modular coordination

BCA Buildability Series

Building and Construction Authority

MODULAR COORDINATION

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The Modular Coordination Steering Committee was formed in 1985 to promote and oversee the implementation of Modular Coordination in Singapore. These notes were updated from the earlier guide to include more current examples of projects and components that have used modular coordination in design.

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CONTENTS

INTRODUCTION

These notes on Modular Coordination in the Buildable Design Appraisal System are produced as part of BCA's Buildability Series. Its objective is to introduce designers to the concept of modular coordination and its benefits. At the same time, it gives some practical advice on the application of modular coordination using actual projects as examples. The recommended modules in these notes take into consideration the need for flexibility in design and the sub-module has been introduced for this purpose. As modular coordination becomes more widely practised in the local industry, these notes may be revised and the recommendations will be reviewed to achieve a higher level of modular coordination that will benefit the building industry.

Background

Modular Coordination was first explored as an aid to design shortly after the introduction of prefabrication in the construction industry in the industrialised nations. It was conceived as a further step in the development of systematic design and construction of buildings. This subject has been discussed and attempted in actual building experiments in practically every developed country. At present, the actual application of Modular Coordination varies in different countries. For Scandinavian countries and the Republic of Ireland, it has become an essential tool in their building design and construction.

Modular Coordination was first studied in Singapore when metrication was introduced, in the early seventies. The Housing & Development Board implemented the concept in 1973 in the new generation flats. Through standardisation, it had to some extent solved the problems faced by the construction industry then: material shortage in steel, cement, timber and plywood, manufacturing delay; and labour shortage, especially the skilled labourers such as carpenters and plasterers. Prefabrication and standard components were subsequently introduced. Modular blocks and bricks were introduced in 1983. There are merits to extend the use of Modular Coordination in other components as well.

Basis Of Modular Coordination

Modular Coordination is essentially based on:

(a) the use of modules (basic module, multi-modules and sub-modules);

(b) a reference system to define coordinating spaces and zones for building elements and for the components which form them;

(c) rules for location of building elements within the reference system;

(d) rules for sizing building components in order to determine their work sizes;

(e) rules for defining preferred sizes for building components and coordinating dimensions for buildings.

Benefits Of Modular Coordination

Modular Coordination is a useful design tool that provides modern design principles and rules which combine freedom in architectural planning and free choice of construction method, with the possibility of incorporating standardised modular components in the project. When applied throughout the industry, it brings the following benefits:

(a) better coordination and cooperation between various parties in construction;

(b) reduction in design time, especially with the use of standard details and dimensional coordination;

(c) benefits through the increased use of Computer Aided Design and Drafting;

(d) reduction in manufacturing and installation costs;

(e) reduction in the wastage of materials, time and manpower in cutting and trimming on site;

(f) facilitating prefabrication.

As in the case of introducing a new machinery, designers who intend to apply the Modular Coordination principles must realise that it would require considerable effort and discipline and the process may not be pleasant, at least initially. However, in the long term, it is likely to pay off when the tool is understood and used effectively; more so if implemented throughout the industry.

CHAPTER 1

Terms And Definitions

The terms on Modular Coordination introduced in this Chapter ensure a common understanding by everyone and the definitions will assist others who are new to the subject. The Chapter consists of the following Sections:-

1.1 Coordination

1.1.1 Dimensional coordination

The application of a range of related dimensions to the sizing of building components and assemblies and the buildings incorporating them.

1.1.2 Modular coordination

Dimensional coordination using the basic module, multi-modules, sub-modules and a modular reference system.

1.2 Modules

1.2.1 Module

A dimension used as a basis for dimensional coordination.

1.2.2 Basic module (M)

A module of 100mm.

1.2.3 Multi-module

A module which is an agreed multiple of 100mm.

1.2.4 Planning module

A multi-module chosen for a planning grid.

1.2.5 Sub-module

A module which is an agreed subdivision of 100mm.

1.3 The Building Reference System

1.3.1 Reference system

A system of points, lines and planes to which sizes and positions of a building component or assembly may be related.

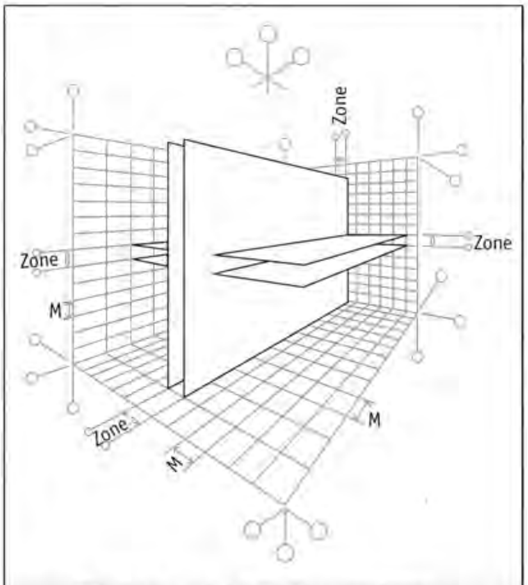


Fig 1-1: Modular Reference System

1.3.2 Reference plane

A plane of a reference system.

1.3.3 Reference zone

A space bounded by reference planes in a building to receive a component, assembly or element including, where appropriate, allowances for tolerances and joint clearances.

1.3.4 Modular line

A line of a modular reference system.

1.3.5 Modular plane

A plane of a modular reference system.

1.3.6 Modular zone

A zone between modular planes.

1.3.7 Modular size

The size of a modular dimension.

1.3.8 Planning grid

A reference grid for the plan of a building.

1.3.9 Modular grid

A reference grid in which the distance between consecutive parallel lines is the basic module or a multiple thereof.

1.3.10 Space grid

A three-dimensional network of reference lines.

1.3.11 Modular space grid

A space grid in which the distance between consecutive parallel lines is the basic module or a multiple thereof.

1.4 Zones

1.4.1 Zone

A space between reference planes within or in relation to which a building component is arranged. The space may be left unfilled.

1.4.2 Wall zone

The zone where the wall is accommodated and it includes the wall finishes.

1.4.3 Floor zone

The space in section where the floor assembly is accommodated, it extends from the top of the floor finish to the bottom of the ceiling of the floor below.

1.4.4 Roof zone

The zone stretching from the bottom of the ceiling of the top floor to the top of the roof of the building.

1.5 The Controlling Reference System

1.5.1 Controlling plane

A plane in a planning grid by reference to which the theoretical positions of structural elements are determined.

1.5.2 Controlling zone

A zone between controlling planes, provided for a floor, roof, loadbearing wall or column.

1.5.3 Controlling dimension

A dimension between controlling planes, such as floor-to-floor height, distance between axes of columns, thickness of controlling zone.

1.5.4 Modular floor plane

A horizontal modular plane spreading continuously over the whole of each storey of a building and coinciding with the upper surface of floor finish.

1.5.5 Floor-to-floor height

The dimension between the upper controlling plane of one floor zone and the upper controlling plane of the floor zone immediately above.

1.5.6 Floor-to-ceiling height

The dimension between the upper controlling plane of one floor zone and the lower controlling plane of the floor or roof zone immediately above.

1.5.7 Height of floor zone

The dimension between the controlling plane of a ceiling and the upper controlling plane of the floor immediately above.

1.5.8 **Floor-to-roof height**

The height between the upper controlling plane of one floor and the upper controlling plane of the roof immediately above.

1.5.9 **Height of roof zone**

The dimension between the controlling plane of a ceiling and the upper controlling plane of the roof immediately above.

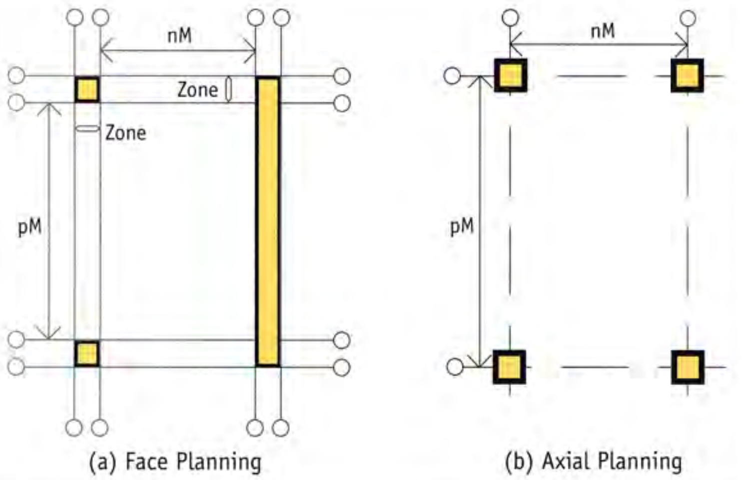


Fig 1-2: Horizontal Controlling Dimensions

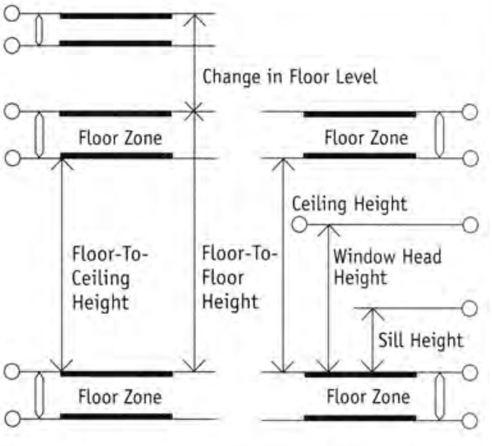


Fig 1-3: Vertical Controlling Dimensions

1.6 The Component Reference System

1.6.1 Coordinating line

Line bounding the zones where elements or components are fitted.

1.6.2 Coordinating plane

A plane by reference to which a building component or assembly is coordinated with another.

1.6.3 Coordinating space

A space bounded by coordinating planes, allocated to a building component or assembly, including allowance for joints and tolerances.

1.6.4 Coordinating dimension

(1) A dimension of a coordinating space.
(2) A dimension which is common to two or more building components to permit their assembly.

1.6.5 Coordinating size

The size of a coordinating dimension.

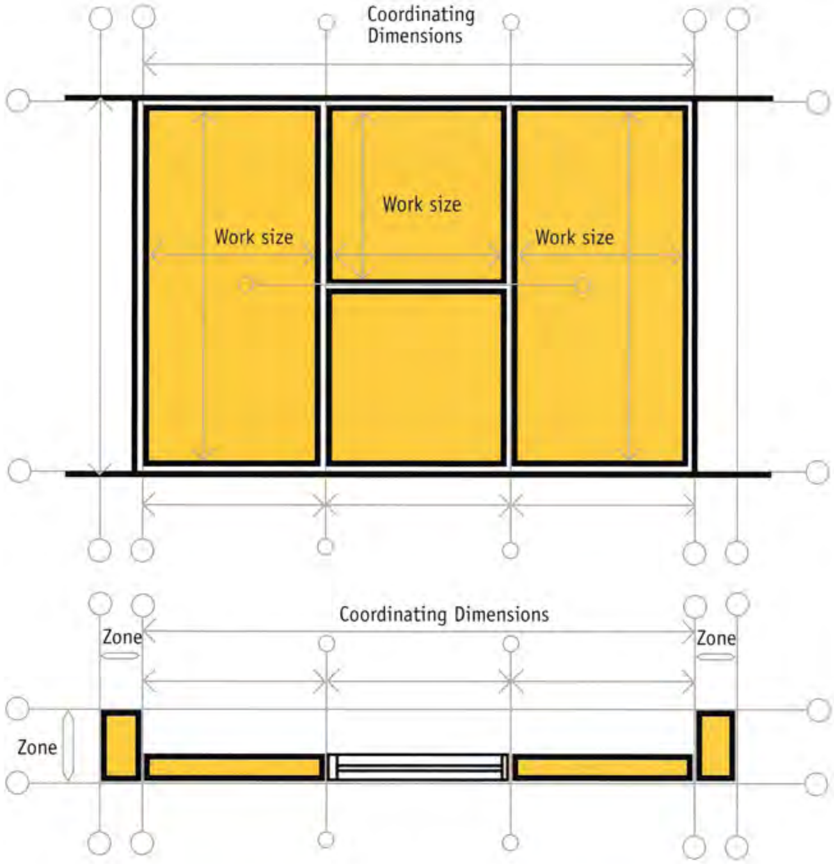


Fig 1-4: The Building Component And Controlling Planes

1.7 The Building Component And Its Sizes

1.7.1 Component
A building product formed as a distinct unit.

1.7.2 Modular component
A component whose coordinating sizes are modular.

1.7.3 Element
A part of a building or structure having its own functional identity, such as a footing, a floor, a roof, a wall or a column.

1.7.4 Modular element
An element whose coordinating sizes are modular.

1.7.5 Preferred dimension
A dimension chosen in preference to others for specific purposes.

1.7.6 Preferred size
A size chosen in preference to others for specific purposes.

1.7.7 Work size (manufacturing dimension)

A dimension used by the manufacturer of a building component or assembly to ensure that the actual dimension lies between the maximum dimension and the minimum dimension.

Terms & Definitions

1.8 Alphabetical Index

CHAPTER 2

Graphic Convention

The graphic convention is to provide a better understanding of the drawings for buildings designed using Modular Coordination. They differentiate the modular items from those that are not and enable easy identification.

The convention in this Chapter includes:-

Dimensioning Lines

Zones And Spaces

Grid Reference

2.1 Dimensioning Lines

Fig 2-1

Reference spaces allocated for particular elements of construction and the associated usable spaces are bounded by a system of reference planes represented on drawings by lines terminating in small circles (Figure 2-1).

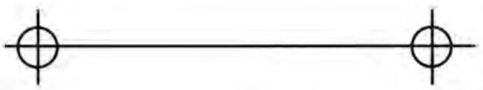


Fig 2-2

Additional reference planes are represented as above but with crossed lines in the circles (Figure 2-2).

Fig 2-3

Reference planes which coincide with axes of columns or axes of other components may be represented by chain lines terminating in small circles (Figure 2-3).

Fig 2-4

The dimensions of the spaces between two relevant reference planes (coordinating dimensions) are represented on drawings by straight lines with open arrows at each end (Figure 2-4).

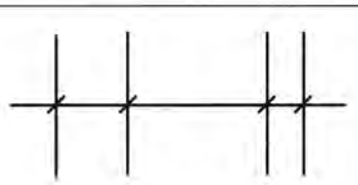


Fig 2-5

Where, due to limitations of space, it is not considered practical to use closed arrows at the ends of the work-size dimension lines, they may be indicated by the intersection of oblique strokes (Figure 2-5).

2.2 Zones And Spaces

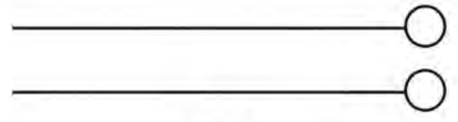


Fig 2-6

Modular zones are indicated by a pair of parallel lines terminating in small circles (Figure 2-6).

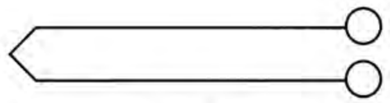


Fig 2-7

For product information and other purposes, such as on exhibition drawings, sketch plans, etc., the ends of the parallel lines may be joined to form an arrow head, the other ends terminating in small circles (Figure 2-7).

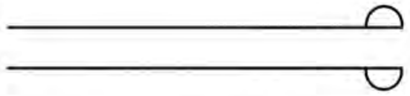


Fig 2-8

Non-modular zones which interrupt the modular grid are indicated by a pair of parallel lines terminating in small semi-circles at each end (Figure 2-8).

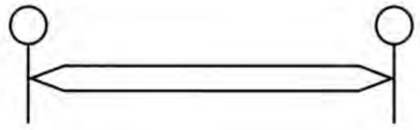


Fig 2-9

Coordinating spaces for components may be indicated in catalogues, standards, handbooks, etc. by a pair of parallel lines joined by an arrow head at both ends (Figure 2-9).

2.3 Grid Reference

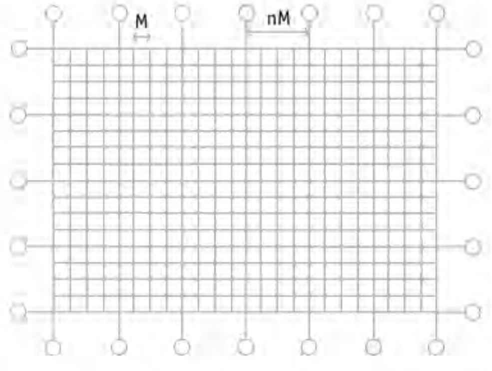


Fig 2-10: Grid Reference

On drawings in which grids having different line intervals are superimposed, thin lines may be used to define the small intervals in order to faciliate the reading of drawings, particularly those in printed publications (Figure 2-10).

CHAPTER 3

Modular Grids And Planning

Modular Coordination entails the employment of a space reference system. This is expressed in the plans and sections of the building with controlling planes and lines. This chapter introduces the Basic Module and different modular grids and the applications in horizontal and vertical planning. The dimensions recommended here are in modules and sub-modules for the various practical reasons and functional requirements.

Recommended Modular Dimensions

Basic Module	:	**1M** = 100mm
Structural Grid	:	**3M** (**1M** as the second preference)
Horizontal Multi-Module	:	**3M** (**1M** as the second preference)
Vertical Multi-Module	:	**1M** (**0.5M** as the second preference)
Doors	:	Multiples of **1M** (width and height)
Windows	:	Multiples of **1M** (width and height)
Sub-modular increment	:	**0.5M** and **0.25M**

3.1 Applications

3.1.1 The basic module

The basic module is the fundamental unit in **Modular Coordination**. It is represented by the letter **M** and is adopted internationally. The unit **M** is 100mm. The symbol **nM** (or **n'M**) represents multiples of **M**.

Multiples of				
3M	**6M**	**9M**	**12M**	**15M**
3				
6	6			
9		9		
12	12		12	
15				15
18	18	18		
21				
24	24		24	
27		27		
30	30			30
33				
36	36	36	36	
39				
42	42			
45		45		45
48	48		48	
	54	54		
	60		60	60
		63		
	66			
	72	72	72	
				75
	78			
		81		
	84		84	
	90	90		90
	96		96	
		99		
				105
		108	108	
			120	120
			etc.	etc.

Table 3-1: Series Of Recommended Multi-Modular Sizes For Horizontal Controlling Dimensions

3.1.2 The structural grid

The recommended structural grid is **3M** or multiples of **1M**.

3M is chosen as most materials like the precast floor slabs are in multiples of this dimension.

3M also fits into the carpark lots of **24M** x **48M.**

3.1.3 Horizontal multi-modules

In selecting the planning module, the designer will have to take into consideration the function of the building and the components to be used. See Table 3-1.

In the selection of the sizes from the table, preference should be given to the series of the larger multi-modules compatible with the functional requirements and economic design.

For practical considerations, a second preferred module of **0.5M** is introduced to supplement the primary module. This allows for more design flexibility.

3.1.4 Doors

Multiples of **1M** (width and height).
The measurements include the door frames.

3.1.5 Windows

Multiples of **1M** (width and height).
The measurements include the window frames.

3.1.6 Sub-modular increment

0.5M
0.25M

The thickness of many building components may be governed by economic and functional considerations. The sub-modular increment is to allow for this. The determination of the size for planning modules shall not be based on sub-modular increments.

3.2 Modular Grids

Plans, sections and elevations are expressed in two dimensions. These are horizontal and vertical projections of the modular space grid. Different modular grids may be superimposed on the same plan or elevation for different purposes. The advantage of using grids is that they provide a continuous reference system in a project, provided that the basic modular grid is kept uninterrupted throughout the building. The position of the components and their corresponding modular dimensions can thus be recognised by those preparing the drawings and also by those reading them.

3.2.1 Basic modular grid

This is the smallest planning grid used as a basis for developing other grids. The basic modular grid is normally shown only on small-scale drawings to clarify the relationships between components. Each square is **1M** by **1M** ie. 100mm x 100mm. These drawings are in the scales of 1:10 or 1:20. They are also used in full scale detail drawings (Figure 3-1).

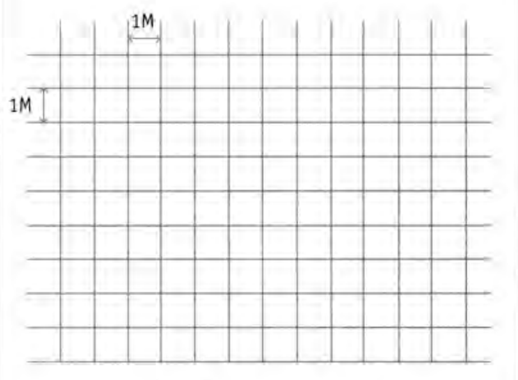


Fig 3-1: Basic Modular Grid

3.2.2 Multi-modular grid

The multi-modular grid is formed with the intervals being multi-modules. They can either be squares with same intervals in both directions (Figure 3-2a) or rectangular (Figure 3-2b). These grids are based on the recommended multi-modules. They are used in key plans, showing the layouts of building complexes, buildings and the positions of main buildings components. These drawings usually have scales of 1:50 and above.

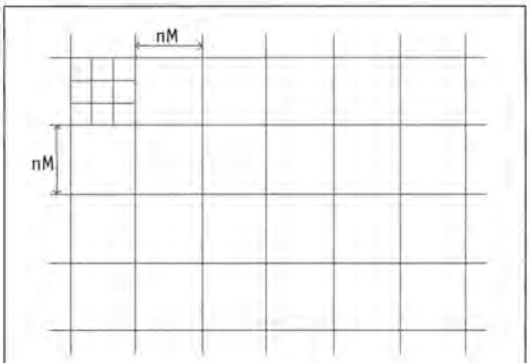


Fig 3-2a: Square Multi-Modular Grid

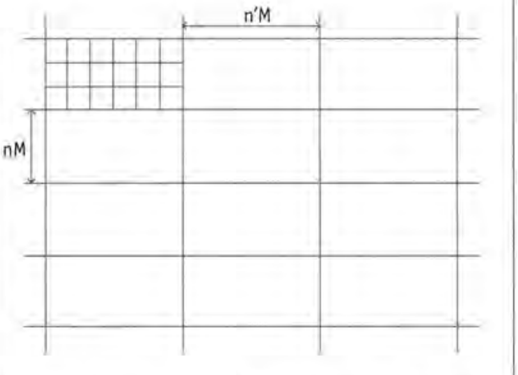


Fig 3-2b: Rectangular Multi-Modular Grid

3.2.3 Tartan grid

The tartan grid is an interrupted modular planning grid in which the intervals or bands of interruption are regularly spaced in both directions and are of different modular order to the general modular planning grid (Figure 3-3). This pattern may be used in very regular plans like those with columns at constant intervals throughout the floor (Figure 3-4).

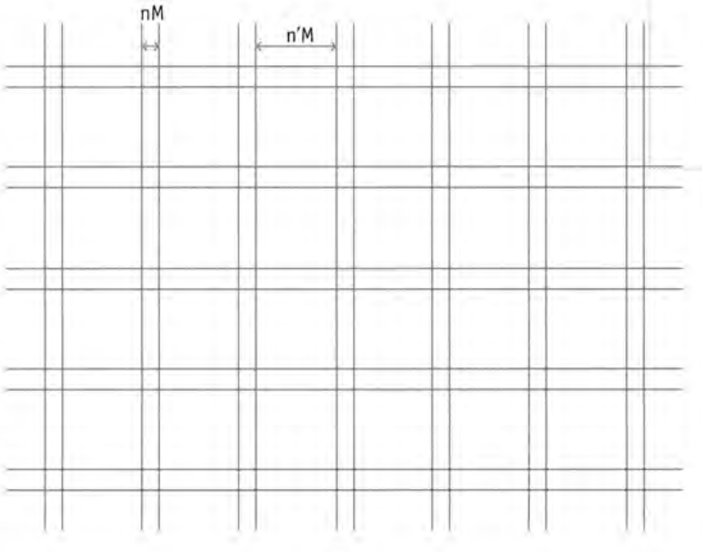


Fig 3-3: Tartan Grid

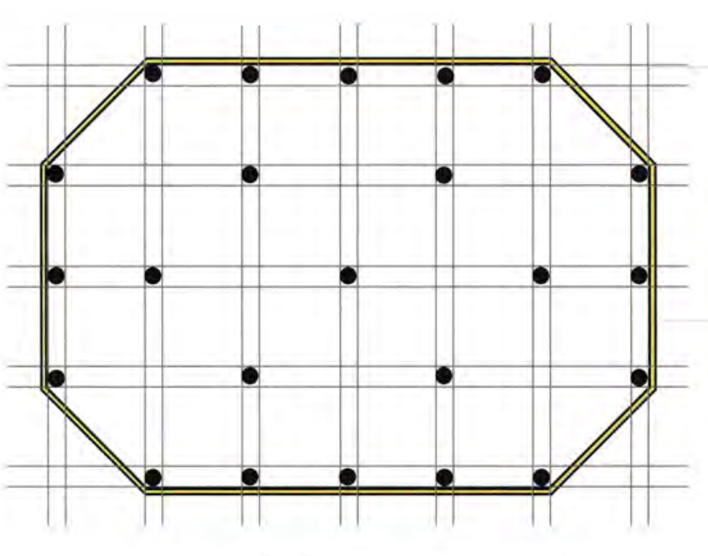


Fig 3-4: Grid For Regular Column Pattern

3.3 Planning Approaches

There are 2 basic approaches to planning in Modular Coordination.

3.3.1 Face planning

Face planning is used to position components and elements of construction in relation to the grid. It determines both the positions and sizes of components and elements of construction. It also shows the relationship between different components.

It is represented by pairs of parallel lines. The components or element is placed with the faces on the lines. The distance between the sets of parallel lines is always modular (Figure 3-5).

3.3.2 Axial planning

Axial planning normally determines the positions of major components e.g. columns, cross walls.

The grid lines in this plan will run along the centre lines of the components. The distance between the grid lines is always modular (Figure 3-6).

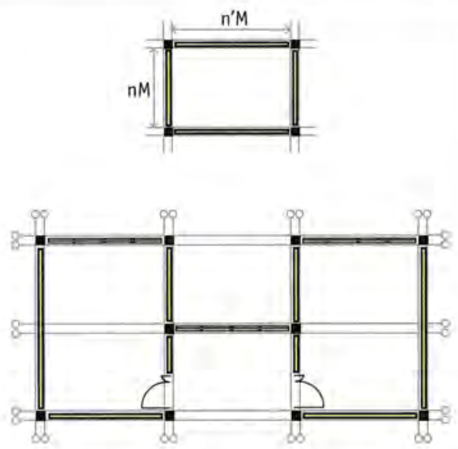


Fig 3-5: Face Planning

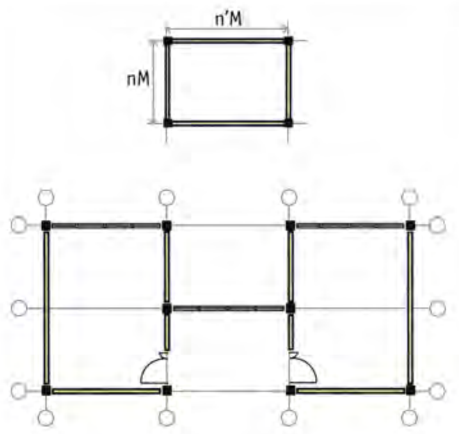


Fig 3-6: Axial Planning

3.3.3 **Application**

In practice, the 2 approaches of planning can be combined. In the planning process, it is easier to begin with the modular grid and determine the positions of the major elements using the **axial planning**. The **face planning** will then be introduced for the positioning and sizing of various components and also to design the joints (Figure 3-7, 3-8).

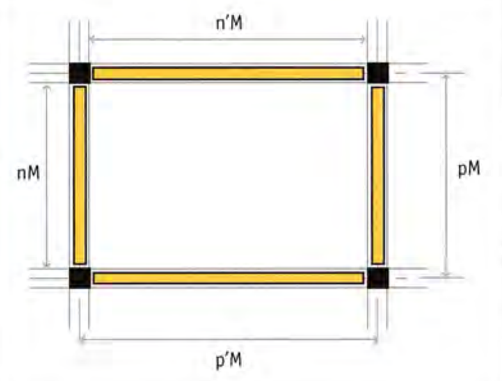


Fig 3-7

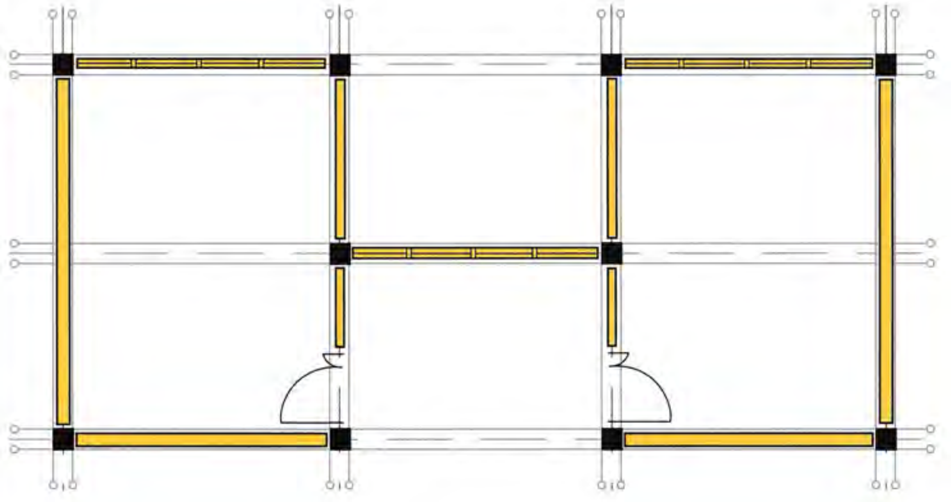


Fig 3-8: Combination Of Face And Axial Planning

3.4 Vertical Planning

3.4.1 Preferred dimensions

The preferred vertical dimensions are as follows:

(a) Vertical Planning: **1M** (**0.5M** as second preference)

For projects which face stringent control on building height, **0.5M** increments in floor-to-floor height can become critical in maximising the total number of storeys in a building.

(b) Windows: Multiples of **1M**

(c) Doors: Multiples of **1M**

3.4.2 Vertical controlling dimensions

The main vertical controlling dimensions, taken from coordinating planes in the reference system are:-

(a) Storey height or floor-to-floor height

(b) Floor-to-ceiling height

(c) Floor zone and roof zone

The intermediate controlling dimensions are:-

(a) Door head height

(b) Window head height

(c) Window sill height

The window head height may coincide with the lower coordinating plane of the floor above.

The door head height and window head height are usually the same.

The modular floor plane from which vertical coordinating dimensions are taken is a continuous horizontal plane over the whole of each storey of a building. This means that there is only one floor plane for each level (Figure 3-9).

Modular Grids & Planning

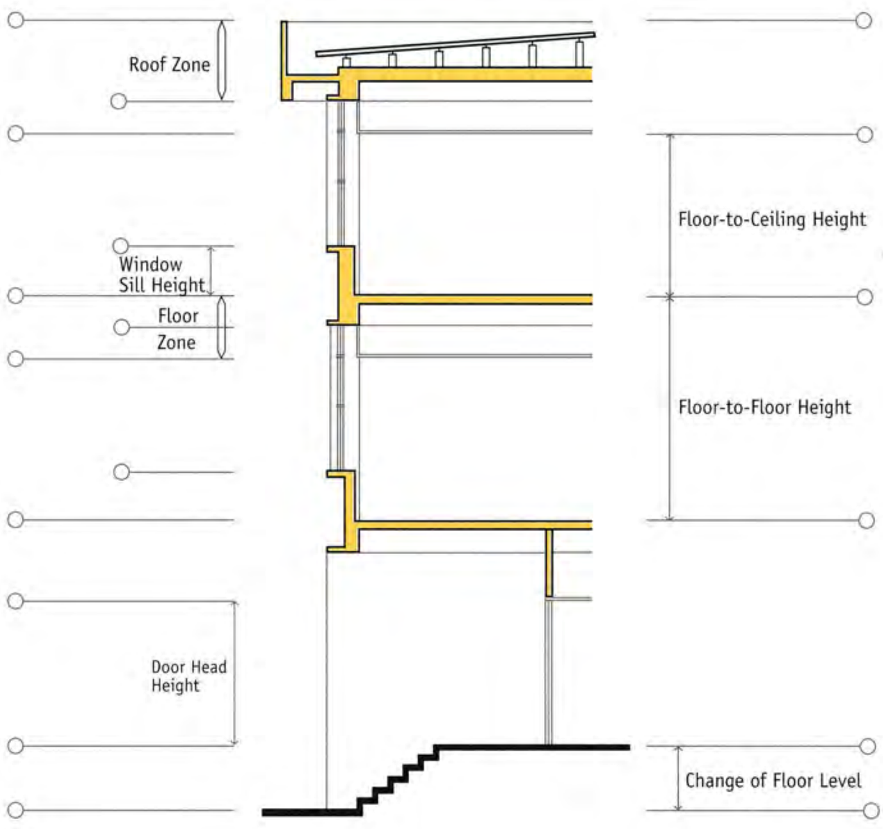


Fig 3-9: Vertical Controlling Dimensions

3.5 Hierarchy Of Planning

It may not be possible in practice to achieve a complete modular system using only preferred dimensions and sizes. In these situations, the order of priority should be as follows:-

(a) Planning Grid

(b) Elements of Building
e.g. external envelope

(c) Components
e.g. windows and doors

(d) Finishes and Built-in Equipment

The design should follow Modular Coordination principles as much as possible.

3.5.1 Practical application guildelines

In order to ensure that modular coordination is effective in the design and planning of a building and all related building components, the following guidelines should be applied:-

(a) use the recommended modular dimensions as much as possible. If not, then

(b) standardise the building components as much as possible. If not, then

(c) for the building components that cannot be designed in modules or standardised, choose a dimension that is proportional (subdivision/multiple) to the modular dimension and apply it consistently.

For example, use ½ (150mm), ⅓ (100mm), ¼ (75mm), ⅙ (50 mm) for the **3M** module. This will help to rationalise the dimensional system used for the whole project.

CHAPTER 4

Components And Finishes

When Modular Coordination is used, different parts of the building will be perceived as components. These include prefabricated components like doors and windows as well as those put up during the construction such as floor slabs and walls. The building process will then be seen as the assembling of different components. The influencing factors will be the positions and sizes of the components and the tolerances allowed between them and their corresponding coordinating spaces. The idea of components will therefore have to be conceived in the early stages of design as they will have a bearing on the planning grids and approaches.

This chapter suggests the ways the components fit into their coordinating spaces, both on plan and in section and their juxtaposition. The following will be discussed:

Structural Components

Columns
Beams
Floor Slabs
Walls
Stairs and Lift Cores

Architectural Components

Cladding
Partitions
Doors
Windows
Prefabricated Toilets
CD Shelter

Finishes

Ceiling finishes
Floor finishes

4.1 Structural Components

4.1.1 Columns

The recommended dimensions for columns are multiples of **1M** with **0.5M** as second preference.

This dimension fits into the **modular planning grid** of the building. When the columns are not modular, the distance between adjacent columns will be non-modular and will result in odd dimensions for the other infilling components. It may also pose problems if modular precast floor slabs or modular formwork are to be used.

The main concern of the structural engineer is the cross sectional area of the column. With the basic dimension of **1M**, there can still be columns with a range of cross sectional areas. There is also the possibility of using columns of different sizes (Figure 4-1).

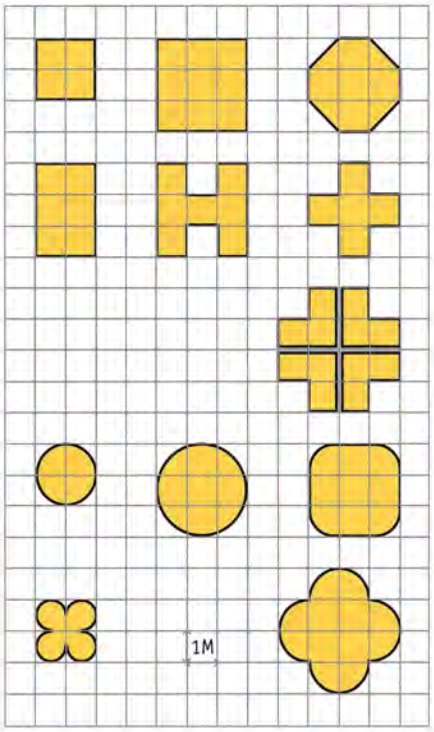


Fig 4-1: Column Sections

Non rectangular columns can also be fitted into the **face planning** and **axial planning grid** (Figure 4-2).

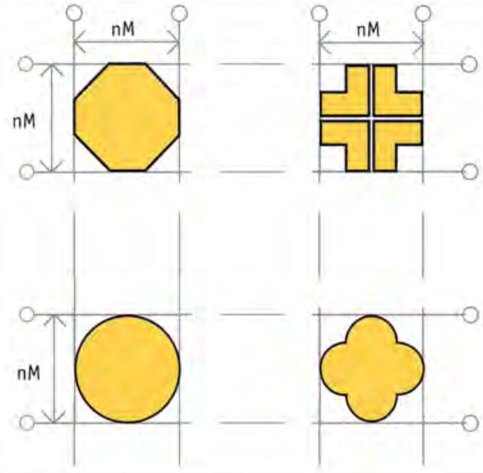


Fig 4-2: Controlling Planes For Columns

As non-rectangular columns are usually free-standing, there will not be any problem in the interface with other components. In situations where walls/partitions do butt against the columns, the junctions will be treated in the same way as with rectangular columns (Figure 4-3).

It should be noted that the dimensions given for the columns, as with other components are their finished dimensions. Allowances must therefore be provided for the thickness of the finishes to be used on the columns. In **Modular Coordination** where dimension coordination of elements and components is essential, a clearance of 5mm is to be allowed for construction inaccuracies. A **6M x 6M** column will therefore be 590mm x 590mm.

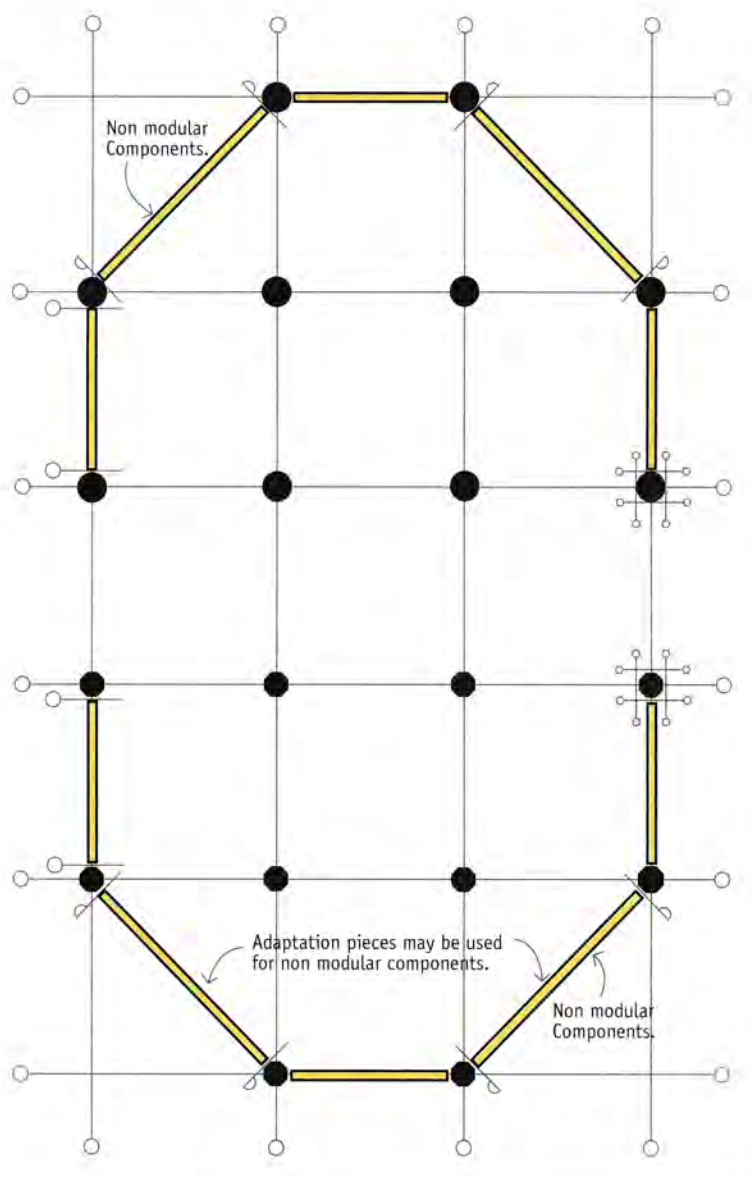


Fig 4-3: Non Rectangular Columns

In axial planning the centre to centre distance between columns is modular (Figure 4-4).

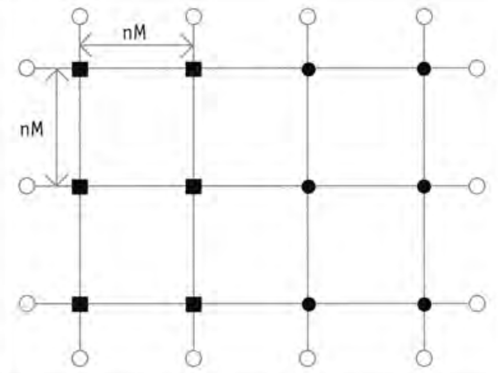


Fig 4-4: Axial Planning

In face planning, the distance between the faces of columns is modular (Figure 4-5).

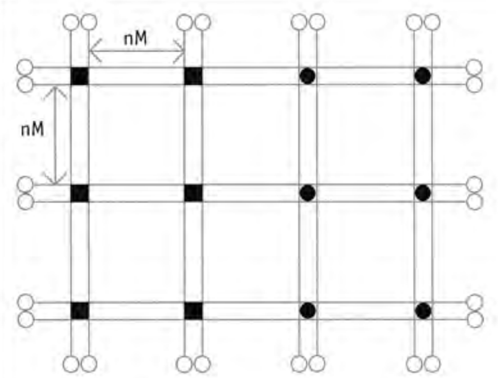


Fig 4-5: Face Planning

The selection of the type of planning will thus depend on the way the other components, like the cladding and internal partitions, are assembled. Most of the problems of assembly and sizing will not arise when the columns are **Modular**, regardless of whether the **axial** or **face planning** is used (Figure 4-6).

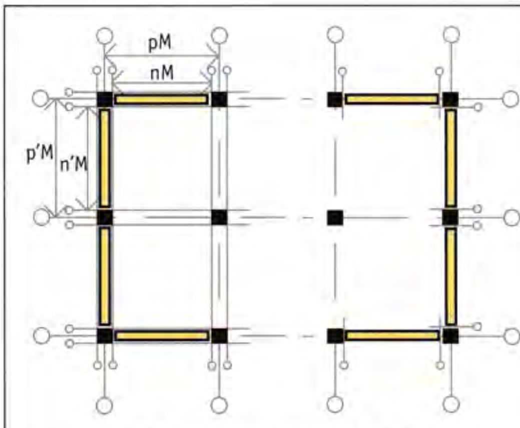


Fig 4-6: Combination Of Axial And Face Planning

4.1.2 **Beams**

The width of the beam generally has less implications on Modular Coordination design. The recommended depth for beams is in increments of **0.5M**.

In a building where there is false ceiling, the beam is accommodated within the floor zone and the depth of the beam would only affect the services and not the walls or partitions below (Figure 4-7).

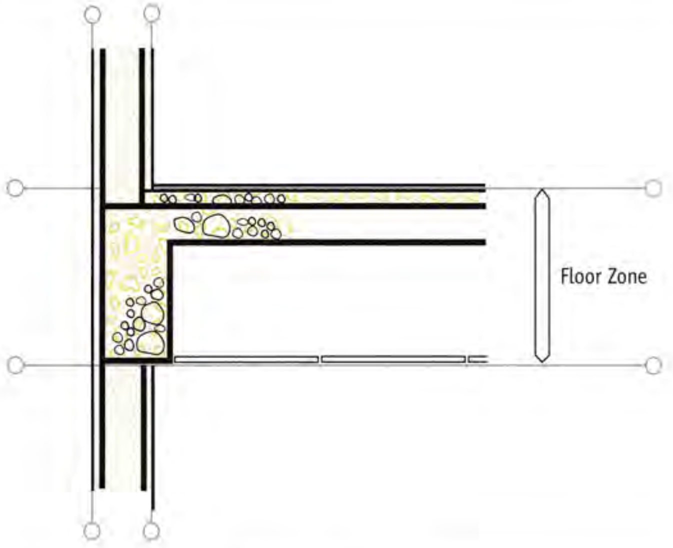


Fig 4-7: Floor Zone

In buildings where there is no false ceiling, the distance between the base of the beam and the floor slab must be modular so as to accommodate the components below (Figure 4-8).

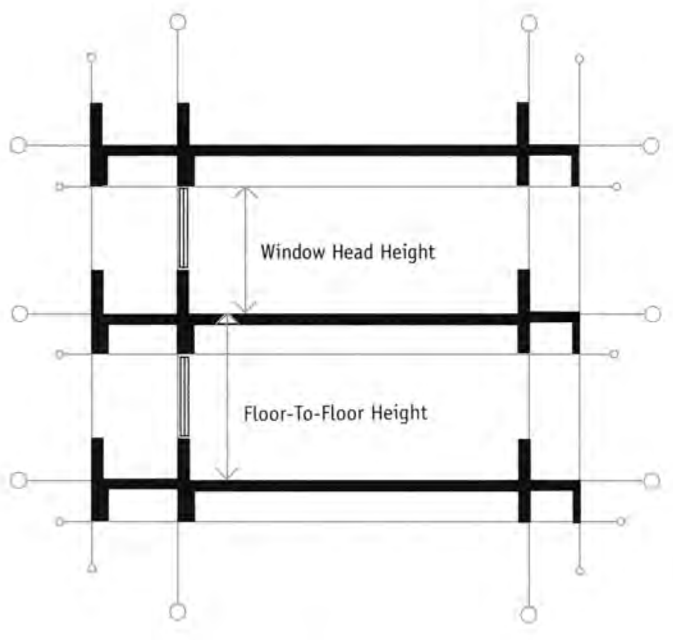


Fig 4-8: Floor Zone Without False Ceiling

4.1.3 **Floor slabs**

The depth of floor slabs will be in sub-modular increments of **0.5M** (50mm) or **0.25M** (25mm).

When precast slabs are used, they will be in the widths of **6M**. This dimension fits the structural grids and therefore there will be no wastage. The length of the precast slabs will be according to the site requirements.

The **floor zone** is the space allocated for the floor assembly. It extends from the reference plane of the ceiling to that of the finished floor surface above it. In principle, the upper face of this zone coincides with the storey height reference plane. The ceiling should be accommodated within the floor zone.

The floor zone may be subdivided in several subzones. The number of sub-divisions is determined by the composition of the floor and services and vary with different projects.

The top of the floor zone should be the top of the floor finish and the base of the floor zone the bottom of the ceiling of the floor below.

The appropriate allowances must be given when determining the level of the standard floor slab, the amount will depend on the thickness of the floor screed and the floor finish (Figure 4-9).

In the construction process, the wall/partition may, in many buildings, be erected from the floor slab or from the screed. It will then be more practical to fix the top of the floor zone at the level of slab or screed to ensure that the height of the component is modular.

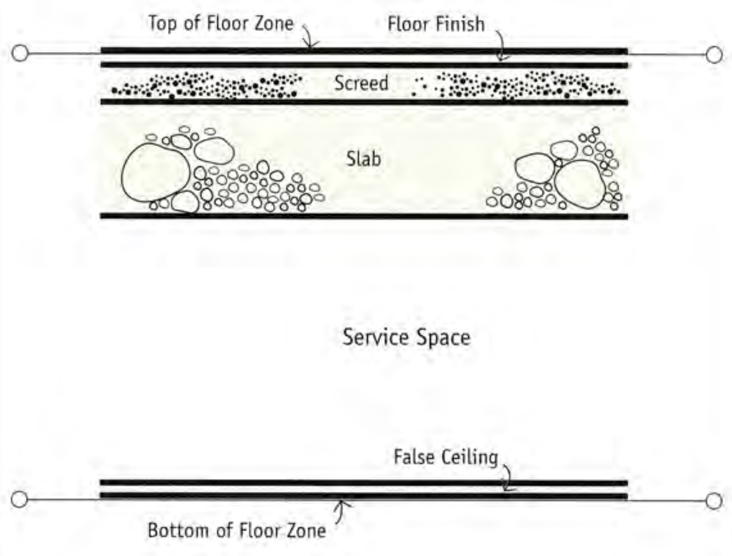


Fig 4-9: Composition Of The Floor Zone

4.1.4 Walls

The walls discussed in this section refers to cast-in-situ or precast load bearing walls. The length of walls will be determined by the chosen planning grid.

Sub-modular increments of **0.5M** and **0.25M** are recommended for the thickness of the walls if they are not modular. As in the case of the columns, the dimensions are for finished walls. Allowance must be given for the thickness of the finishes to be used.

In cases where the walls do not fill the whole wall zone, where the structure allows, the wall should line with one side of the zone to minimize the number of adaptation pieces (Figure 4-10).

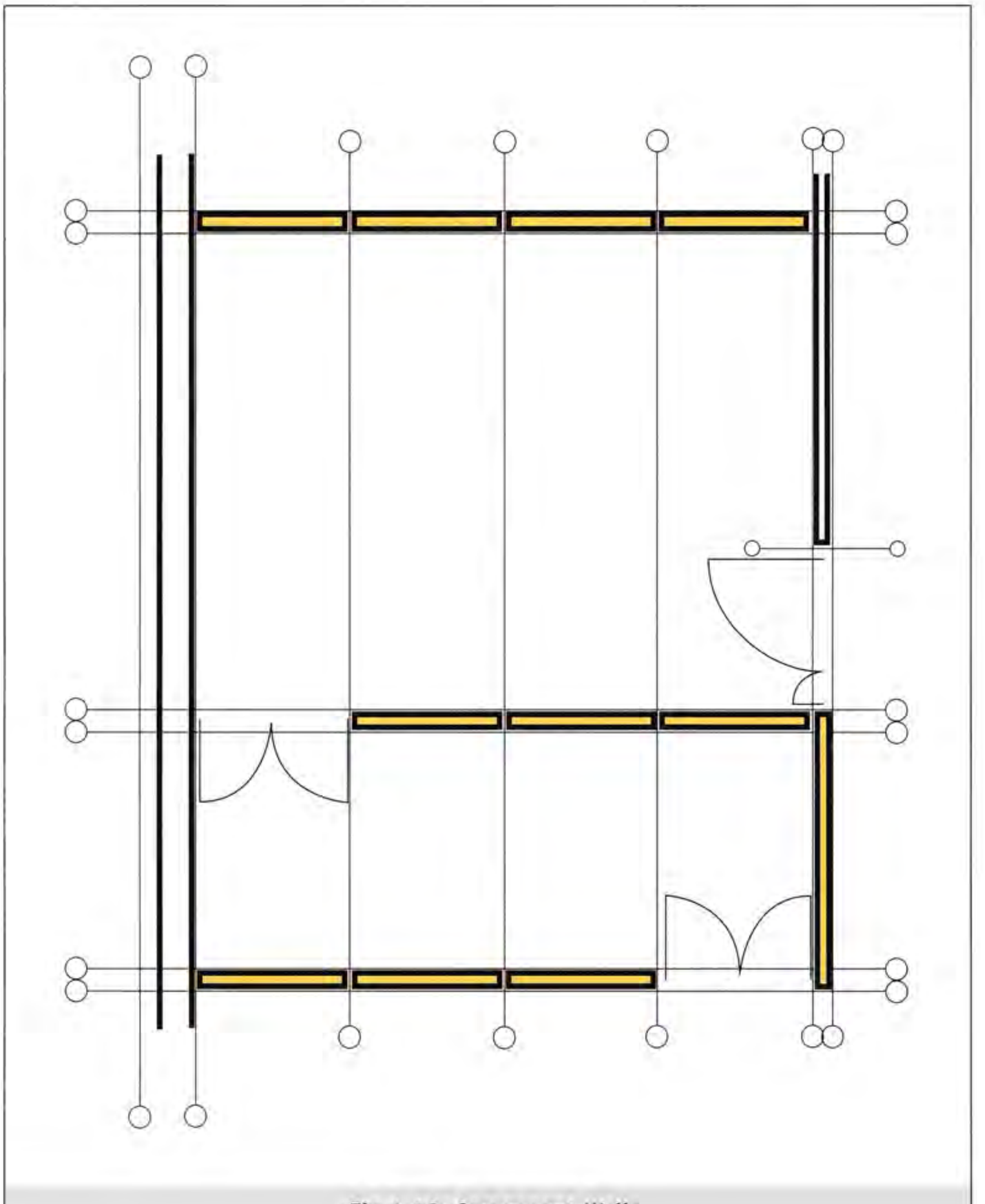


Fig 4-10: Component Walls

4.1.5 **Lift cores**

In the buildings with lifts, the internal dimensions of lift cores will be determined by the types of lifts and the sizes of the lift cars. They can be adjusted by multiples of **1M** with **0.5M** as second preference.

The size of the lift door will also be determined by the manufacturer, it is recommended that the opening be in multiples of **1M** to enable the neat laying of walls tiles/panels.

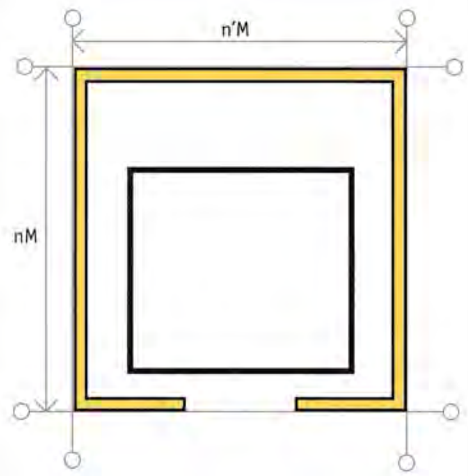


Fig 4-11: Single Lift

The external dimensions will be modular as they are positioned in relation to other modular elements (Figure 4-11).

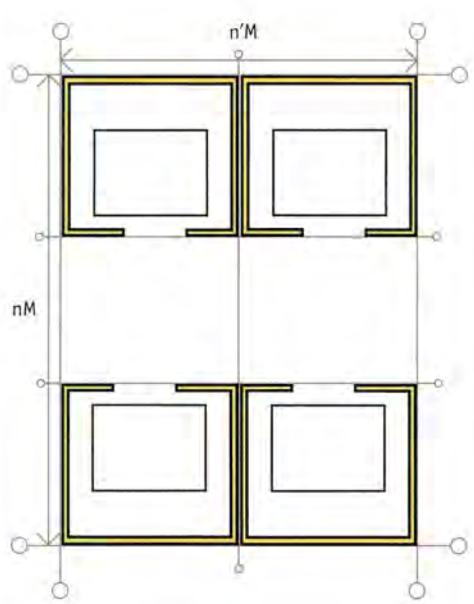


Fig 4-12: Lifts And Lobby

In cases where there are more than one lift, the whole assembly, including the lobby may be treated as one single element. The external dimensions will be multiples of **1M** (Figure 4-12).

In cases where the lifts and stairs are adjacent to one another, the recommended external dimension of the lift well is **24M**. The width of the stairs is **12M**, giving the overall dimension of **48M** (Figure 4-13).

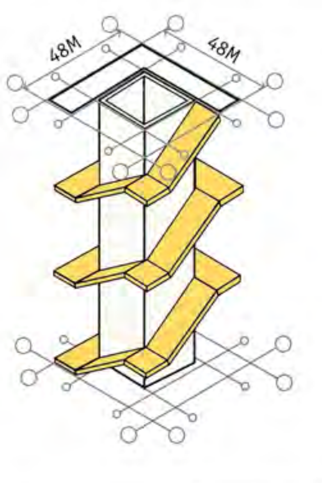


Fig 4-13: Lifts And Stairs

4.1.6 **Stairs**

On plan, the width of the coordinating spaces accommodates the two flights and the possible space in between. Both the length of the flights and the landing dimensions are modular. The goings, risers and widths of the flights and landings will be as required by statutory regulations (Figure 4-14).

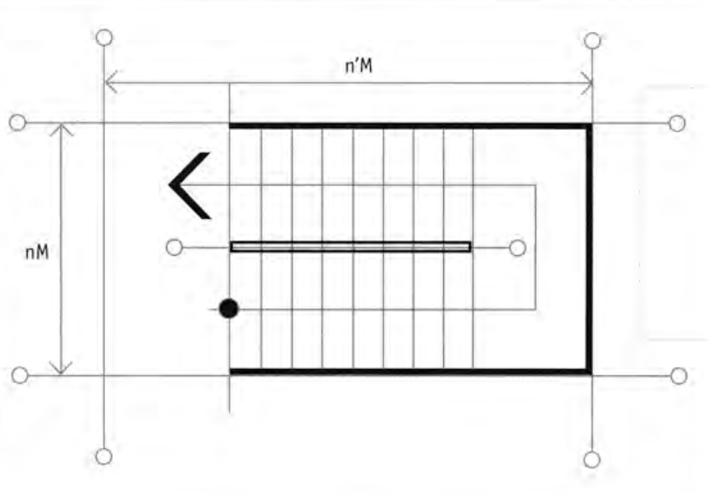


Fig 4-14: Plan Of Stairs

In section, the stairs will be located in between the floor coordinating lines. This means that the top of the stair will coincide with the top of the floor zone (Figure 4-15).

In order that the stairs can fit into the horizontal and vertical coordinating dimensions, the dimensions for the total width, the length of flights and the width of landings must be in multiples of **1M** and **0.5M**. A summary of the recommended floor-to-floor heights which are in multiples of **1M** and **0.5M** and the corresponding riser heights is shown in Table 4-1.

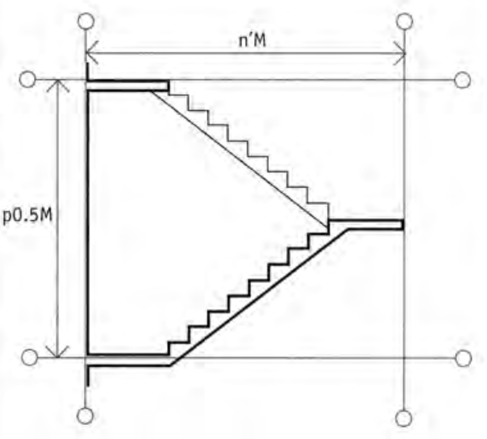


Fig 4-15: Section Through Stairs

	16 risers	18 risers	20 risers	22 risers	24 risers
Riser Dimesions (mm)	**Floor-to-floor Height (mm)**	**Floor-to-floor Height (mm)**	**Floor-to-floor Height (mm)**	**Floor-to-floor Height (mm)**	**Floor-to-floor Height (mm)**
150			3000	3300	3600
165			3300		
175	2800	3150	3500	3850	4200

Table 4-1: Standard Staircase Riser Heights And Floor-to-Floor Heights

Note: Size of thread = 250mm

4.2 Architectural Components

4.2.1 External Envelope

Cladding within structure

This form of cladding is commonly done for small buildings like houses, schools and other institutional buildings. It is important to maintain the modular spacing between the columns as this space usually has a band of windows running across it. **Face planning** is recommended for these types of buildings.

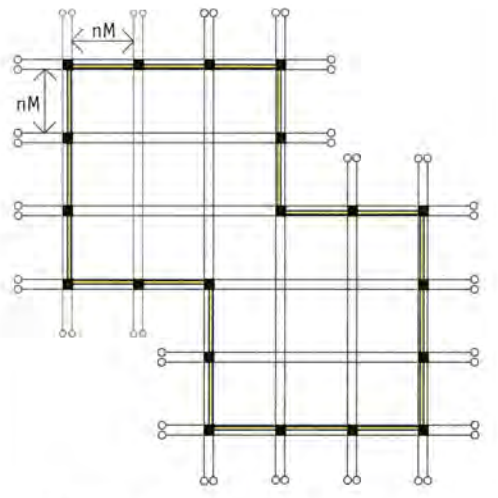


Fig 4-16: Cladding Within Structure - Face Planning

For **face planning**, the columns may be non-modular as the distance between the faces of columns are already so (Figure 4-16).

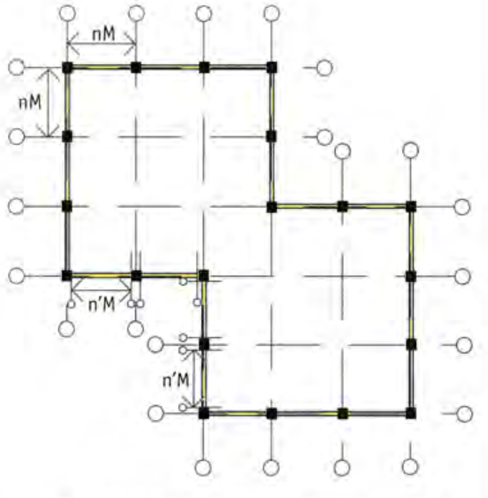


Fig 4-17: Cladding Within Structure - Axial Planning

In **axial planning**, the columns will have to be of modular dimensions to ensure that the modular infill cladding be fitted properly (Figure 4-17).

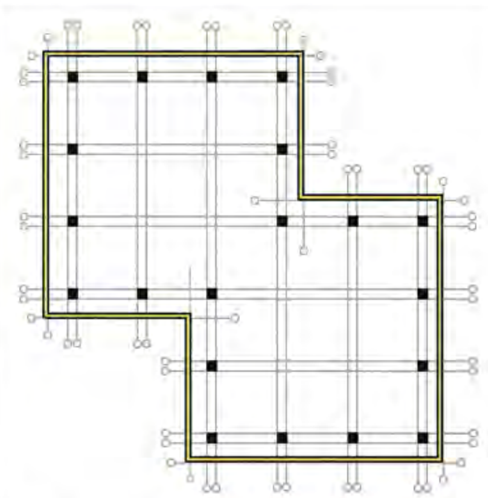


Fig 4-18: Cladding Outside Structure - Face Planning

Cladding outside structure

This usually applies to commercial buildings like offices and shopping complexes with free standing columns. The cladding can be curtain walls, independent from the columns. The areas to note are the corners, the building can still be planned with the elevation appearing consistent. For these types of buildings, **axial planning** is more suitable.

In **face planning**, the spaces between the columns will be modular, whether or not the columns are modular. It is recommended that the structural zone be modular too so that the external cladding will be modular and the elevation of the building will be neat and orderly (Figure 4-18).

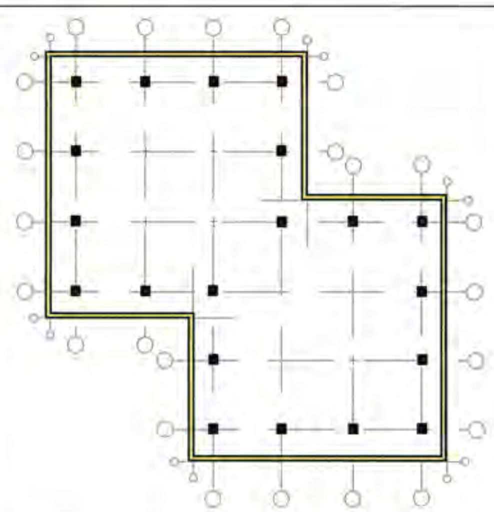


Fig 4-19: Cladding Outside Structure - Axial Planning

In **axial planning**, since the distances between column centres are modular, the spaces between the columns will also be modular. If the columns are non-modular, the spaces between them will consequently be non-modular. As shown in the figure, the external cladding will not be affected whether the columns are modular or not, but the internal partitions will be affected (Figure 4-19).

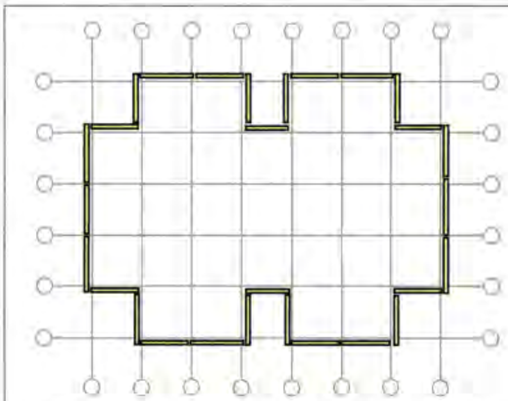


Fig 4-20: Corners And Re-entrant Angles

Corners and re-entrant angles

Balconies and niches can be detailed where components can still be of modular sizes. Special attention will have to be given in the treatment of the edges which will be exposed (Figure 4-20).

On a larger scale, there is no problem in buildings on **face planning** as the space between columns will be modular (Figure 4-21).

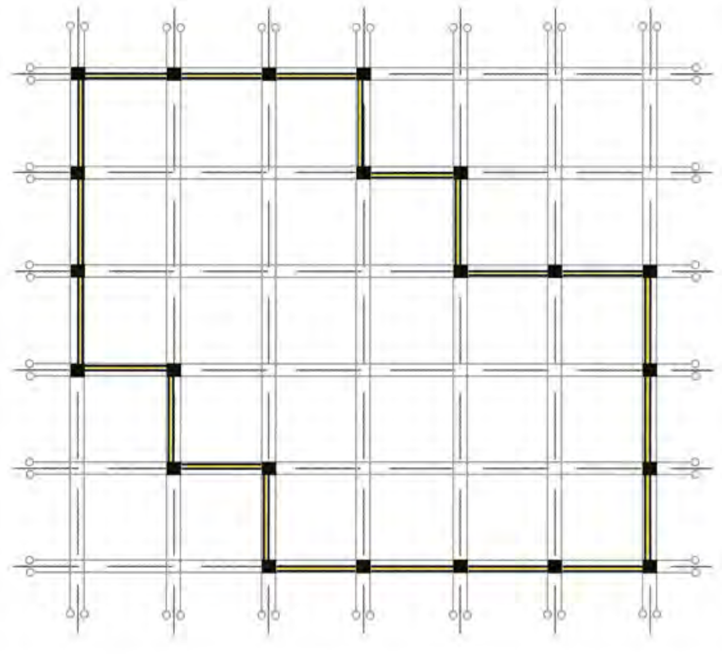


Fig 4-21: Corners And Re-entrant Angles - Face Planning

For buildings on **axial planning**, the space between the edge columns and the cladding can be adjusted so that each component is modular and the elevation still appearing consistent (Figure 4-22).

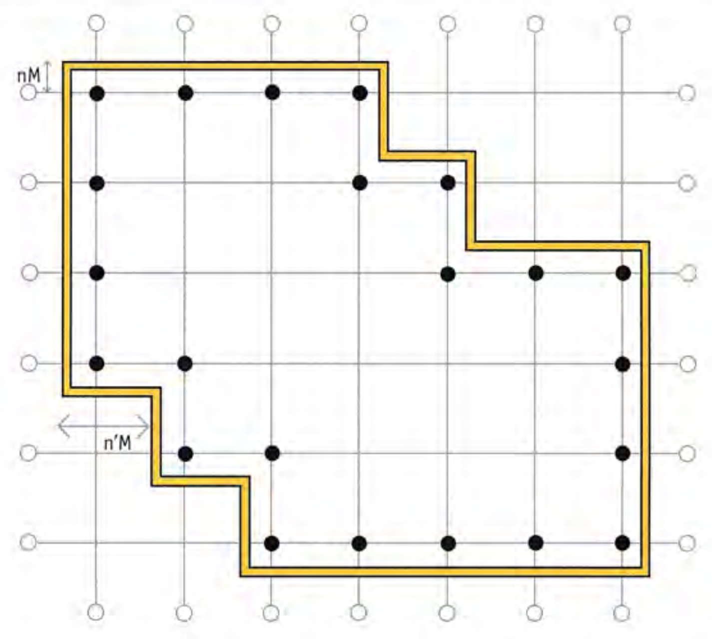


Fig 4-22: Corners And Re-entrant Angles - Axial Planning

4.2.2 Internal partitions

Internal partitions and walls are usually narrower than the **3M** grid. It is therefore important to have these partitions and components correctly placed on the grid so that the benefits of modular coordination can still be enjoyed. In most situations, the resulting spaces will still be possible to fall into the dimension of the second preference of **1M.** Internal partitions and walls of the thickness of **1M**, and **2M** can be arranged as in Figure 4-23 and Figure 4-24. In the case of the thicknesses not being in a multiple of **1M**, adaptation pieces can be used.

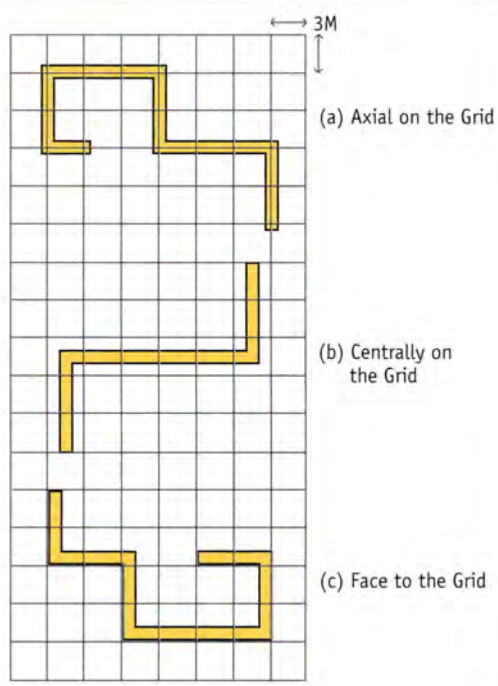


Fig 4-23: 1M Thick Partitions

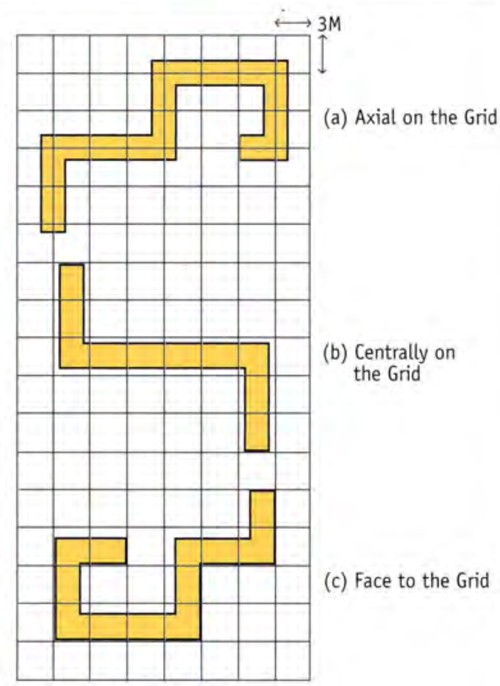


Fig 4-24: 2M Thick Partitions

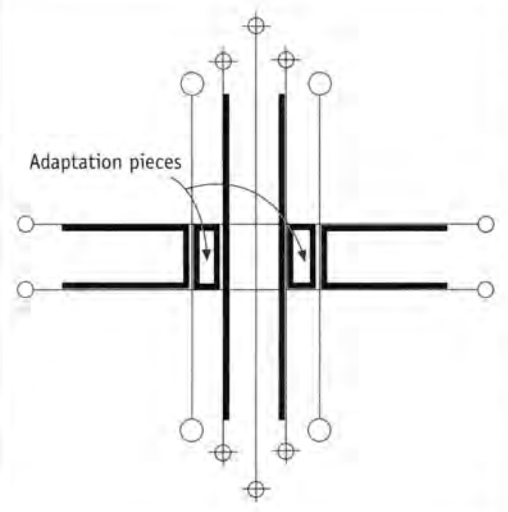


Fig 4-25: Adaptation Pieces

For walls, the face-to-grid arrangement is preferred as it ensures the modular dimensions for adjoining components.

In order to maintain the modular zones, non-modular elements are placed in the zone and the left-over space filled with adaptation pieces. The advantage of maintaining the modular zone is that all other dimensions will still be modular (Figure 4-25).

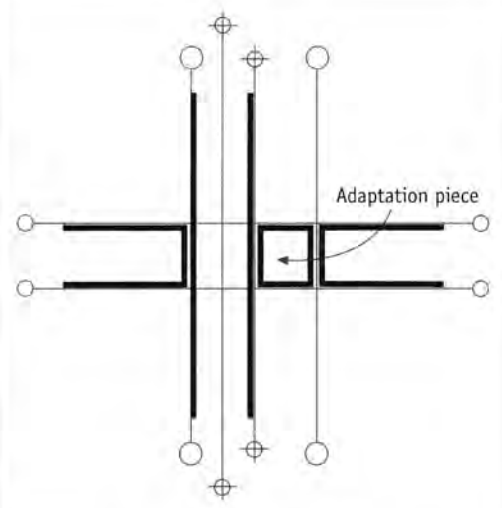


Fig 4-26: Adjusted Wall

In practice, if symmetry is not necessary, the wall should be placed at one edge of the zone and the adaptation need only to be done at one face and not two (Figure 4-26).

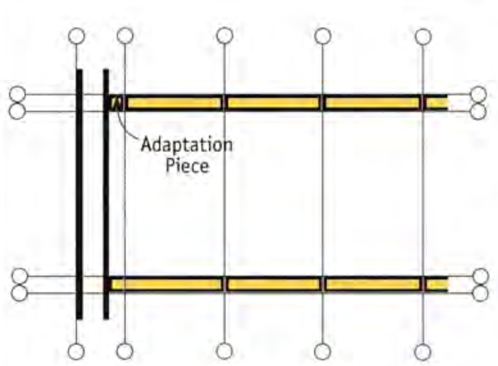


Fig 4-27: Component Assembly With Adaptation Piece

The adaptation piece need not be a separate component, it can, in many cases be an extension of one of the walls (Figure 4-27).

4.2.3 **Doors**

Width: Multiples of **1M**.

Height: Multiples of **1M**.

The second preference for doors is **0.5M**.

The measurements include the door frames.

The height of the doors are determined by the functional requirements.

It is important to note that the controlling spaces for the components like doors and windows be maintained as the preferred dimensions. This is to allow the components to be fitted without undue adjustments. The other adjustments, using adaptation pieces can be done in the walls or partitions (Figure 4-28).

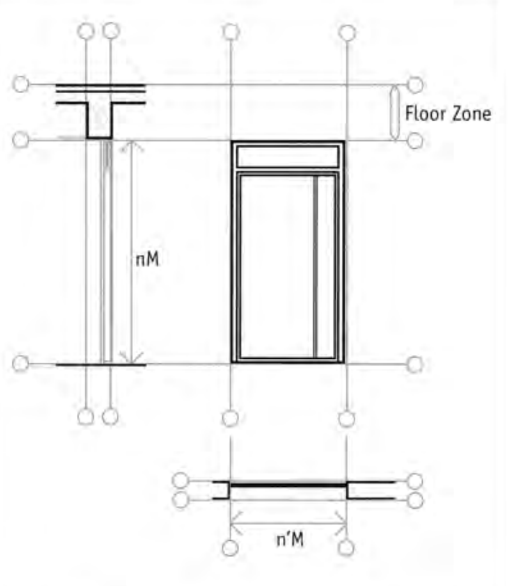


Fig 4-28: Door Component

4.2.4 **Windows**

Width: Multiples of **1M**.
Height: Multiples of **1M**.
The second preference for windows is **0.5M**.
The measurements include the window frames.

The types and sizes of the windows depend on the functional requirements. The recommended dimensions will apply for all window types.

In certain circumstances, the sill reference plane may coincide with the floor reference plane and/or the window head reference plane with the ceiling reference plane (Figure 4-29).

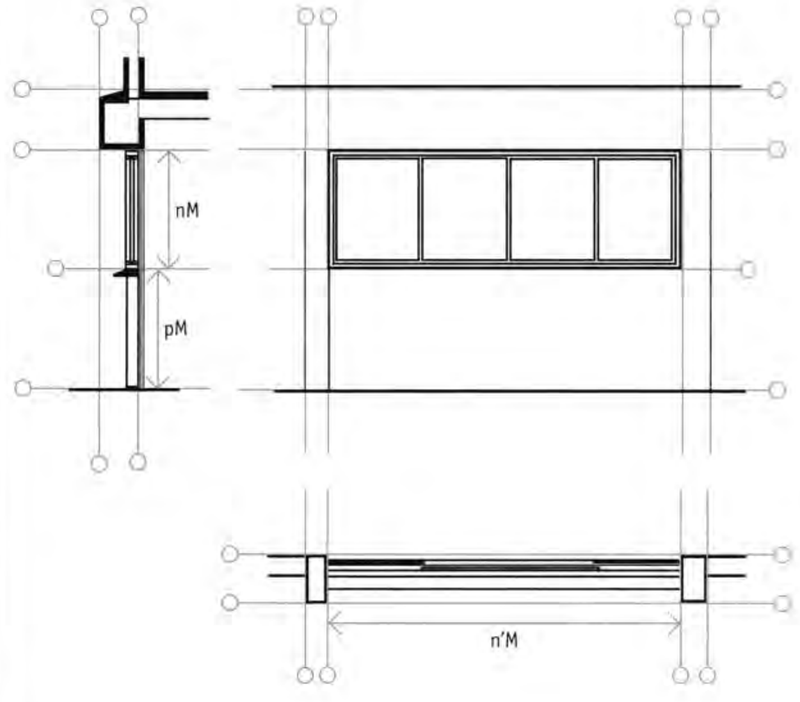


Fig 4-29: Window Component

4.3 Finishes

Most of the finishes are imported and unless the project is of a significantly large scale, the suppliers will seldom conform to the dimensions required by the designers. As finishes are usually done at the concluding stages of the construction process they are at the lower end of the hierarchy of Modular Coordination application. However, if the finishes are also modular, the appearance and interiors of the buildings will be enhanced.

4.3.1 Ceiling finishes

When the building is designed on Modular Coordination, the space will be modular. This fits in neatly with the suspended ceiling layout. It is advisable that in the early design stage, the reflected ceiling plan should be drawn so as to incorporate services and fittings such as light fittings, air condition inlets and outlets, speakers, smoke detectors and sprinkler heads and access panels. The commonly used grid is **6M** x **6M**.

4.3.2 Wall and floor finishes

The main consideration here is the thickness of the materials as the dimensions are determined by the suppliers. This is more so if the components are prefabricated and are installed with the finishes already laid on them. Allowances must be given within the column, wall or floor zones for the finishes to ensure that the remaining spaces between the zones are modular.

CHAPTER 5

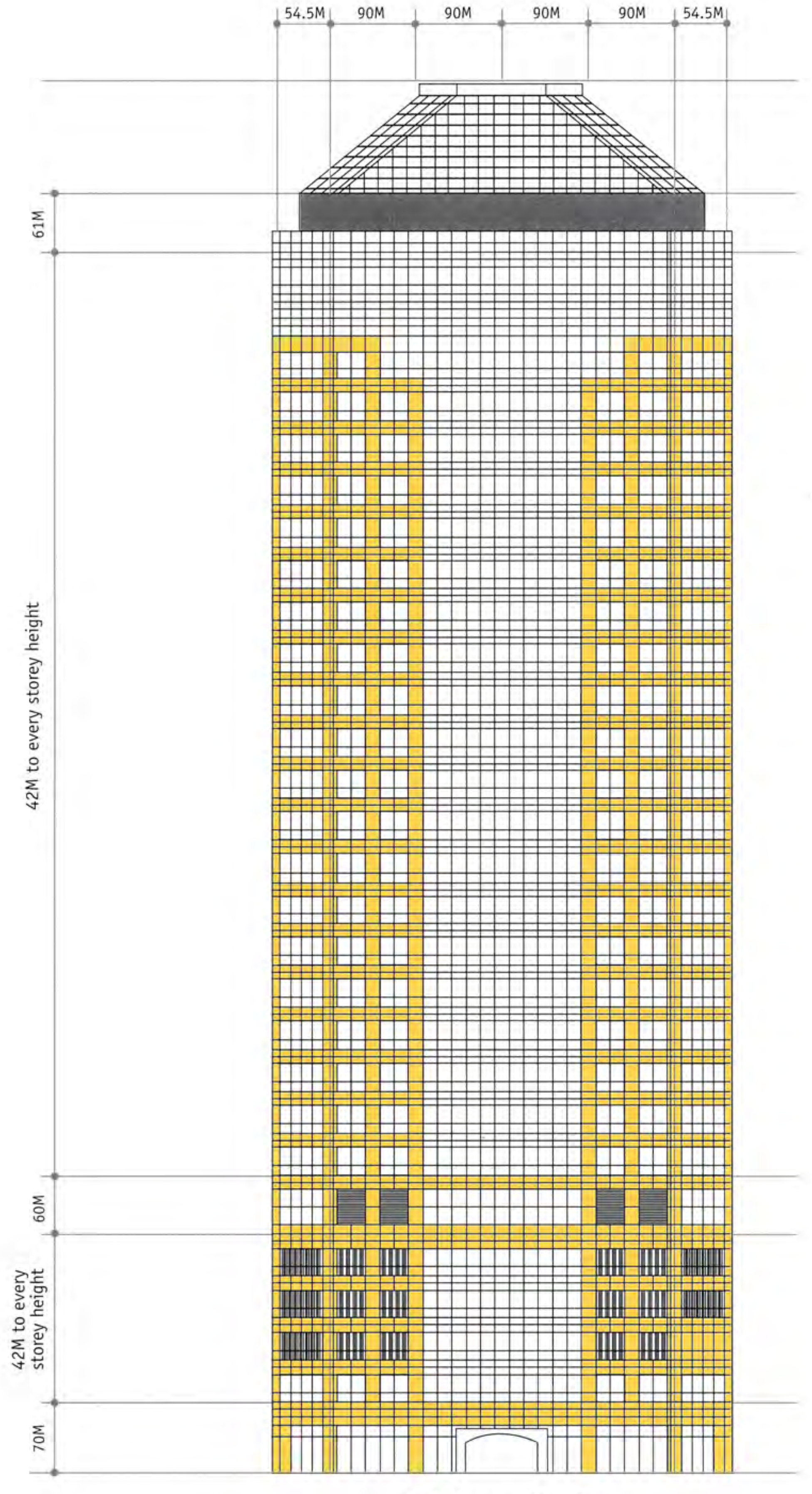
Examples

The drawings in this chapter are those of three projects where the concept of Modular Coordination is applied. In the examples shown, two planning approaches are used; face planning for the public housing and private residential blocks and axial planning for the office building.

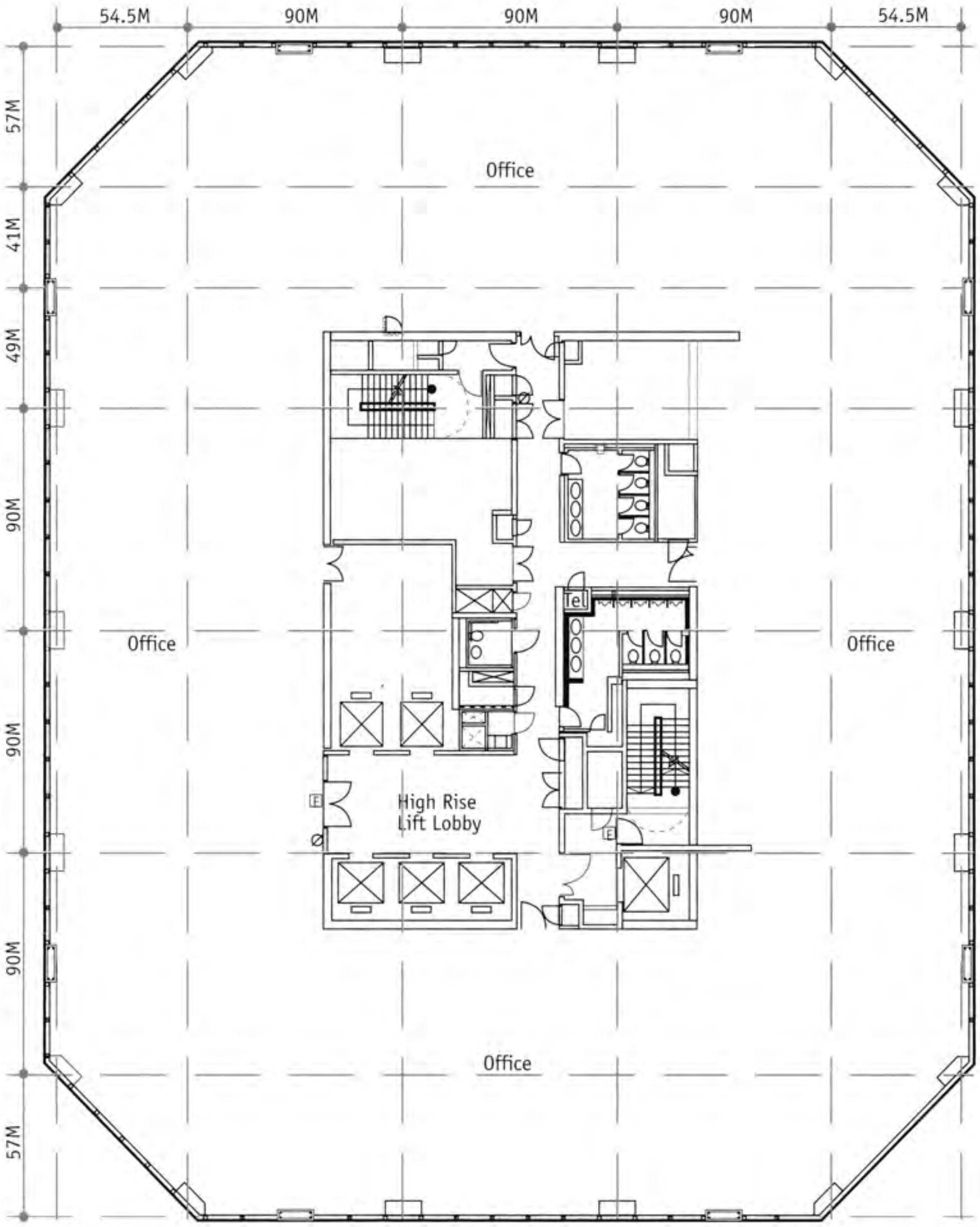
One of the main considerations in deciding the type of planning is the structural design of the building. In the case of the apartment blocks, although it is not linear in form, the face planning permits the use of system formwork, prefabricated walls, standard doors and windows and other minor components.

The column and slab construction of the office building uses axial planning. With the columns of modular sizes, the cladding components in this instance are also modular (see section 4.2.1). The axial planning is most suitable for buildings with open or flexible planning as positioning of the major elements and components like columns, walls, doors and windows are not affected by the partitions or the absence of them.

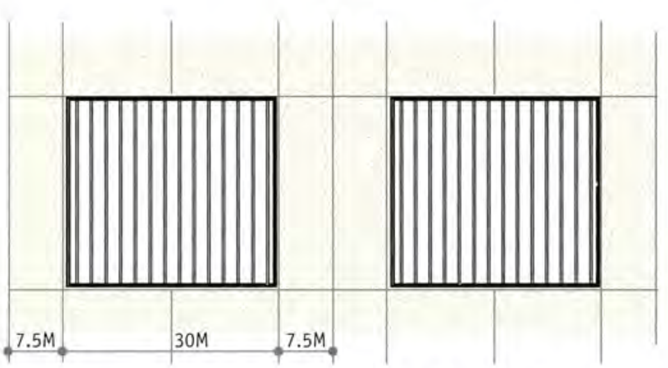
5.1 DBS Square - Office Building



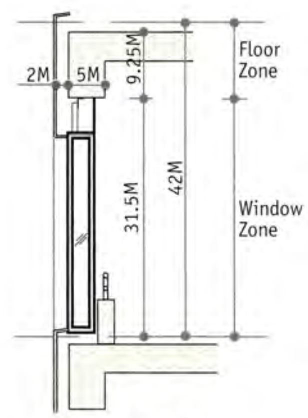
DBS Square - Elevation



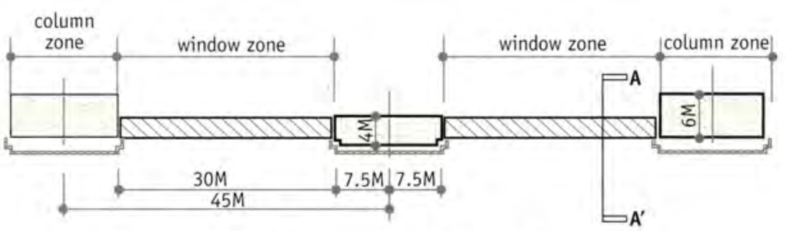
DBS Square - Typical Floor Plan



DBS Square - Facade Part Elevation

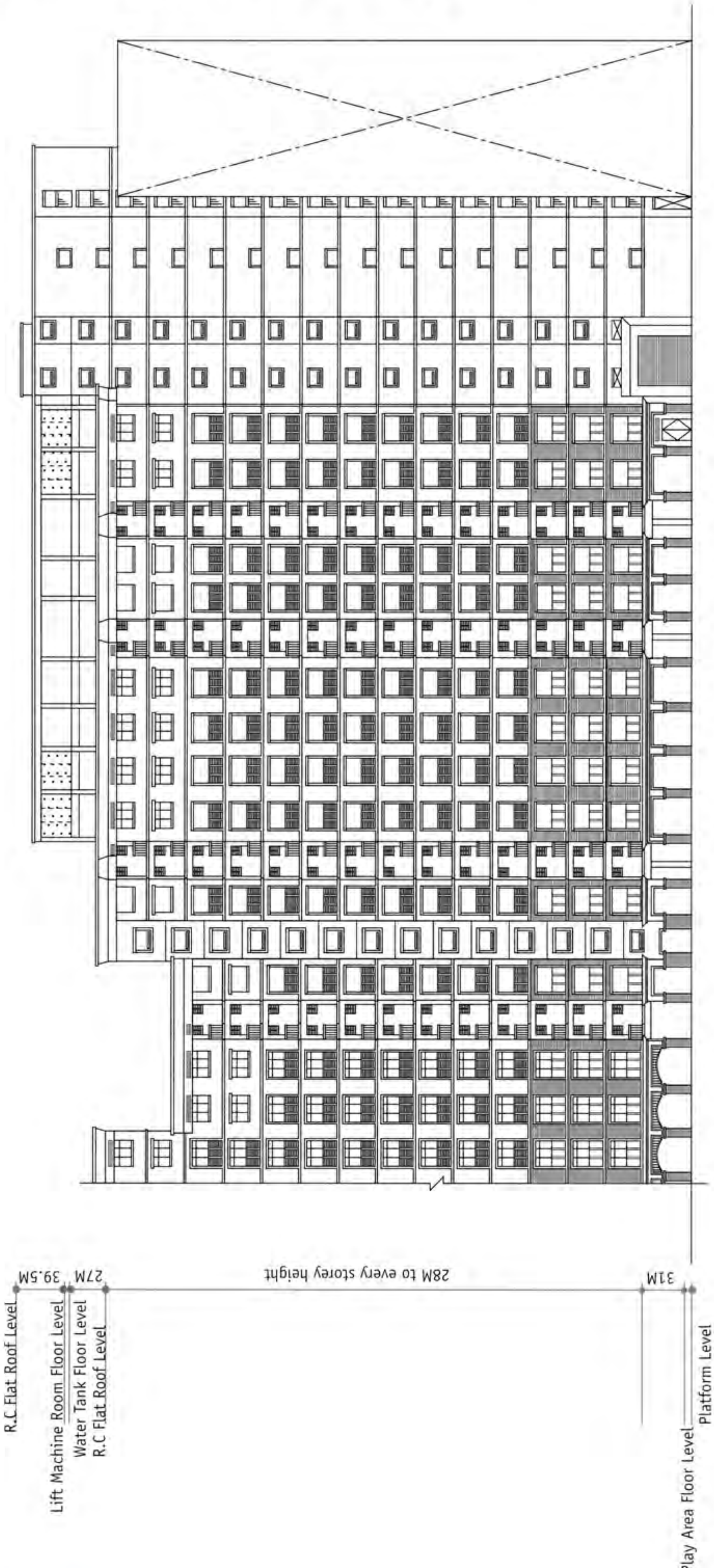


Section AA'



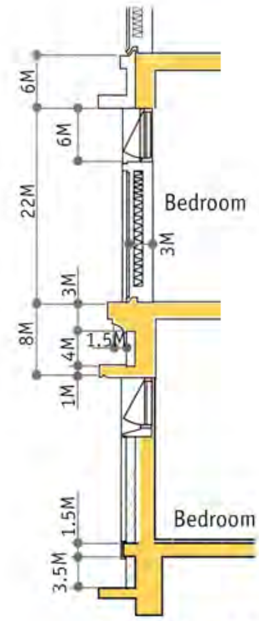
DBS Square - Facade Part Plan

5.2 HDB Sembawang N3C6 - Public Housing Block

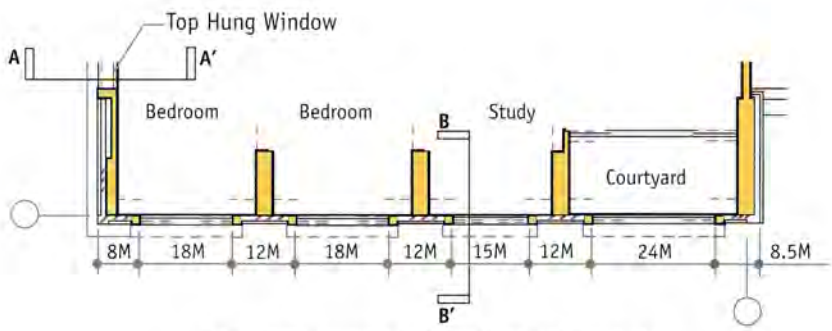


HDB Sembawang N3C6 - Elevation

HDB Sembawang N3C6 - Facade Part Elevation

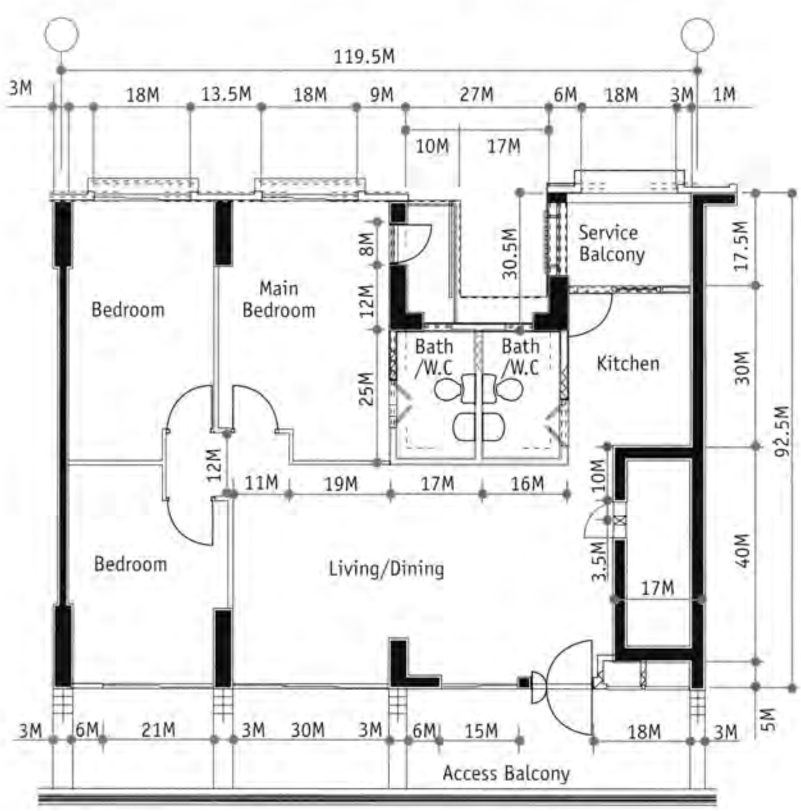


Section AA'



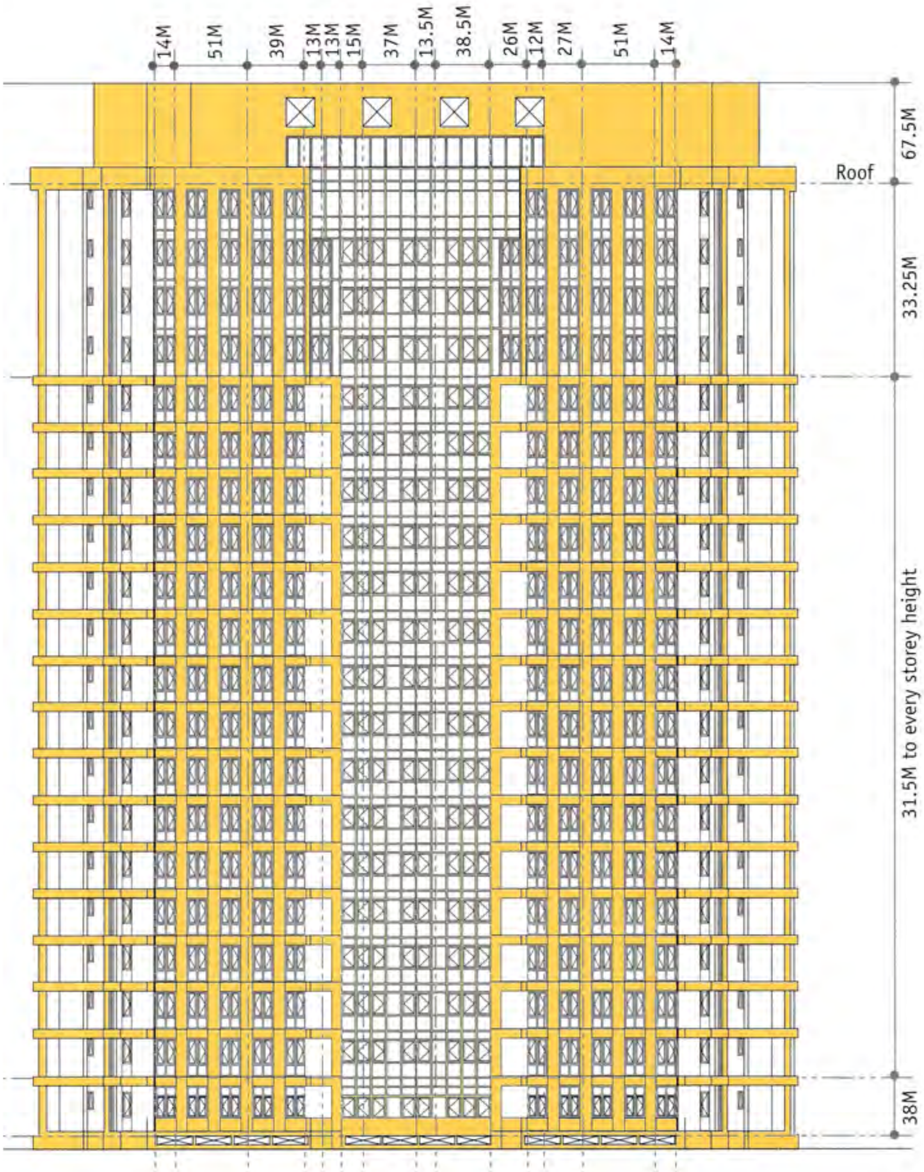
HDB Sembawang N3C6 - Facade Part Plan

Section BB'

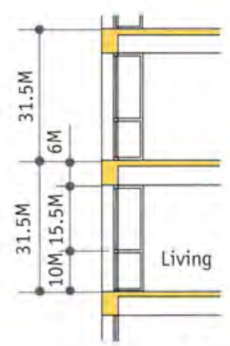


HDB Sembawang N3C6 - Typical Apartment Plan

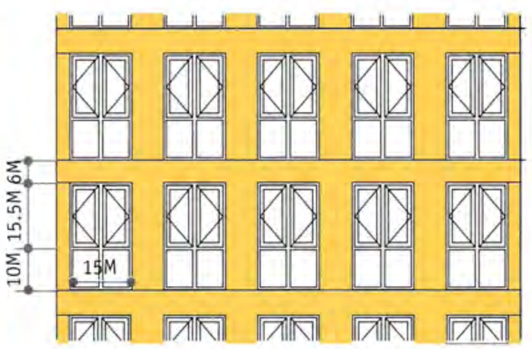
5.3 Tanglin View - Private Residential Block



Tanglin View - Elevation

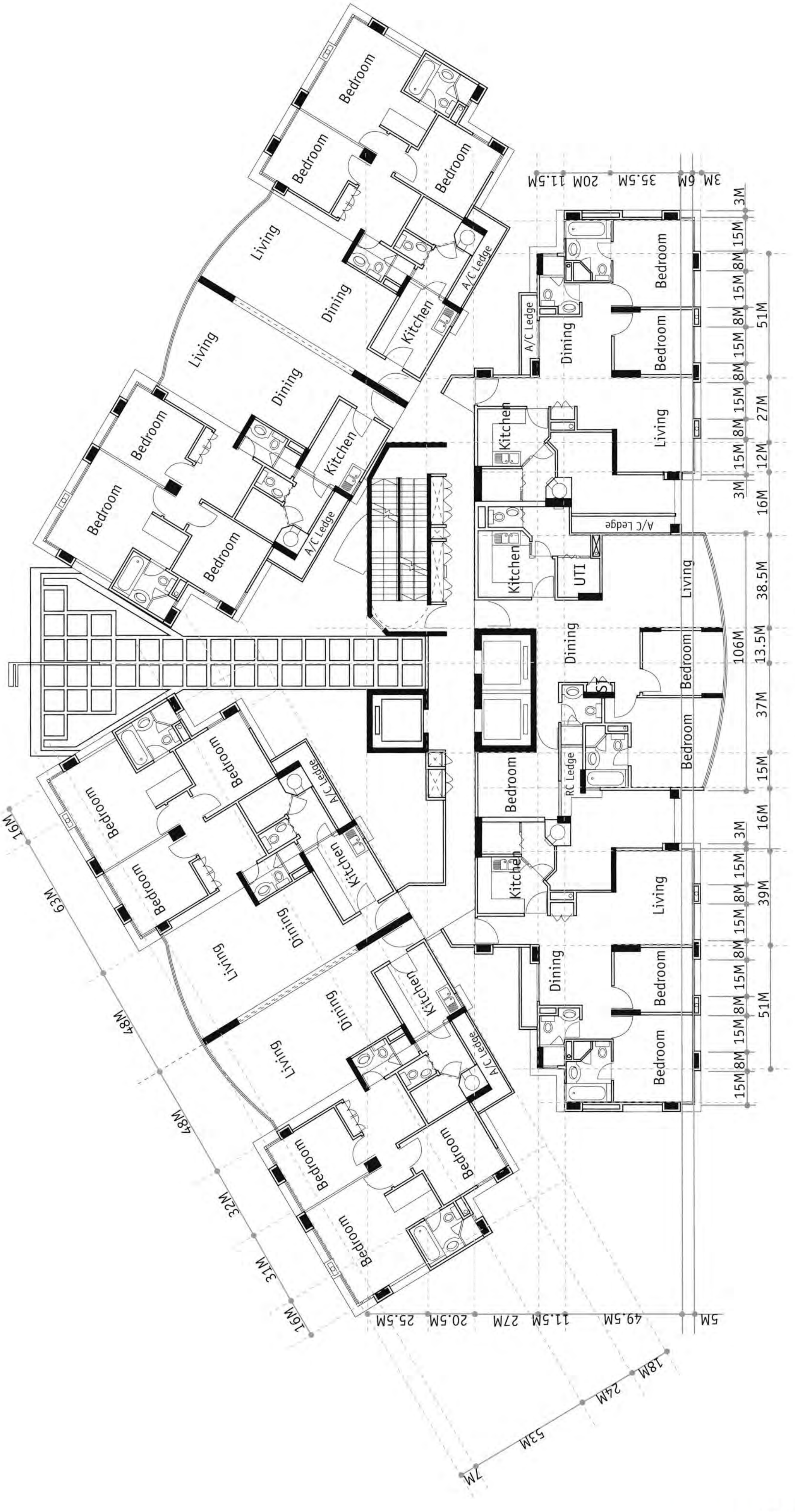


Section AA'



Tanglin View - Facade Part Elevation

Tanglin View - Facade Part Plan



Tanglin View - Floor Plan

APPENDIX A

SUMMARY OF PREFERRED SIZES

The materials and components are classified under the following:-

(a) Doors and Windows

(b) Precast Concrete Components

(c) Rigid Sheet Materials

(d) Ceiling Related Components

(e) Flooring Materials

All dimension are given in millimetres unless stated otherwise.

A.1 Doors And Windows

The coordinating dimensions include door and window frames.

A.1.1 **Doors**
Width : Multiples of **1M**.
Height : Multiples of **1M**.
(**0.5M** may be used as second preference for vertical increment)

A.1.2 **Windows**
Width : Multiples of **1M**.
Height : Multiples of **1M**.
(**0.5M** may be used as second preference for vertical increment)

A.2 Precast Concrete Components

A.2.1 Hollow-core slabs

Length : Multiples of **3M**
Width : **6M**

A.2.2 Precast prestressed concrete floor planks

Length : Multiples of **1M**
Width : **12M** to **24M**
Thickness : 65mm, 80mm, 110mm

A.2.3 Precast wall panels

Height : **24M** to **36M**
Width : **3M, 6M**, **12M**
Thickness : 75mm, 80mm, 90mm, 100mm

A.2.4 Stairs and stair openings

Coordinating dimensions:-
Horizontal and vertical distance between coordinating planes:
Horizontal : Multiples of **1M**
Vertical : Multiples of **0.5M**

A.2.5 Precast toilets

Internal coordinating dimensions:-
Length, Breadth and Height: Multiples of **1M** with second preference of **0.5M**

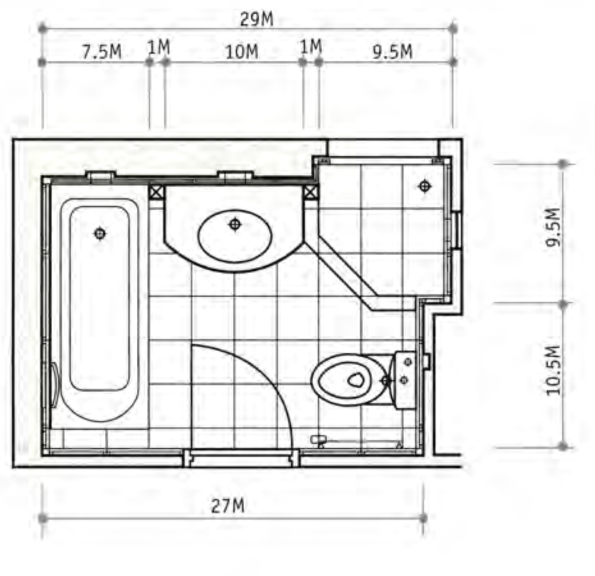


Fig A.2.5: Trellis Tower prefabricated bathroom

A.2.6 **Precast CD shelter**

Width : **12M** to **15M** in **3M** increments
Length : **18M** to **24M** in **3M** increments
Height : **30M** to **33M** in **3M** increments

Thickness of walls are in **0.25M** increments

The following table shows the recommended internal dimension for the various sizes of household shelters.

Gross Floor Area (GFA) Of Dwelling Unit	Minimum Internal Clear Floor Area Of HS	Nominal Occupancy Of HS (No. Of Person)	Recommended Internal Dimensions Of HS (W)x(L)x(H)	Thickness Of Wall
GFA $\leq 45m^2$	$2.0m^2$	2	**1.2 x 1.8 x 3.0**	275m
$75m^2 \geq$ GFA > $45m^2$	$2.4m^2$	3	**1.2 x 2.1 x 3.0**	275m
$140m^2 \geq$ GFA > $75m^2$	$3.2m^2$	4	**1.5 x 2.4 x 3.0**	275m
GFA > $140m^2$	$4.0m^2$	5	**1.5 x 2.4 x 3.0**	275m
			1.5 x 2.4 x 3.3	300m

Source: Architecture in Precast Concrete - BCA Buildability Series 1999.

* size of CD shelter depends on GFA of dwelling unit

A.3 Rigid Sheet Materials

A.3.1 **Wall Cladding**

The preferred coordinating sizes of cladding materials should be as follows, including any combination of them:

Width : **3M** to **12M** in **3M** increments
Height : **12M** to **30M** in **3M** increments

A.4 Ceiling Related Components

A.4.1 Panel components

The preferred coordinating sizes are:

3M x **3M**	**6M** x **12M**
3M x **6M**	**12M** x **12M**
6M x **6M**	**12M** x **24M**

A.4.2 Strip components

The preferred widths are: **1M**, **2M**, **3M**

A.5 Flooring Materials

A.5.1 Tile components

The coordinating dimensions (length x width) in order of preference are:

First : Multiples of **1M**
Second : Multiples of **0.5M** up to **3M**
Third : Multiples of **0.25M** up to **3M**

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