be done to an airtightness standard of no greater than 10m³/(h.m²) at 50 Pa. The VMSVM Building System is assembled in a factory-controlled environment, which

**Irregular
Module
Layout On
Regular
Structural
Grid**

allows a higher level of quality control than would be normally possible on a construction site. This level of quality control over workmanship together with module assembly details designed to provide airtight construction allow the modules to achieve an airtightness of less than 3m³/(h.m²) at 50 Pa.

BUILDING ENERGY RATING (BER) CERTIFICATES

As the VMSVM Building System can have excellent elemental U-values, low thermal bridging, very good airtightness and has no chimneys in its design it can be specified to provide an A rated BER Certificate in both the UK and IRL.

SUSTAINABILITY

Off-site construction is ideal for the construction of sustainable buildings and can achieve a Code Level 3, which is a very good rating under the new Code for Sustainable Homes in the UK. The majority of materials used in the VMSVM Building System receive an A rating in the BRE 'Green Guide' 2007.

QUALITY

VMSVM are manufactured in a quality controlled factory environment, which allows a higher level of finish to be achieved than could normally be expected on site. All 1st and 2nd fix plumbing, electric, carpentry, tiling, painting and installation of kitchen and white goods is done in the factory which allows all work leaving the production facility to be virtually snag free. This high quality level of finish is a unique benefit of the VMSVM Building System.

**Factory
Controlled
Quality**





FIRE PERFORMANCE

All load bearing walls have been structurally Fire tested to EN 1365-1. The fire performance of walls can be designed to vary from 90 minutes to over 180 minutes or higher if required.

The standard load-bearing wall in the system provides 120 minutes fire resistance with services integrated within the wall.

All floors within the system are 150mm concrete and are designed to provide 90 or 120 minutes fire resistance to suit building regulations.

ACOUSTIC PERFORMANCE

The separating walls and floors in the system provide excellent acoustic performance and exceed both the airborne and impact acoustic sound requirements for the UK and IRL Building Regulations.

DURABILITY

The system has been assessed for a minimum design life of 60 years.

CERTIFICATION

The VMSVM Building System has BRE Certification for IRL and UK for single or multi occupancy residential buildings. The system has been assessed with brick/block and stone cladding systems but can also accommodate other suitable approved external cladding systems.

**Parkview
Balcony**

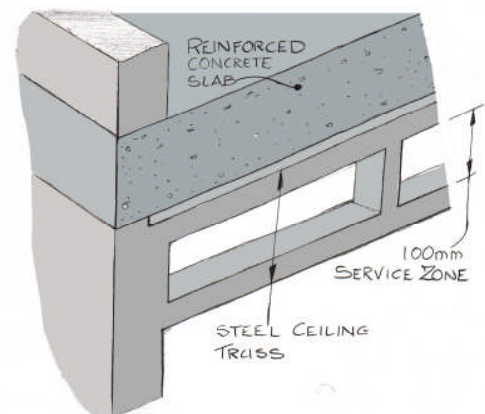
The system will also have IAB certification in the near future.

BALCONIES

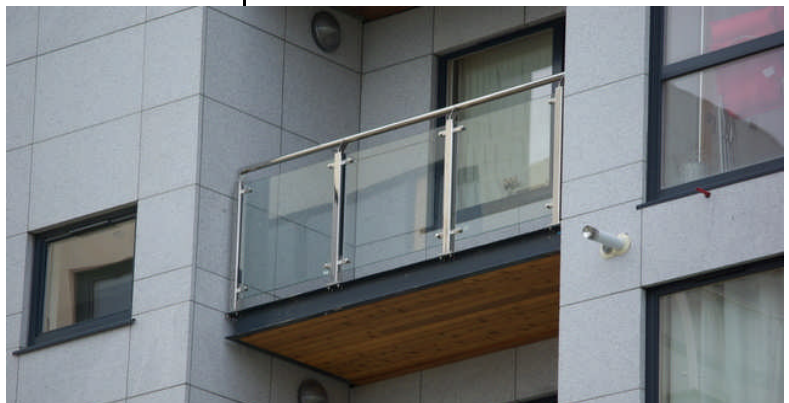
Vision Modular Structures Volumetric Modules will support a variety of balcony types. The most common types are the cantilevered balcony and the self supporting balcony. Cantilevered balconies are supported by fin plates from the structural floor with size limitations similar to cantilevered balconies on traditional construction. Self supporting balconies usually with a series of structural columns need only be tied back to the modules for stability with no size restrictions.

FLOOR AND CEILING ZONE

The finished floor to underside of ceiling zone is 350mm in the Vision Structural System. This zone includes a 150 deep reinforced concrete slab in each module and a service zone of 100mm throughout the ceiling. The 150 floor slab is designed to support the required imposed loading based on occupancy and detailed to provide the required fire resistance.



**Parkview
Finishes**





The ceiling truss provides the support structure for workers during the erection process. This is the most onerous loading on the truss as the in service condition only require the truss to support lightweight services and the ceiling finishes. A service zone of 100mm is achieved in the centre of the truss allowing comfortable space for the apartment services.

CLADDING

There are various types of cladding suitable for use with the Vision Modular Structures Module. Masonry is commonly used and in this case the floor to floor height is taken as 2775 to tie in with the 75mm brick standard coursing. Where possible returns and windows are co-ordinated with a multiple of 225mm in the horizontal. Variable cavity widths may be necessary to achieve the 225 coursing width. In some instances the lower four storeys of masonry may be supported from the ground level and masonry above this must get vertical support from the modules. All the masonry is tied horizontally to the module for lateral support.

Another finish which is regularly applied is stone which must be supported at each storey. Therefore brackets are provided at each floor slab level to achieve vertical support. All stones are tied back horizontally to the module for lateral support. Stone cladding is detailed to match returns and window locations.

Various other cladding materials are available with a range of weights, finishes and support methods.

Parkview Completed Block

Lifting Module Onto Podium



MODULE DIMENSIONS

A number of factors may influence the allowable sizes of a module. These factors include transportation, site accessibility, weight and factory limitations. For standard production rates the preferred module limitations are as follows:

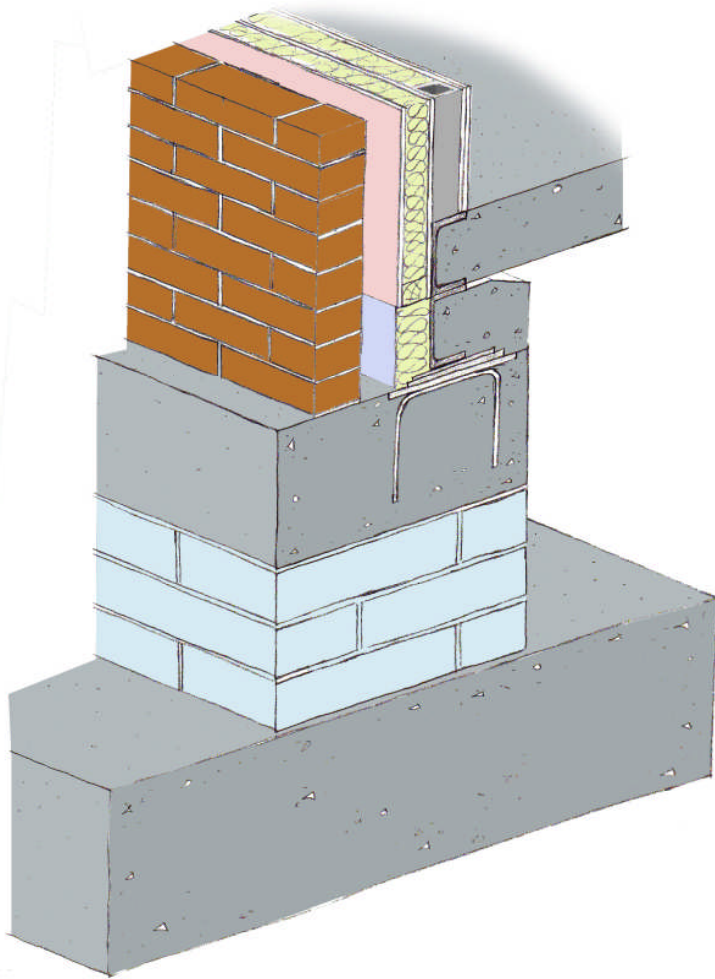
1. Width 4.0m outer face of floor steel
2. Length 10.6m outer face of floor steel
3. Height 2.8m floor to floor

Larger sizes are common but not preferred as part of the standard production and must be considered in terms of:

1. Frequency
2. Transportation
3. Construction difficulty

The walls are constructed with structural box sections allowing the system to be erected up to 16 storeys in height. The overall wall width between modules is 200mm finished increasing to 240mm on the lower floors of the taller buildings. The combined floor and ceiling depth is 350mm.

The preferred storey heights are 2775 for masonry finishes and 2800 for other finishes. Higher modules may be constructed for applications such as apartment and hotels. Typically the floor to floor in these units are in the region of 3150 and they are usually on the lowest floor. Taller modules have also been used at penthouse levels with sloped ceilings in some instances.



platform for the erection of the modules. This ensures that the modules are erected very accurately and vertical.

SERVICES

The Vision Structural module arrives to site almost fully finished internally with many services in place. Plumbing and wiring are completed in the module with site connections required between adjacent modules and into the cores.

Kitchens and bathrooms are complete with all fixed furniture in place. Vertical connections to soil stacks and horizontal connections of other services are completed on site.

As a result all service locations must be determined at an early stage in a projects life in order to fully plan the modules. Fittings must also be selected at a much earlier stage than in traditional construction as these are in place when modules arrive on site.

Numerous services rise and fall through the modules. These services enter and exit at the underside of the lowest module. Where the use of the structure below facilitates it, the services will drop through and run along the ceiling below. This is generally the case with car parking structures where exposed services are acceptable. Where the occupancy below is under separate ownership such as retail or commercial, then access to services may be an issue. An alternative in this instance is to create a service void above the supporting structure such that services can run to vertical drops. Drops may be local to cores or structural elements such as columns and walls.

SUPPORT STRUCTURE

Vision Structural Modules are suitable for a variety of occupancies and as such are suitable for numerous development types. Often they are used for purely residential situations and also where lower floors are either commercial or car parking.

Where the modules commence at ground level with no basement works then subject to ground conditions a simple strip footing with a rising wall may be used to support the modules. This would change to a system of ground beams where piling was employed due to ground conditions.

Where the ground floor is commercial or basement car parking is required then the modules are generally supported off a reinforced concrete transfer slab.

In all instances a system of steel work is erected on the founding structure to a high degree of accuracy providing a level

Module Support On Strip Foundation

Steel Supports On Foundations





FINISHES

These photographs indicate some of the finishes that may be achieved with the VMSVM. The projects in Ireland may use the following finishes which achieve the 60 Year design life where required

- 1 Stone
- 2 Masonry
- 3 Lightweight render up to 4 storeys
- 4 Timber at Penthouse
- 5 Metal at Penthouse

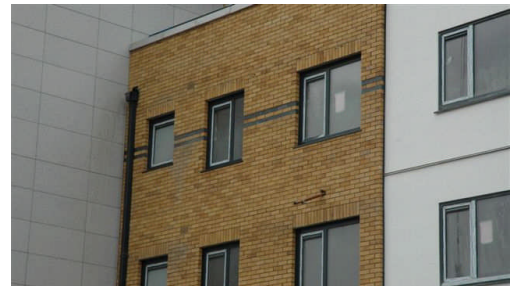
The lifetime requirements in the UK are less only requiring 25 years and so a significant range of cladding materials are available.

- 1 Stone
- 2 Masonry
- 3 Lightweight Render
- 4 Timber Cladding
- 5 Metal Cladding
- 6 Rainscreens

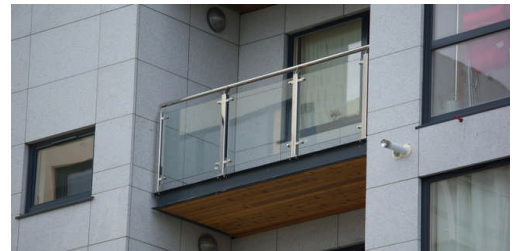
Finished Apartments Parkview



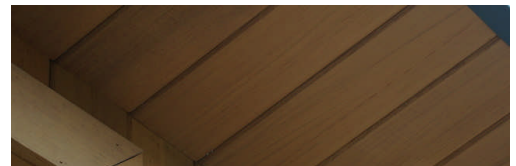
Brick And Render Finish



Stone Cladding On Parkview Apartments



Timber Soffit



KITCHENS

The kitchens are ordered at an early stage of the project and are delivered to the Vision factory for installation. The kitchen layout is based on the Architects design with suggestions by the team in Vision. Loose items are restrained in place for transportation.

Floor and wall finishes are applied in the factory and again will achieve a very high standard of finish. All the services for the kitchen are connected and centralised for connecting between modules or to the services in the core.



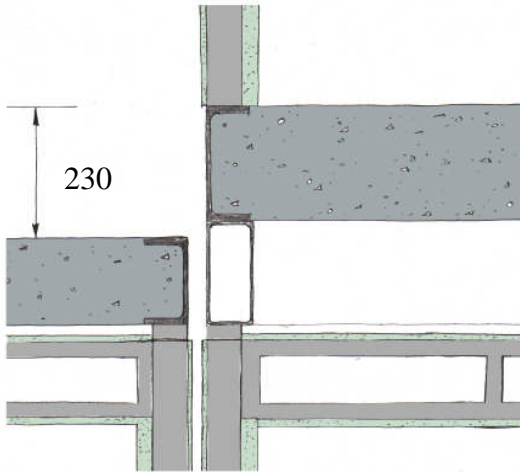
BALCONIES

Balconies may be cantilevered, supported off columns or created by a recess in the building. The balcony locations are identified at an early stage and the applied loads considered in the module design. The detailed design of these element is required somewhat later than the module sign off date.

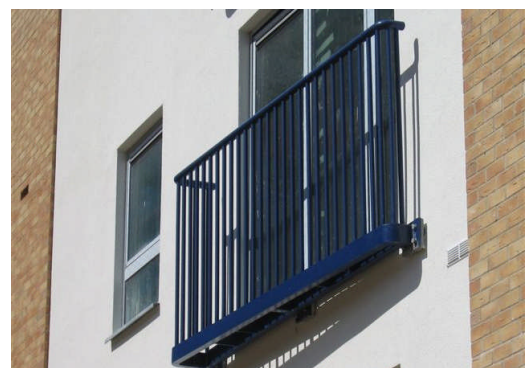
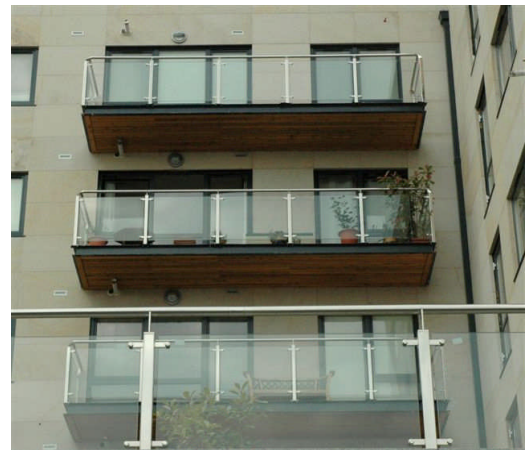
The cantilevered balcony has been completed on a number of projects varying from standard balcony sizes to Juliet balconies. In the majority of cases the finish is constructed with a timber deck. Soffits may be finished with a variety of materials.

Column supported balconies are also used extensively on the Rockbrook apartment development. Column supports will allow larger balconies than the traditional cantilevered type.

The handrails may be stainless steel or mild steel galvanised and painted. The infill panels are most commonly constructed in glass but there are no restrictions.



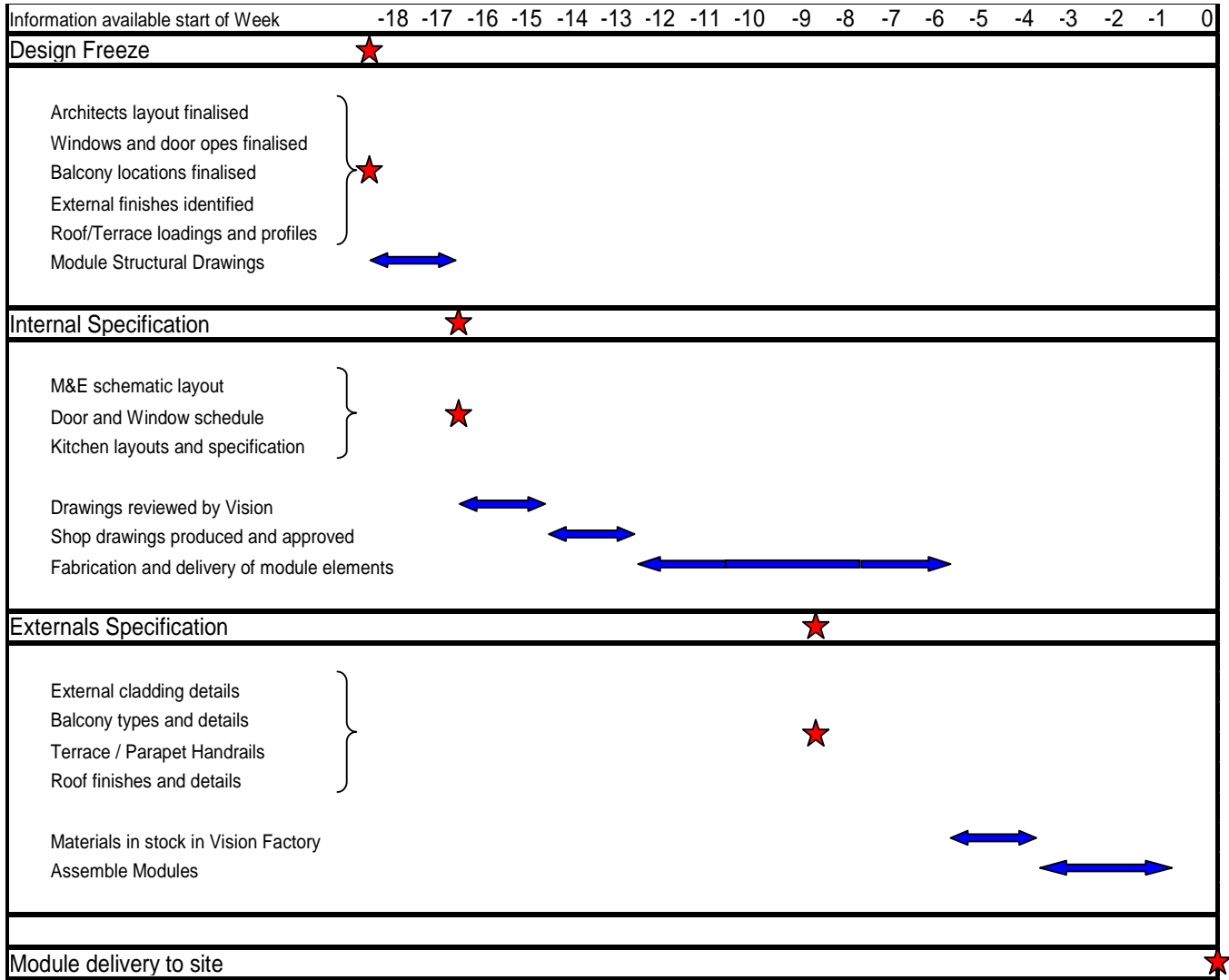
External terrace areas are also achievable with the VMSVM. A concrete plank is used in the terrace area and the adjoining floor is lifted 230mm to allow for weathering.



INTERIORS



TYPICAL PROJECT PROGRAM

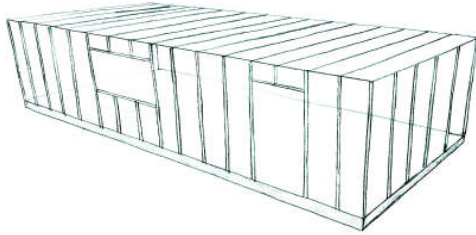


MODULE SIZE AND SHAPE

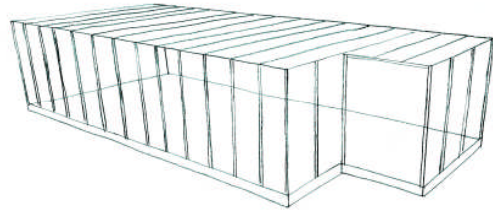
The modules are designed individually to suit each project and may have a significant range of shape and sizes. The preferred dimensions are listed below but many variations to this are available:

1. Width 4.0m outer face of floor steel
2. Length 10.6m outer face of floor steel
3. Height 2.8m floor to floor

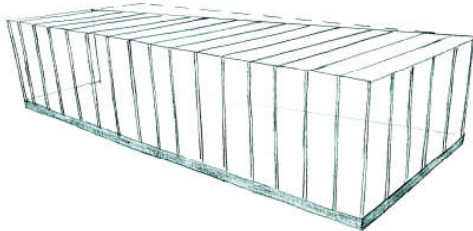
The following are typical shapes for modules used in the majority of cases.



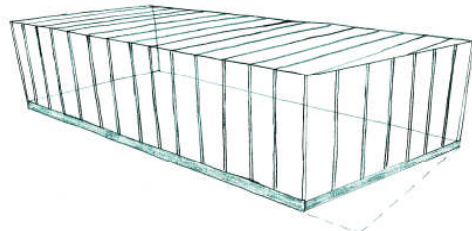
Standard



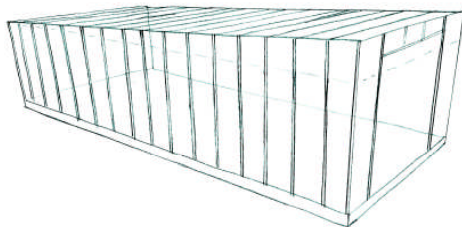
Notched



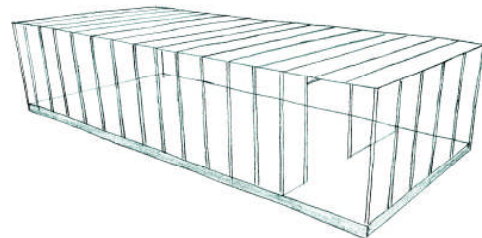
Side Tapered



End Tapered

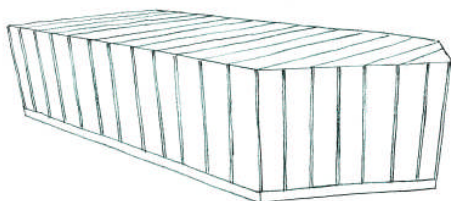


Penthouse

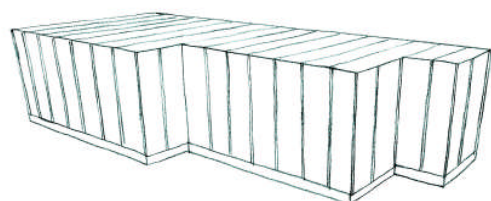


Corridor

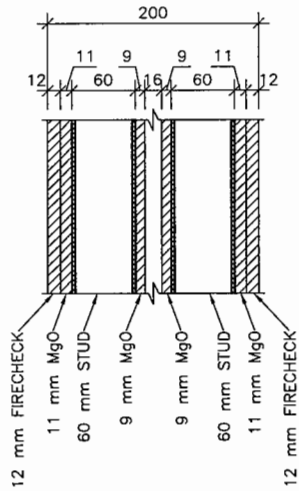
The system of construction is also flexible to allow totally bespoke modules to fit difficult layouts. These modules often allow the surrounding modules to be of standard construction



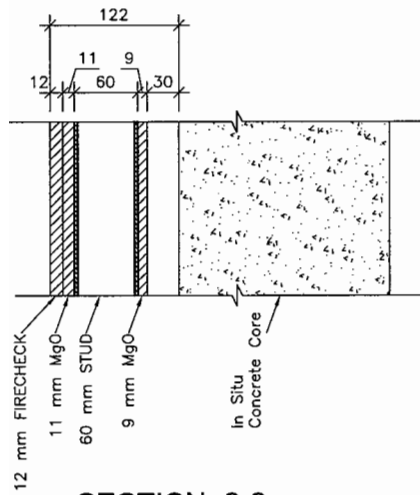
Bespoke



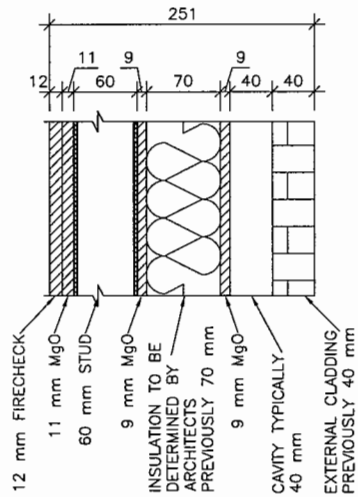
Bespoke



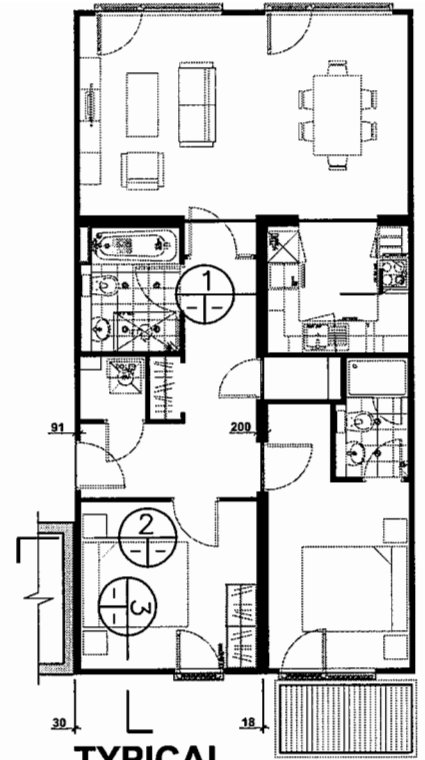
SECTION 1-1



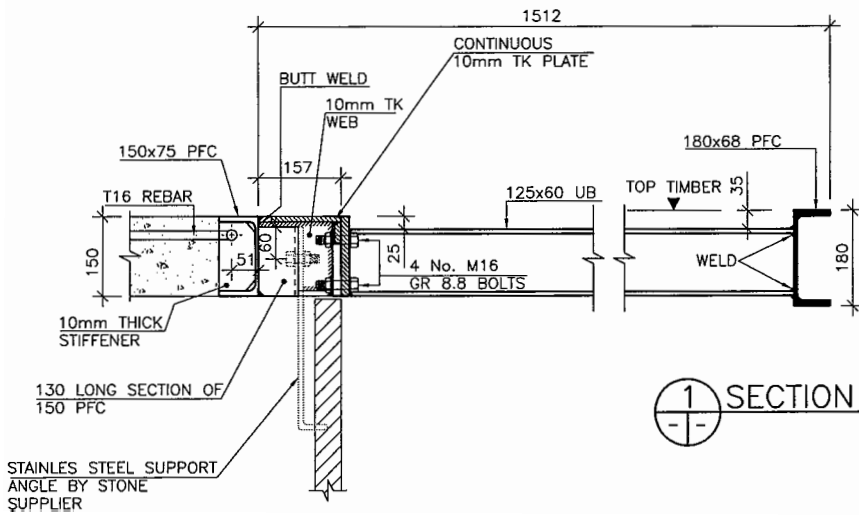
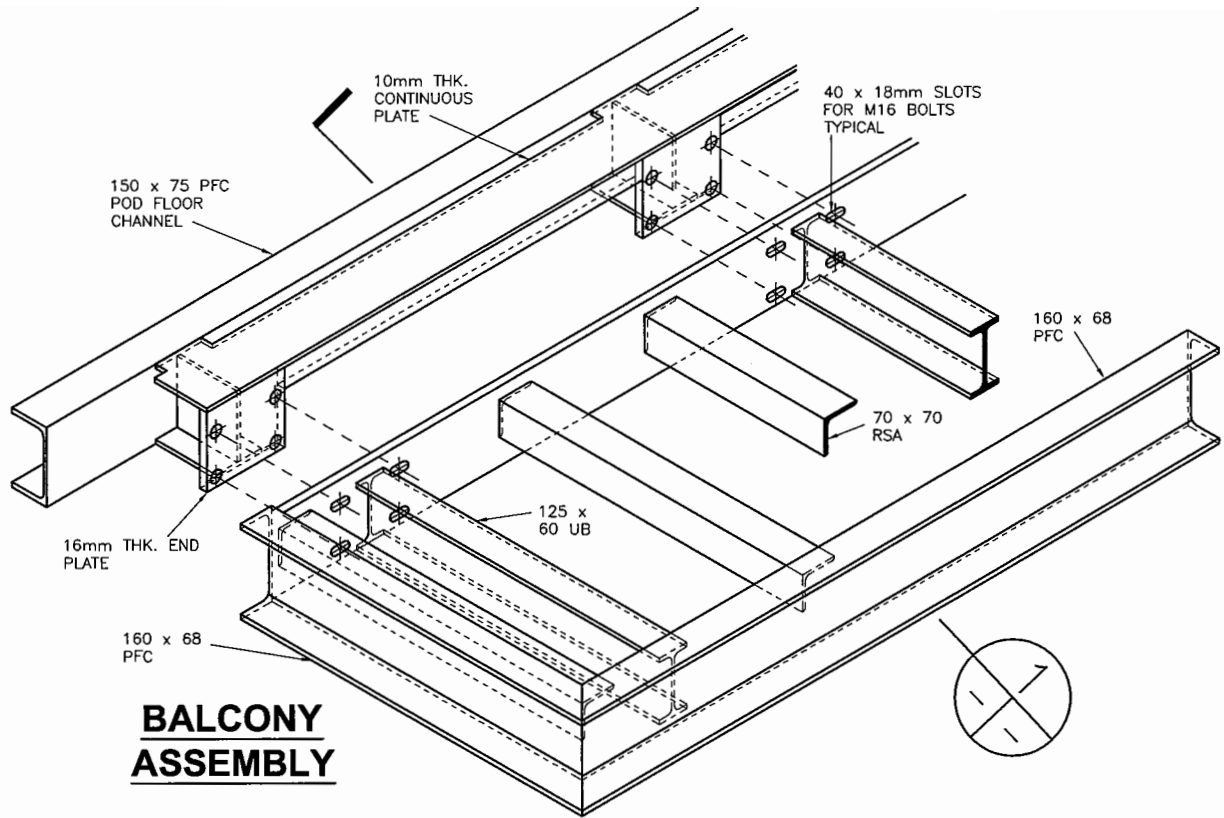
**SECTION 2-2
AT CORE**

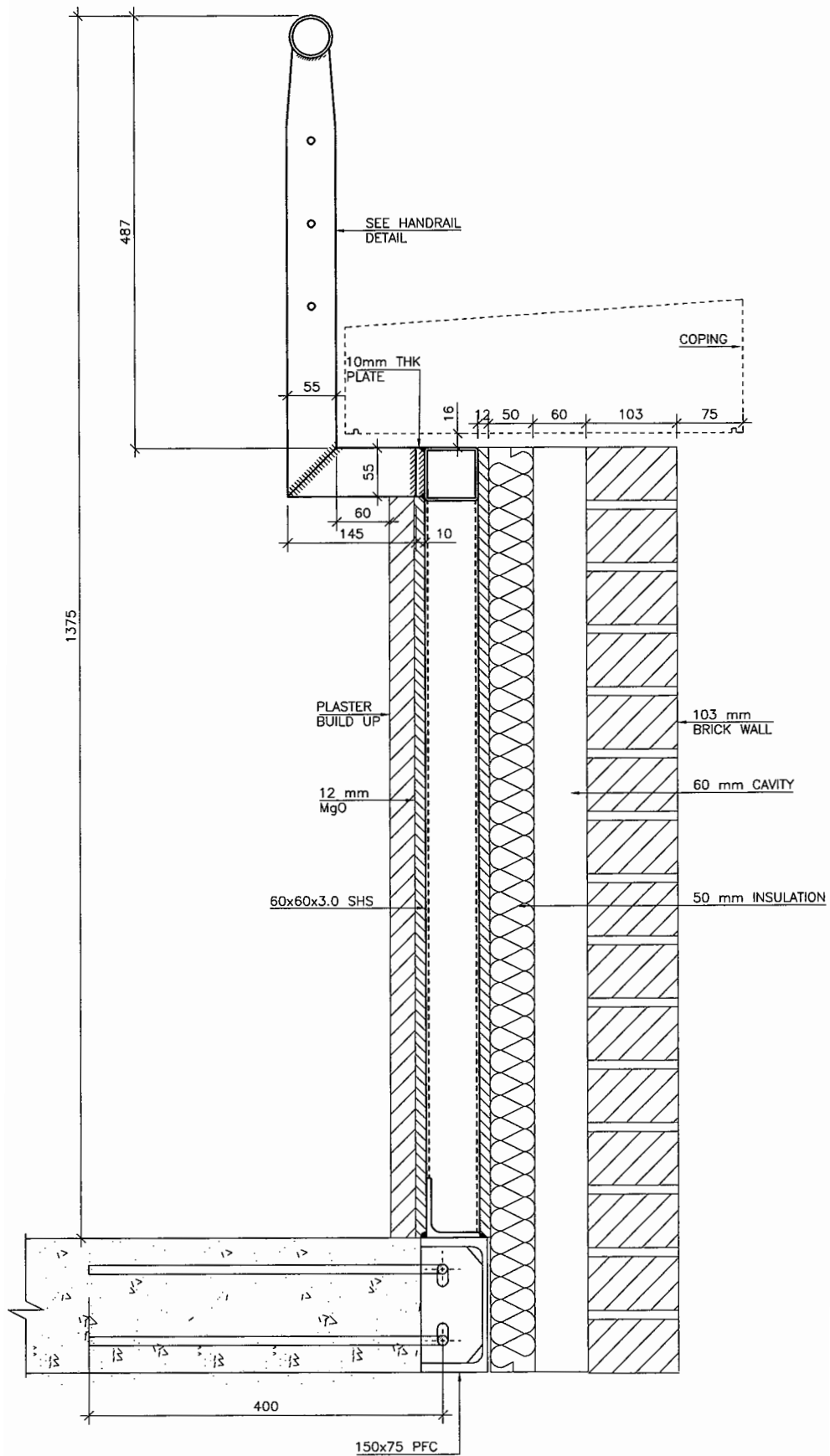


**SECTION 3-3
EXTERNAL WALL**

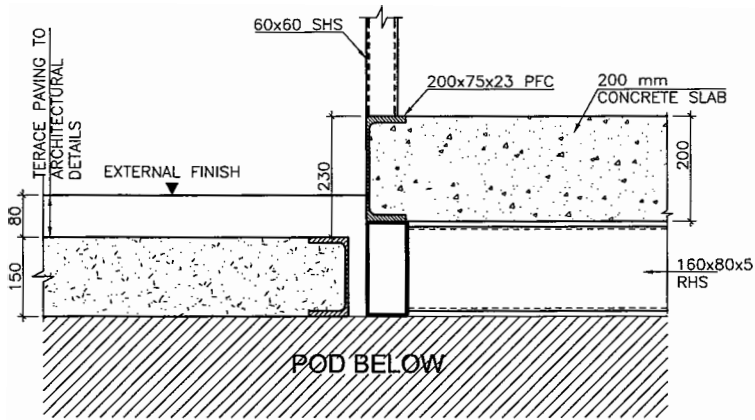


**TYPICAL
APARTMENT
ARCHITECTS
FLOOR PLAN**

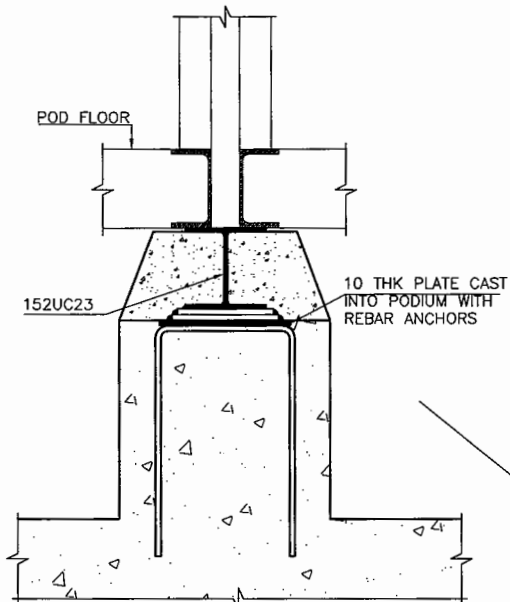




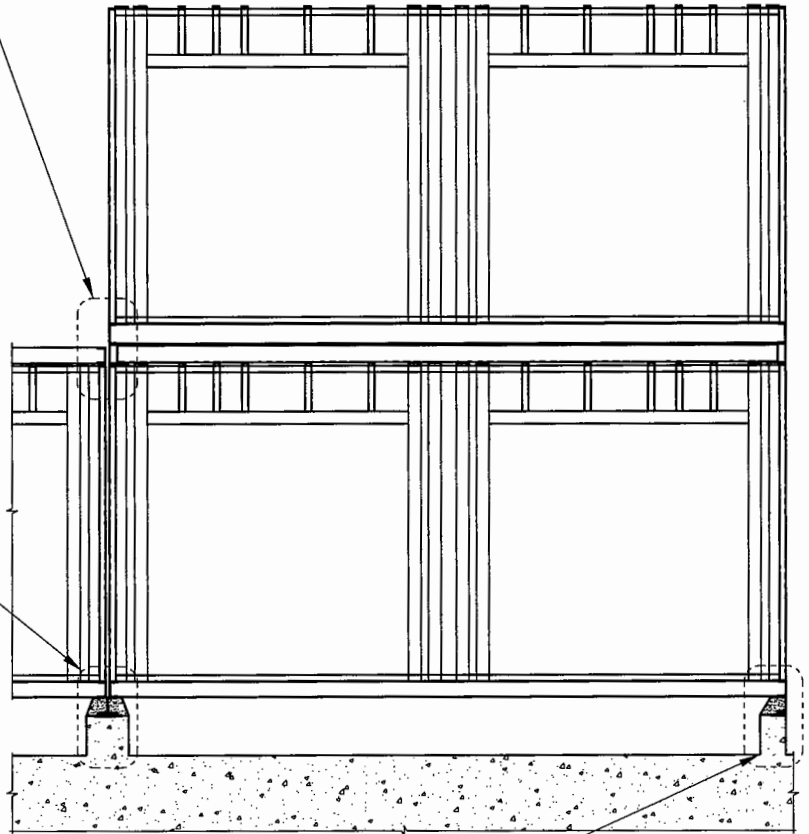
**HANDRAIL
DETAILS**



TYPICAL SECTION THROUGH TERRACE

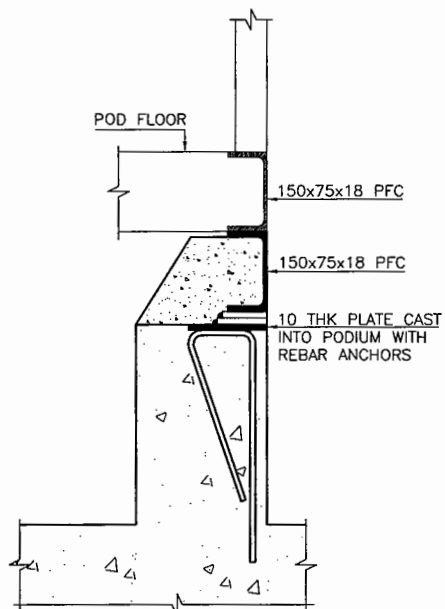


TYPICAL PODIUM STEEL INTERNAL DETAIL

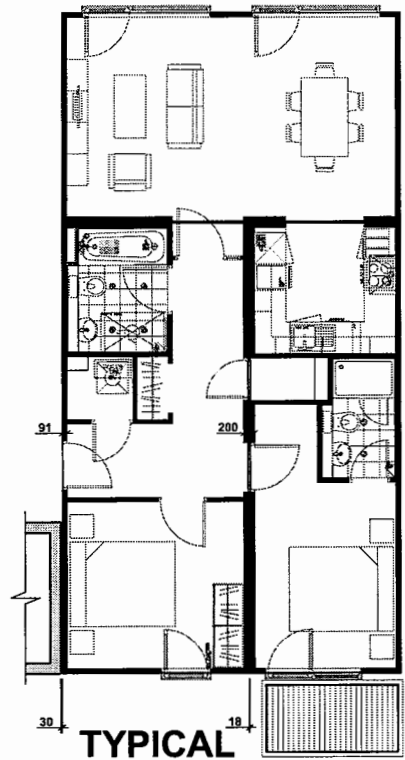
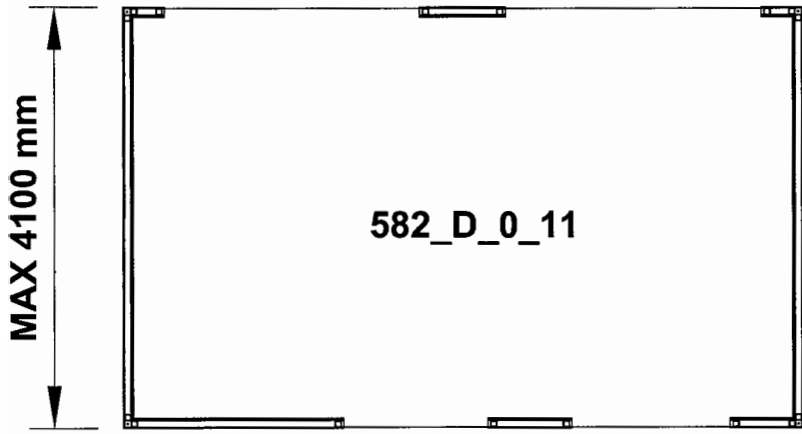


TYPICAL WALL ELEVATION

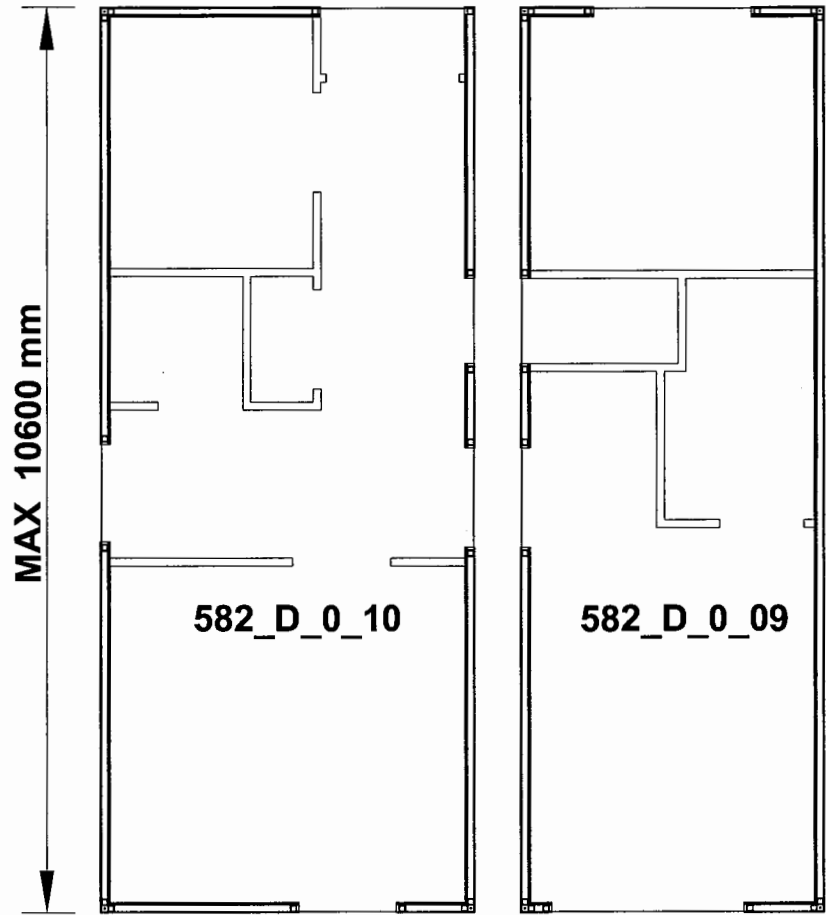
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TYPICAL PODIUM STEEL EDGE DETAIL



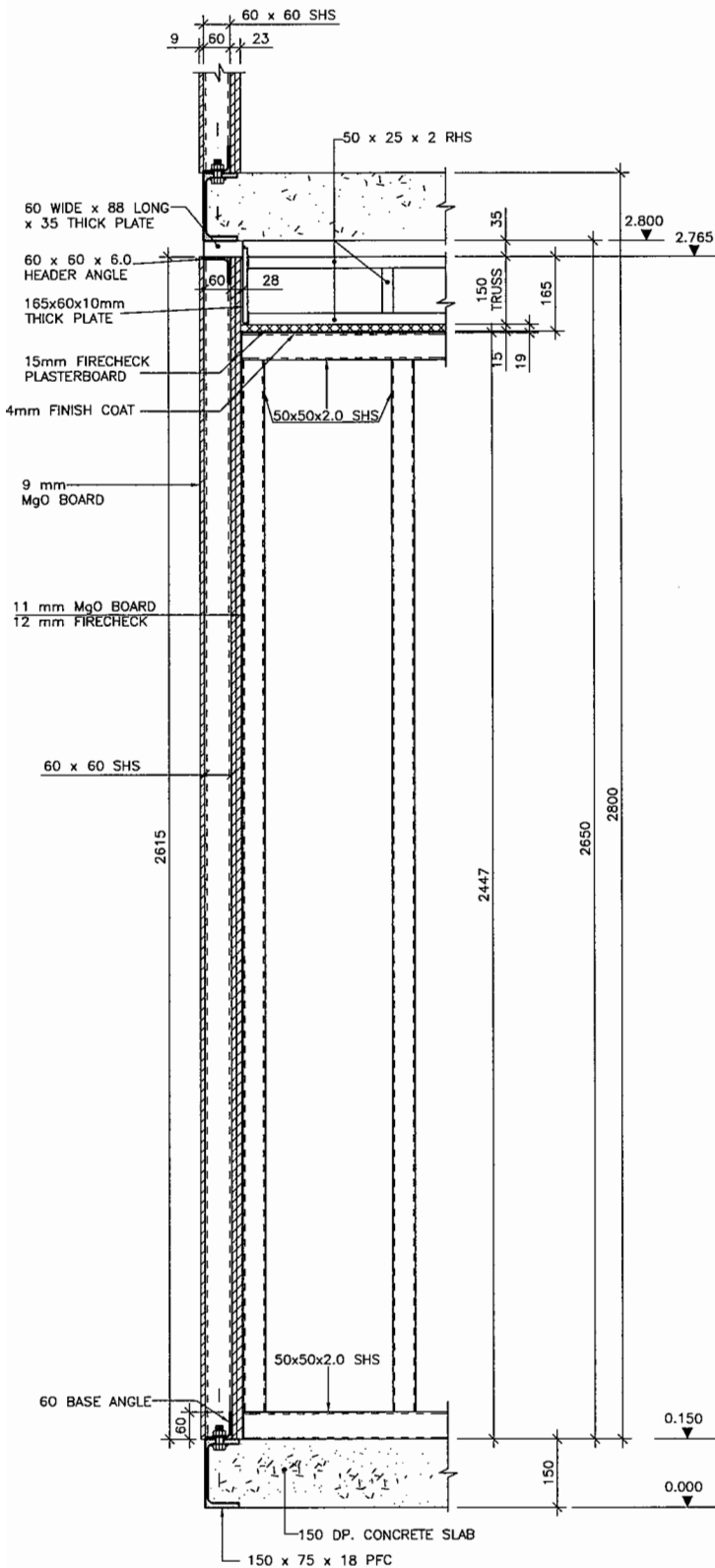
**TYPICAL
APARTMENT
ARCHITECTS
FLOOR PLAN**



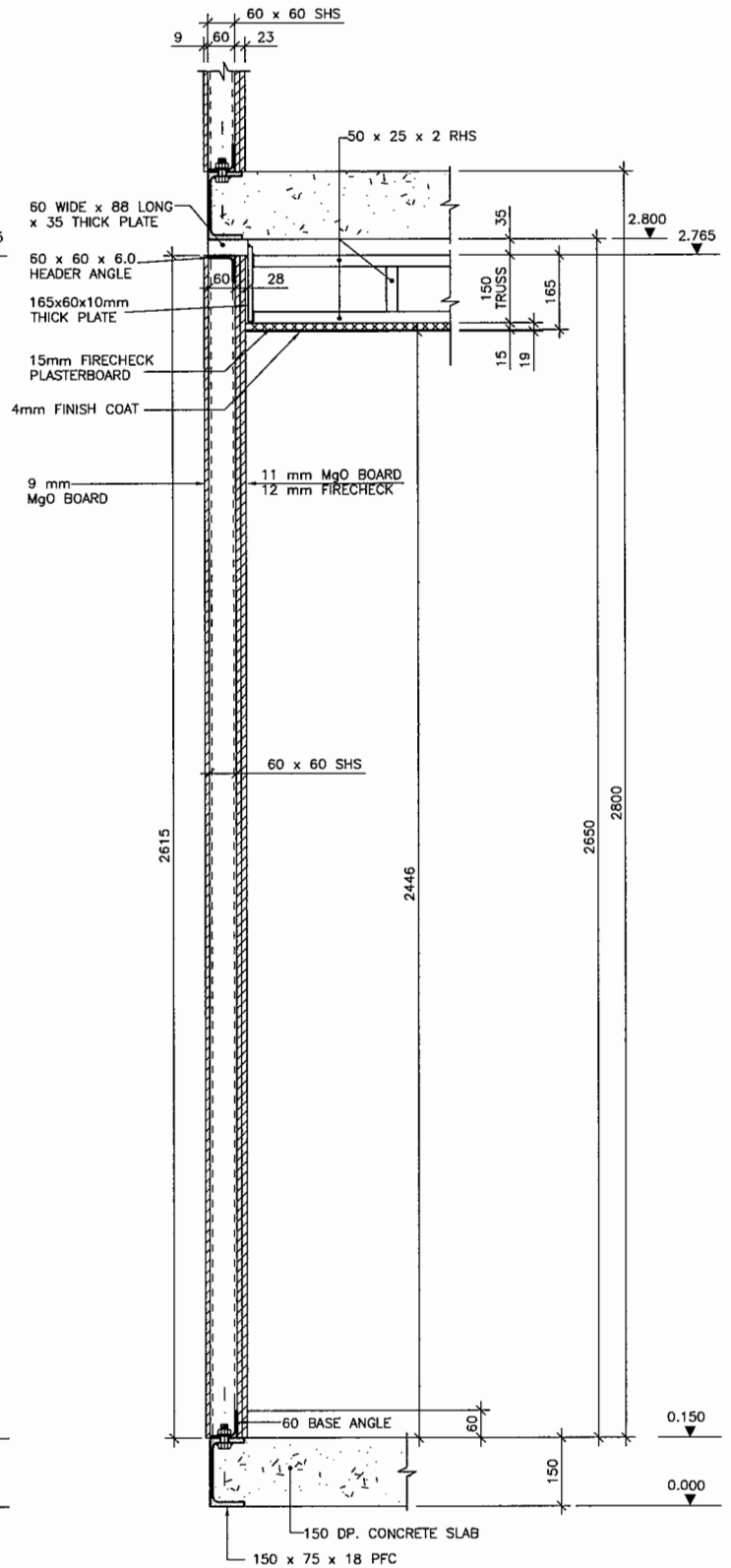
**TYPICAL APARTMENT
POD FLOOR PLAN**

NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL ENGINEERS & ARCHITECT'S DRAWINGS. FIGURED DIMENSIONS ONLY (NOT SCALING) TO BE USED. WHERE A CONFLICT OF INFORMATION EXISTS OR IF IN ANY DOUBT - 'ASK'.
2. CONSULTANTS TO BE INFORMED IMMEDIATELY OF ANY DISCREPANCIES BEFORE WORK PROCEEDS.



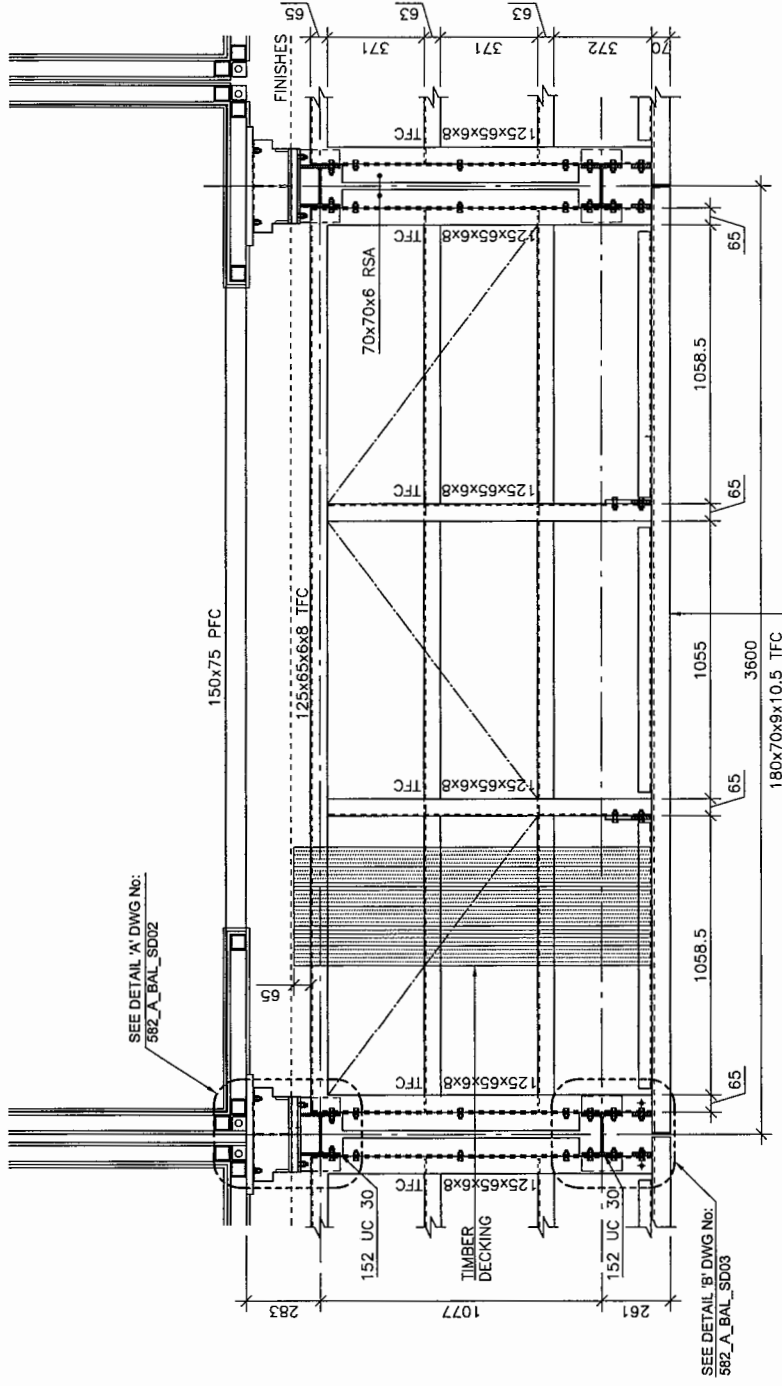
**FULL HEIGHT
SECTION THROUGH
MODULE WALL
WITH INTERNAL WALL**



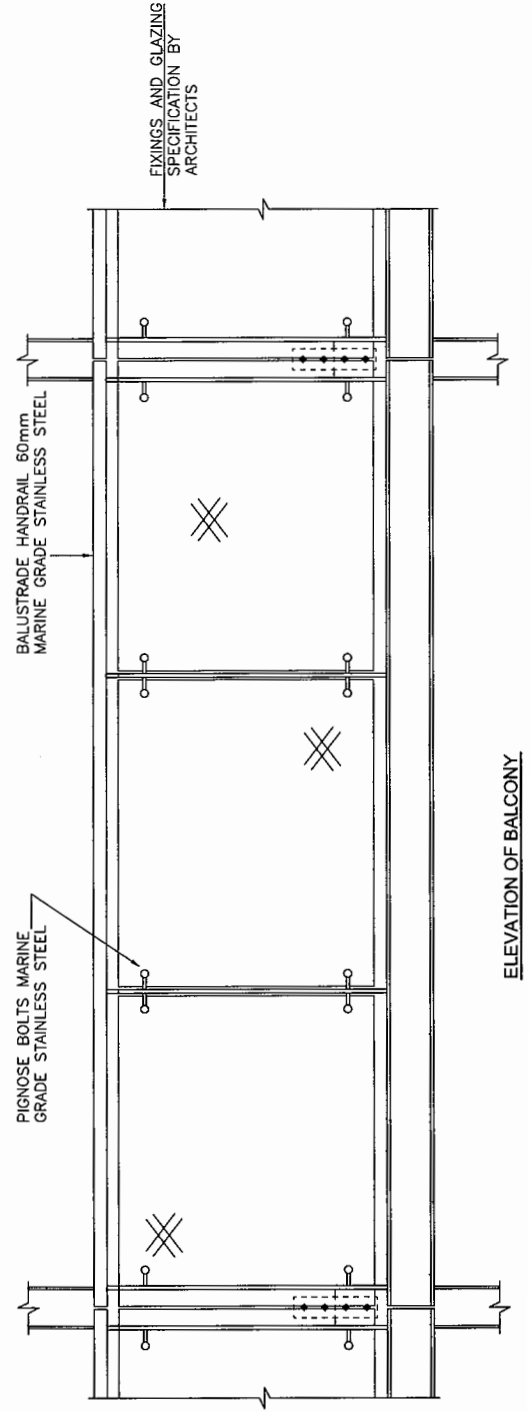
**FULL HEIGHT
SECTION THROUGH
CORRIDOR WALL**

NOTES

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TYPICAL BALCONY PLAN



ELEVATION OF BALCONY

