

Reference Guide on

**STANDARD  
PREFABRICATED  
BUILDING  
COMPONENTS**

BCA Buildability Series

The **Reference Guide on Standard Prefabricated Building Components** is published by  
the Buildability Development Section, Innovation Development Department,  
Technology Development Division of the Building and Construction Authority.

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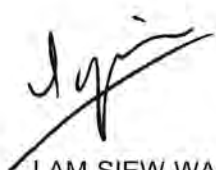
Information provided in this Reference Guide had been designed to cater for the building developments. The onus is on the  
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It is vital that Singapore's construction industry upgrades its technology and practice to meet the increasing customer expectations and new legislative requirements. The legislation of Buildable Design, which will be enforced in 2001, will quicken the pace of change.

To prepare the industry, BCA has organised a comprehensive promotion and training programme in buildability. Several design aids have also been published by the Authority. This Reference Guide is the fifth in the series of publications to encourage the industry to use more prefabricated components to improve construction efficiency. It is a follow-up on the recommendation made in the fourth publication, *Architecture In Precast Concrete* to use standard dimensions for various commonly used prefabricated building components.

This Reference Guide put together design details of prefabricated building components that are commonly used by the industry. I hope it will help to simplify the design and construction process and encourage more designers to incorporate prefabricated standard components in their building designs to help them achieve higher buildability.



LAM SIEW WAH

Deputy CEO (Industry Development)

Building and Construction Authority

BCA would like to express its gratitude to all the members in the BCA-Precasters Committee, which helped to review the Guide and the Working Committee of the Reference Guide, which prepared this publication.

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A special note of thanks to Housing and Development Board for its assistance and consent to reproduce its standard precast components details in this publication.

In addition, BCA would also like to express its appreciation to PBU suppliers (listed in Reference Sheet PBU02) for the consent to use their materials and photographs.

CHAPTER	PAGE
<b>1 INTRODUCTION AND SCOPE</b>	<b>1-1</b>
<b>2 PRECAST BUILDING CONSTRUCTION</b>	<b>2-1</b>
2.1 Advantages	2-1
2.2 Rationale of Standardising Prefabricated Building Components	2-3
<b>3 STANDARD PRECAST STAIRCASES</b>	<b>3-1</b>
3.1 Architectural Design Considerations	3-1
3.2 Structural Design Considerations	3-2
3.3 Standard Precast Staircase Dimensions	3-3
3.4 Prefabrication and Labelling	3-6
3.5 Reference Sheets	3-6
Architectural Reference Sheet ST01 - Recommended Dimensions for Standard Precast Staircase	3-7
Architectural Reference Sheet ST02 - Isometric View of Standard Precast Staircase (Dry Joint)	3-8
Architectural Reference Sheet ST03 - Isometric View of Standard Precast Staircase (Wet Joint)	3-9
Architectural Reference Sheet ST04 - General Notes for Standard Precast Staircase	3-10
Architectural Reference Sheet ST05 - Standard Precast Staircase Details (Dry Joint), Type: ST10/165	3-11
Architectural Reference Sheet ST06 - Standard Precast Staircase Details (Wet Joint), Type: ST10/165	3-12
Architectural Reference Sheet ST07 - HDB's Precast Staircase Details	3-13
Structural Reference Sheet ST08 - General Notes for Standard Precast Staircase (Dry and Wet Joint)	3-14
Structural Reference Sheet ST09 - Standard Precast Staircase Reinforcement Details (Dry Joint) Type: ST10/165	3-15
Structural Reference Sheet ST10 - Standard Precast Staircase Reinforcement Details (Wet Joint) Type: ST10/165	3-16

CHAPTER			PAGE
	Structural Reference Sheet	ST11 - HDB's Precast Staircase Reinforcement Details	3-17
	Structural Reference Sheet	ST12 - Design Tables - Precast Staircase Flight and Nib	3-18
	Structural Reference Sheet	ST13 - Design Example Precast Staircase ST10/165	3-20
<b>4</b>	<b>PRECAST REFUSE CHUTES</b>		4-1
4.1	Architectural Design Considerations		4-1
4.2	Structural Design Considerations		4-2
4.3	Standard Precast Refuse Chutes		4-2
4.4	Prefabrication and Labelling		4-3
4.5	Reference Sheets		4-3
	Architectural Reference Sheet	RC01 - Recommended Dimensions for Standard Precast Refuse Chute	4-4
	Architectural Reference Sheet	RC02 - Isometric View of Precast Refuse Chute	4-5
	Architectural Reference Sheet	RC03 - General Notes for Precast Refuse Chute	4-6
	Architectural Reference Sheet	RC04 - Precast Refuse Chute Details Type: RC/610C	4-7
	Architectural Reference Sheet	RC05 - HDB's Precast Refuse Chute Details	4-8
	Structural Reference Sheet	RC06 - General Notes for Precast Refuse Chute	4-9
	Structural Reference Sheet	RC07 - Precast Refuse Chute Reinforcement Details, Type: RC/601C	4-10
	Structural Reference Sheet	RC08 - HDB's Precast Refuse Chute Reinforcement Details	4-11

CHAPTER	PAGE
<b>5 PRECAST CIVIL DEFENCE SHELTERS</b>	<b>5-1</b>
5.1 Architectural Design Considerations for Household Shelters	5-2
5.2 Structural Design Considerations for Household Shelters	5-3
5.3 Standard Precast Household Shelter	5-4
5.4 Prefabrication and Labelling	5-5
5.5 Reference Sheets	5-5
Architectural Reference Sheet HS01 - Recommended Dimensions for Semi-Precast Household Shelter Wall (HSW)	5-6
Architectural Reference Sheet HS02 - Isometric View of Semi-Precast Household Shelter Wall (HSW)	5-7
Architectural Reference Sheet HS03 - Recommended Dimensions for Standard Precast Household Shelter Door Frame (HSD)	5-8
Architectural Reference Sheet HS04 - Isometric View of Precast Household Shelter Door Frame (HSD)	5-9
Architectural Reference Sheet HS05 - General Notes for Semi-Precast Household Shelter Wall and Precast Household Shelter Door Frame	5-10
Architectural Reference Sheet HS06 - Semi-Precast Household Shelter Wall Details Type: HSW/2700 x 3000	5-11
Architectural Reference Sheet HS07 - Precast Household Shelter Door Frame Details Type: HSD/1300 x 3000	5-12
Structural Reference Sheet HS08 - General Notes for Semi-Precast Household Shelter Wall and Precast Household Shelter Door Frame	5-13
Structural Reference Sheet HS09 - Semi-Precast Household Shelter Wall Reinforcement Details Type: HSW/2700 x 3000	5-14



CHAPTER	PAGE
Structural Reference Sheet HS10 - Precast Household Shelter Door Frame Reinforcement Details Type: HSD/1300 x 3000	5-15
Structural Reference Sheet HS11 - HDB's Precast Household Shelter Door Frame Reinforcement Details	5-16
<b>6 PRECAST / PREFABRICATED BATHROOM UNITS</b>	<b>6-1</b>
6.1 Types of Precast / Prefabricated Bathroom Units	6-2
6.2 Benefits of Precast / Prefabricated Bathroom Units	6-5
6.3 Architectural Design Considerations	6-5
6.4 Structural Design Considerations	6-7
6.5 Dimensioning and Labelling System	6-8
6.6 Reference Sheets	6-8
Reference Sheet PBU01 - Installation of Prefabricated Bathroom Units	6-9
Reference Sheet PBU02 - List of Suppliers for Precast / Prefabricated Bathroom Units	6-10
Reference Sheet PBU03 - Precast / Prefabricated Bathroom Unit Suppliers	6-11
• Eastern Pretech Pte Ltd	6-11
• Eng Seng Cement Products Pte Ltd	6-12
• Fermold Pte Ltd	6-13
• Framework Building Products Pte Ltd	6-14
• G & W Precast Pte Ltd	6-15
• Hong Leong Asia Ltd	6-16
• Keppel Sea Scan Pte Ltd	6-17
• National Matsushita Electric Works (Asia Pacific) Pte Ltd	6-18
• Plus Link Industries Pte Ltd	6-19
• Prefab Technology Pte Ltd	6-20

#### List of Suppliers for Precast Concrete Building Components

# CHAPTER 1

## 1.1 Introduction

This Reference Guide is a design tool for designers (including developers, architects, engineers, contractors, precasters, etc.), who may, from time to time, need to make reference to the dimensions and connection details of standard prefabricated building components commonly used and specified by the industry. It describes the applications of standard prefabricated building components, which are being adopted by the industry and their design considerations.

## 1.2 Scope

The Committee studied different types of prefabricated building components. However, as a start, only the standard precast concrete staircases, refuse chutes, civil defence shelter wall / door frame and precast / prefabricated bathrooms units are introduced in the Reference Guide.

The dimensions recommended in the Reference Guide are for residential, commercial and institutional developments. Nevertheless, with the assistance from precasters and designers, some of the recommended dimensions could be modified to meet individual project requirements.

The Reference Guide will be updated and expanded periodically. The Committee welcomes feedback or suggestions for improving the Reference Guide.

# CHAPTER 2

Precasting is recognised as a staple of modern construction for its many inherent benefits such as good quality, speed of erection, durability and flexibility for aesthetics.

## 2.1 Advantages

Benefits from the use of standard prefabricated building components include:

- **Better project management**
- **Shorter project / construction period**
- **Competitive construction cost**
- **Better control of labour**
- **Minimal housekeeping**
- **Quality assurance**

### Better project management

The successful implementation of precast concrete projects requires careful planning and good co-ordination among the clients, architects, engineers and also the potential precasters and contractors, right from the inception of a project. With the Reference Guide in-place, the awareness of the standard details would enable better design, integration and co-ordination, resulting in better project management.

### Shorter project / construction period

In a competitive environment such as in Singapore, shorter construction period would mean lower interest cost on construction development loans and quicker investment returns. With the use of prefabrication / precast technology, standard building components could be produced in the factory without affecting site operations, thereby shortening the construction cycle and construction period.

### Competitive construction cost

With the impending legislation of Buildable Design in 2001, the production level of prefabricated components is expected to increase. For mass production of prefabricated components to be viable, there is a need to have a high level of standardisation. This would enable some savings in producing

shop drawings and using inter-changeable components that are suitable for a wider range of building types. In addition, standardisation of prefabricated components would lower the cost of production and offset the high capital investment in equipment and mould.

### Better control of labour

Singapore relies heavily on foreign workers. In the *Construction 21* report, the Government has signalled that; "The Man-Year Entitlement (MYE) will be further reduced to 70% of the current levels by 2005 and eventually to 50% of the current level by 2010, or earlier if practicable."

The productivity of the construction industry could be improved through the usage of standard prefabricated building components. The use of these components would allow contractors to increase productivity at site with fewer unskilled workers.

### Minimal housekeeping

It is not easy for a contractor to maintain a clean, hygienic and tidy site by using the traditional in-situ construction. This is due to the nature of work, which requires labour intensive steel fixing, concreting and carpentry. Past records have identified that an untidy and congested site is prone to accidents.

Prefabrication technology enables the transfer of in-situ construction activities from sites to factories, resulting in a cleaner, less congested and safer worksite.

### Quality assurance

With the higher affluence of our society and higher level of education, customers today demand value for the high cost of their properties and they are less tolerant to poor quality and defects. Prefabricated components produced under a factory environment allow tighter quality control. The result is a more consistent quality product with fewer defects.

## 2.2 Rationale of Standardising Prefabricated Building Components

The objectives of standardising prefabricated building components are to:

- Encourage the industry to move away from labour-intensive to labour-saving construction methods.
- Promote the wider use of standard prefabricated building components.
- Encourage designers to use the recommended dimensions as a starting point of their design.
- Facilitate and provide designers with the necessary design data, which could be purchased off the shelf from precasters.
- Provide the necessary design guidelines and considerations when adopting standard prefabricated building components.
- Provide the necessary reinforcement details, which are commonly adopted by the industry.
- Minimise errors and rectification works, commonly encountered in in-situ construction.

**STANDARD  
PRECAST  
STAIRCASES**

## CHAPTER 3

Highly skilled workers are required to construct staircases in-situ because the step configuration of staircases could not be possibly made without skilled carpentry. The result is longer construction duration.

Using precast staircases will shorten the construction duration. It also allows operational access instantly to all floor areas. When constructed as non-critical structural components, stairwells can be used as access for the delivery of construction materials.

### 3.1 Architectural Design Considerations

The proposed standard precast concrete staircase is designed for use in residential, commercial and institutional developments. It is possible for an architect to specify standardised precast staircases according to Architectural Reference Sheet ST01, instead of detailing staircases. Once the floor to floor height is determined, the architect would merely have to indicate the type of staircase components on the drawings and the contractor can then buy these components off the shelf from the precaster. Using precast components would also eliminate the frequent construction errors in riser height in in-situ construction.



### 3.2 Structural Design Considerations

Precast stair slabs are usually designed to span longitudinally into the landings at right angles to the stair flights or span between supporting beams. In monolithic construction, the stair slab can be designed with continuous end restraints over the supports. But in instances where staircases are precast, the construction is generally carried out after the main structure, with pockets or recesses left in the supporting slabs or beams to receive the stair flights. With no appreciable end restraints, a precast stair slab could therefore be designed as simple slab between supports.

In design, the dead load is calculated along the sloping lengths of the stairs but the live and finishing loads are based on plan area. If the risers were to be covered with finishes, additional loads would have to be added in the design.

The effective span is measured horizontally between the centres of the supports or the actual horizontal length of the precast stair slab where dry connections are used at the supports. The thickness of the waist is taken as the slab thickness.

The basic span-effective depth ratio may be increased by 15% to 23 ( $=20 \times 1.15$ ) if the stair flight occupies at least 60% of the span. This will apply to precast stair slabs without landings.

The supporting nibs of the precast stair slab may be constructed with either dry or wet connections (extended bearings). The design of reinforcement of the nibs can be based on:

- Simple bending
- Strut and tie force model
- Shear friction

Theories and examples of the various design approaches can be obtained in the *Structural Precast Concrete Design Handbook* by BCA. Small diameter rebars should be used at the nibs as a result of the structural dimensions adopted



### 3.3 Standard Precast Staircase Dimensions

In practice, the number of risers and the riser height of a staircase have always been dictated by the storey height of a building. This would result in different riser dimensions. Prefabricating stair flights with many different riser dimensions would not be economically viable.

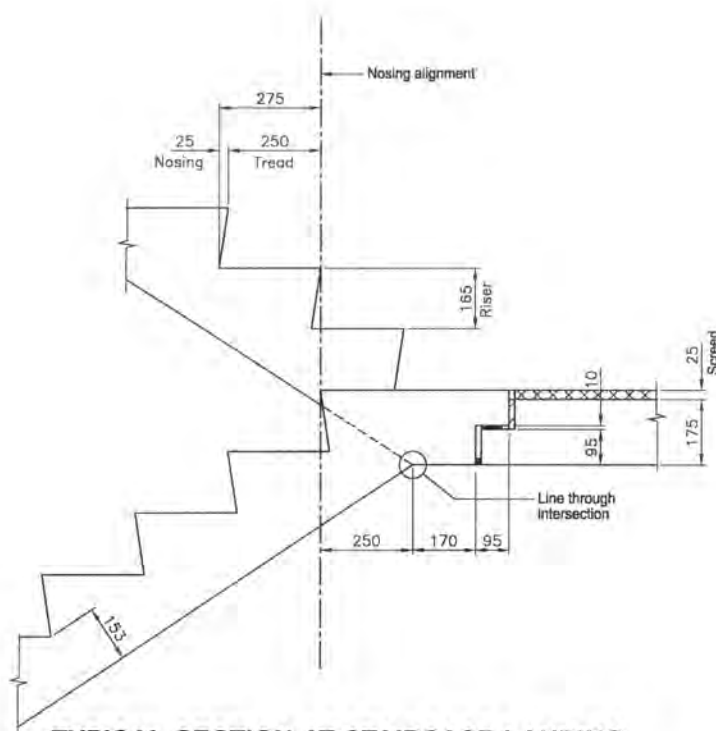
Standard precast staircases for residential projects have already been developed by Housing and Development Board (HDB) and the private sector. The main difference between HDB housing and private housing is the variation in floor to floor height. As most private developers prefer higher headroom, the number of risers and the riser height would vary accordingly.

The Committee considered the design aspects related to the aesthetic, fabrication, handling and erection of precast staircases and incorporated the following two distinct architectural features in the standard precast concrete staircase:

- Alignment of nosing of the first flight flushed with the nosing of adjacent flight.
- Simple and lined through intersection at the soffit of staircases where the flights and landings meet.

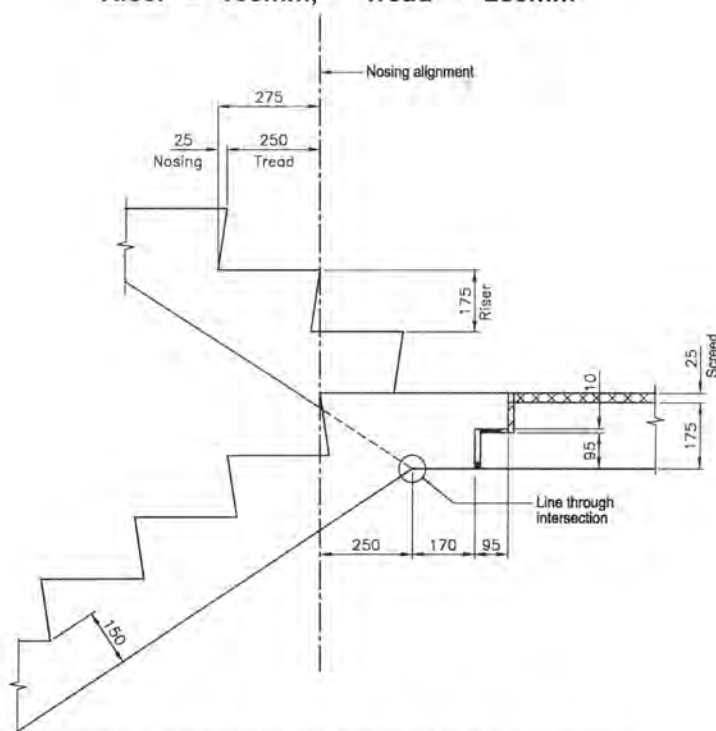
The Committee also proposed to limit the riser height to 165mm and 175mm, with a tread dimension to 250mm. These dimensions are suitable for fire escapes. For school development projects, 150mm riser with 300mm tread (instead of 250mm) are recommended dimensions required by the Ministry of Education, for safety reasons.

The following sketches show the recommended staircase dimensions for private housing and commercial developments.



**TYPICAL SECTION AT STAIRCASE LANDING**

**Riser = 165mm, Tread = 250mm**



**TYPICAL SECTION AT STAIRCASE LANDING**

**Riser = 175mm, Tread = 250mm**

Architectural Reference Sheet ST01 provides the recommended riser flight combinations, which could be used as reference for designers to select the appropriate floor height dimensions. For example in residential developments, a designer could use staircases with 175mm riser for a floor to floor height of 3,150mm, for fire escape. In luxury residential developments, staircases with a 165mm riser would be appropriate for a floor to floor height of 3,300mm.

The recommended width of standard staircase is ideally set to allow for a 1,000mm clearance between handrails and edging kerb. In addition, it allows designers to include or exclude an edging kerb (or buffer zone) of 75mm width to one side of the staircase. The provision is intended for the fixing of balustrades, which could be welded to the base plate, cast in the welding pocket, or bolted to the concrete surface by cast in socket.

### 3.4 Prefabrication and Labelling

Precast concrete staircases are cast on their sides or face down using precision-engineered steel mould and off-formed finished with nosing groove lines. The quality of end product is therefore assured. Dimensions such as the tread and riser should be fixed, to maximise the general usage of standard moulds. The Committee encourages designers to adopt the recommended dimensions as in Table 1, 2 and 3 of Reference Sheet ST01 in their designs.

The Committee also recommends designers to make use of the dimensions and details presented in the Architectural Reference Sheets. The labelling system for Stair Flight Type based on the following system,

ST10	/	150
------	---	-----

is defined as:

ST	-	Standard Precast Stair Flight
10	-	Number of Risers per Stair Flight
150	-	Riser dimension (in mm)

### 3.5 Reference Sheets

Stair Flight Type	1 <sup>st</sup> Flight (Riser Nos.)	2 <sup>nd</sup> Flight (Riser Nos.)	Floor to floor Height (mm)
ST10/150	10	10	3000
ST11/150	11	11	3300
ST12/150	12	12	3600

Note: Standardised 300mm tread, recommended for school development projects.

**Table 2 165mm riser staircase.**

Stair Flight Type	1 <sup>st</sup> Flight (Riser Nos.)	2 <sup>nd</sup> Flight (Riser Nos.)	Floor to floor Height (mm)
ST10/165	10	10	3300

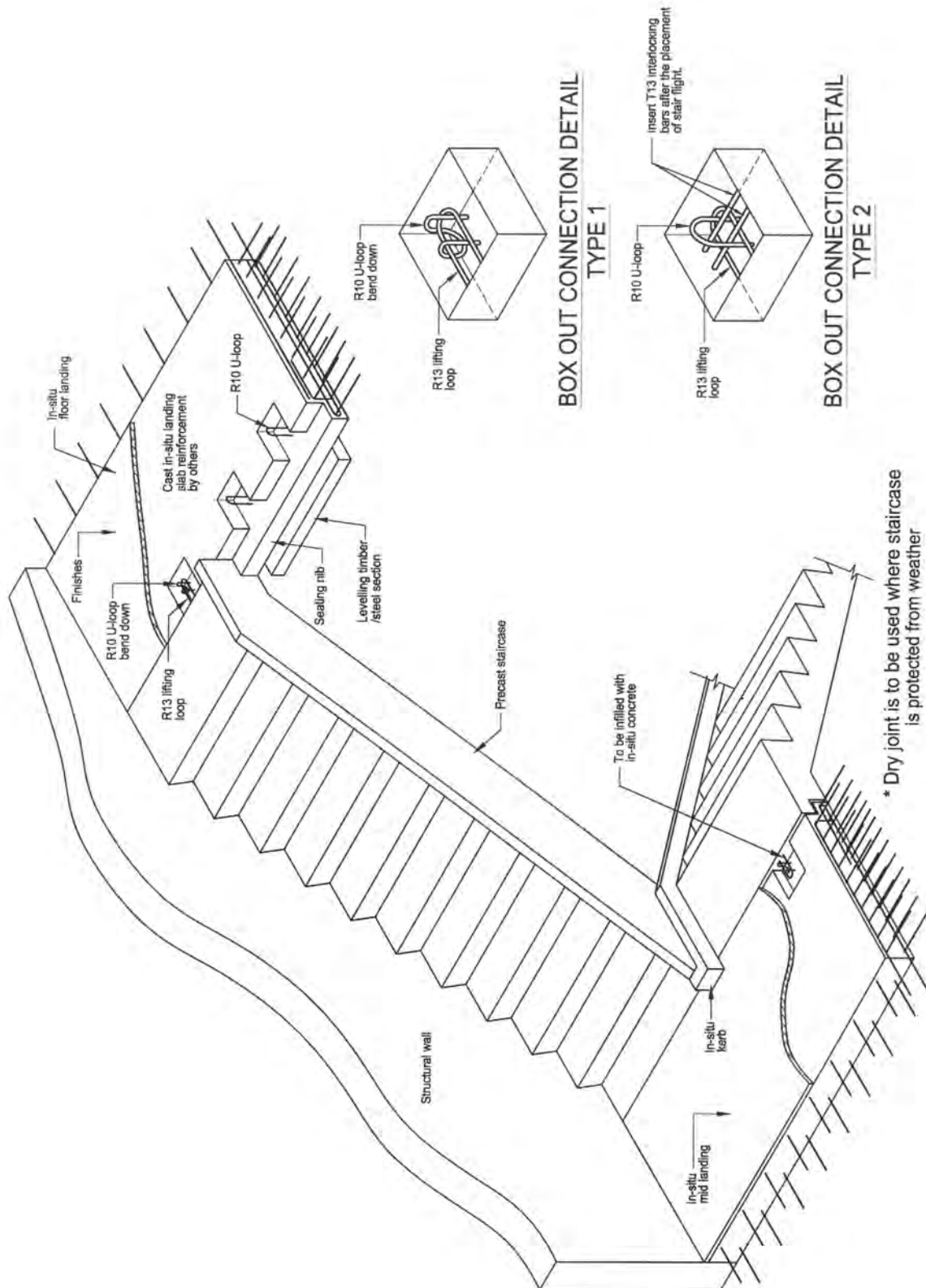
Note: Standardised 250mm tread.

**Table 3 175mm riser staircase.**

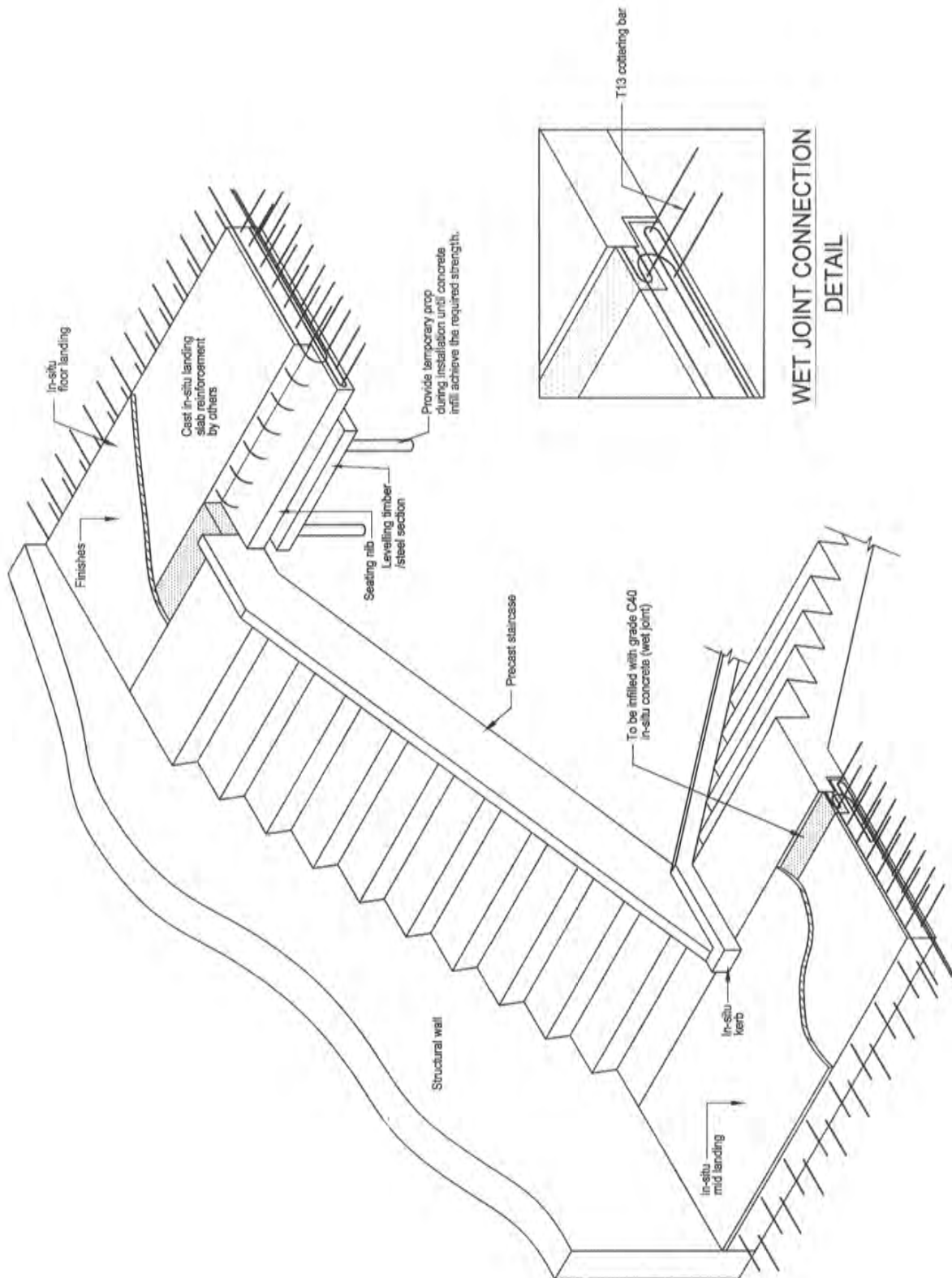
Stair Flight Type	1 <sup>st</sup> Flight (Riser Nos.)	2 <sup>nd</sup> Flight (Riser Nos.)	Floor to floor Height (mm)
ST8/175	8	8	2800
ST9/175	9	9	3150
ST10/175	10	10	3500
ST11/175	11	11	3850
ST12/175	12	12	4200

Note: Standardised 250mm tread.

## ISOMETRIC VIEW OF STANDARD PRECAST STAIRCASE (DRY JOINT)



# ISOMETRIC VIEW OF STANDARD PRECAST STAIRCASE (WET JOINT)



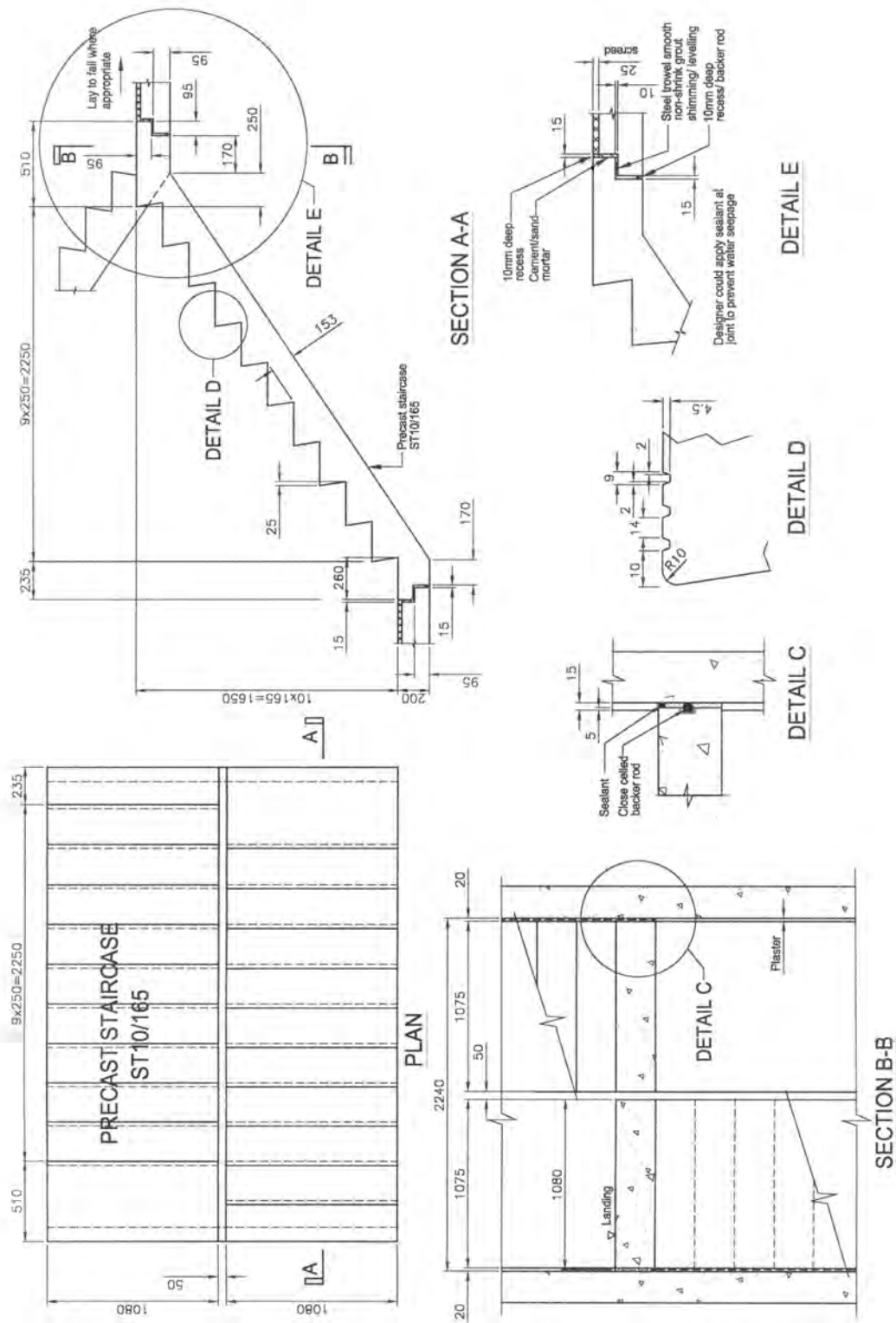
**GENERAL NOTES FOR STANDARD PRECAST STAIRCASE**

1. In practice, the number of risers and the riser height of a staircase have always been dictated by the storey height of a building. This would result in different riser dimensions. Due to the cost of mould, prefabricating stair flights with many different riser dimensions would not be economically viable.
2. The Committee recommends designers to limit the riser height to 165mm and 175mm, with a tread dimension to 250mm. For school development projects, 150mm riser with 300mm tread (instead of 250mm) are recommended dimensions required by the Ministry of Education, for safety reasons.
3. The architectural features of the proposed precast staircase are:
  - Alignment of nosing of the first flight flushed with the nosing of adjacent flight.
  - Simple and lined through intersection at the soffit of staircases where the flights and landings meet.
4. The proposed precast staircase would be suitable for fire escape. However, it could be modified by Qualified Person to suit the intended usage.
5. The recommended width of the standard staircase is ideally set to allow for a 1,000mm clearance between handrails and edging kerb of 75mm to one side of the staircase for the fixing of balustrades.
6. Precast concrete staircases are cast on their sides or face down using precision-engineered steel mould and off-formed finished with nosing groove lines.



## STANDARD PRECAST STAIRCASE DETAILS (DRY JOINT)

**TYPE: ST10/165**



**PRECAST STAIRCASE ST10/165**

**PLAN**

Overall dimensions: 1080 (width) x 2250 (length). The plan shows a series of parallel precast units with a total length of 9x250=2250 and a total width of 1080. A section line A-A is indicated.

**SECTION A-A**

Vertical dimensions: 235, 235, 510. Horizontal dimensions: 250, 170, 200, 153. The section shows the profile of the precast staircase units (ST10/165) and the concrete structure. A detail callout for 'DETAIL E' is shown at the top.

**DETAIL E**

Dimensions: 95, 200, 170, 250. A note indicates 'Lay to fall where appropriate' with an arrow pointing to the sloped surface.

**DETAIL D**

Dimensions: 25, 170. The detail shows the connection between the precast staircase unit and the concrete structure.

**DETAIL C**

Dimensions: 15, 5, 14, 2, 9, 10, 14, 2, 9, 10. The detail shows the connection between the precast staircase unit and the concrete structure, including a 'Close rolled backer rod' and 'Sealant'.

**DETAIL B**

Dimensions: 25, 15, 95, 200, 170, 250. The detail shows the connection between the precast staircase unit and the concrete structure, including a 'Steel trowel smooth non-shrink grout shimming/levelling 10mm deep recess / Backer rod' and a note: 'Designer could apply sealant at joint to prevent water seepage'.

**SECTION B-B**

Vertical dimensions: 20, 1075, 1080, 1075, 20. Horizontal dimensions: 1080, 50, 1075, 20. The section shows the profile of the precast staircase units (ST10/165) and the concrete structure. A detail callout for 'DETAIL C' is shown at the top.

**DETAIL C**

Dimensions: 1080, 50, 1075, 20. The detail shows the connection between the precast staircase unit and the concrete structure, including a 'Close rolled backer rod' and 'Sealant'.

[illegible]

## GENERAL NOTES FOR STANDARD PRECAST STAIRCASE (DRY AND WET JOINT)

### Concrete

1. Minimum grade of concrete in all reinforced concrete elements shall be C40, normal weight concrete.
2. Nominal cover to reinforcement shall be 25mm.
3. Surface finishes shall be off-form.
4. It shall have a minimum fire rating of two hours.

### Reinforcement

1. All reinforcement shall conform to the latest BS4449 with a minimum yield stress:
  - T - Denotes 460 N/mm<sup>2</sup> high yield deformed bar, Type 2
  - R - Denotes 250N/mm<sup>2</sup> for mild steel bars
2. All steel fabric shall conform to the latest BS4483 with a minimum yield stress of 485N/mm<sup>2</sup>.

### Design Considerations

1. Walls shall be designed in accordance with the provisions of BS8110.
2. Precast stair flight was designed as simply support slab between landings.
3. When completed, stair flight shall be restrained by cast in-situ landing.

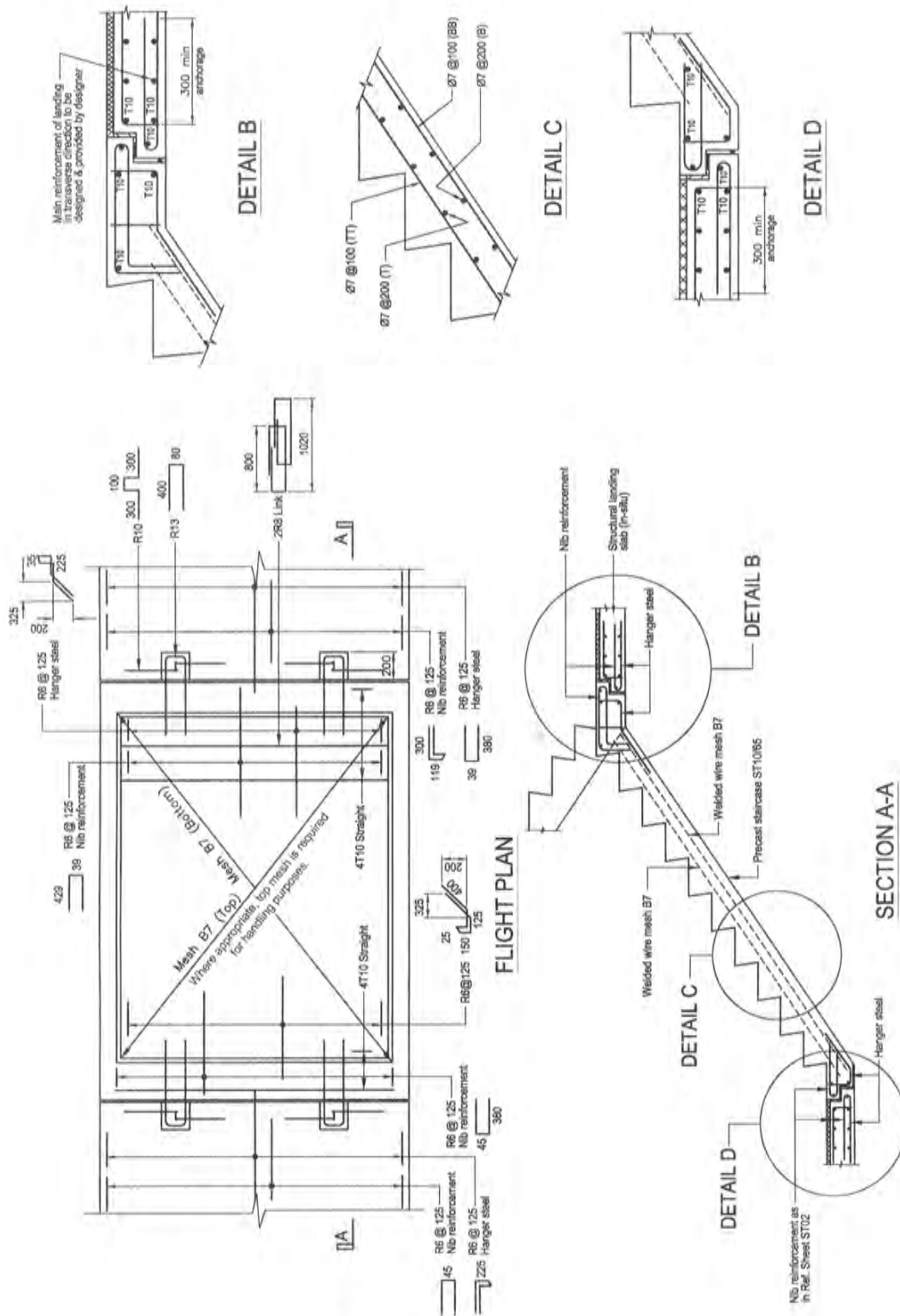
### Dry Joint Construction Sequence

1. Landings shall be cast in-situ before the placement of precast stair flights.
2. Levelling timber or steel section shall be used, to ensure flushed soffit when completed.
3. When dry joint is to be adopted at seating nib, U-loops at landings and ends of stair flight shall be bent and interlocked with each other after the placement of stair flight. Alternatively, interlocking rebars could be inserted after the placement of stair flight on landings. (Reference Sheet ST02)
4. Nominal stair flight / landing contact bearing shall be 75mm.

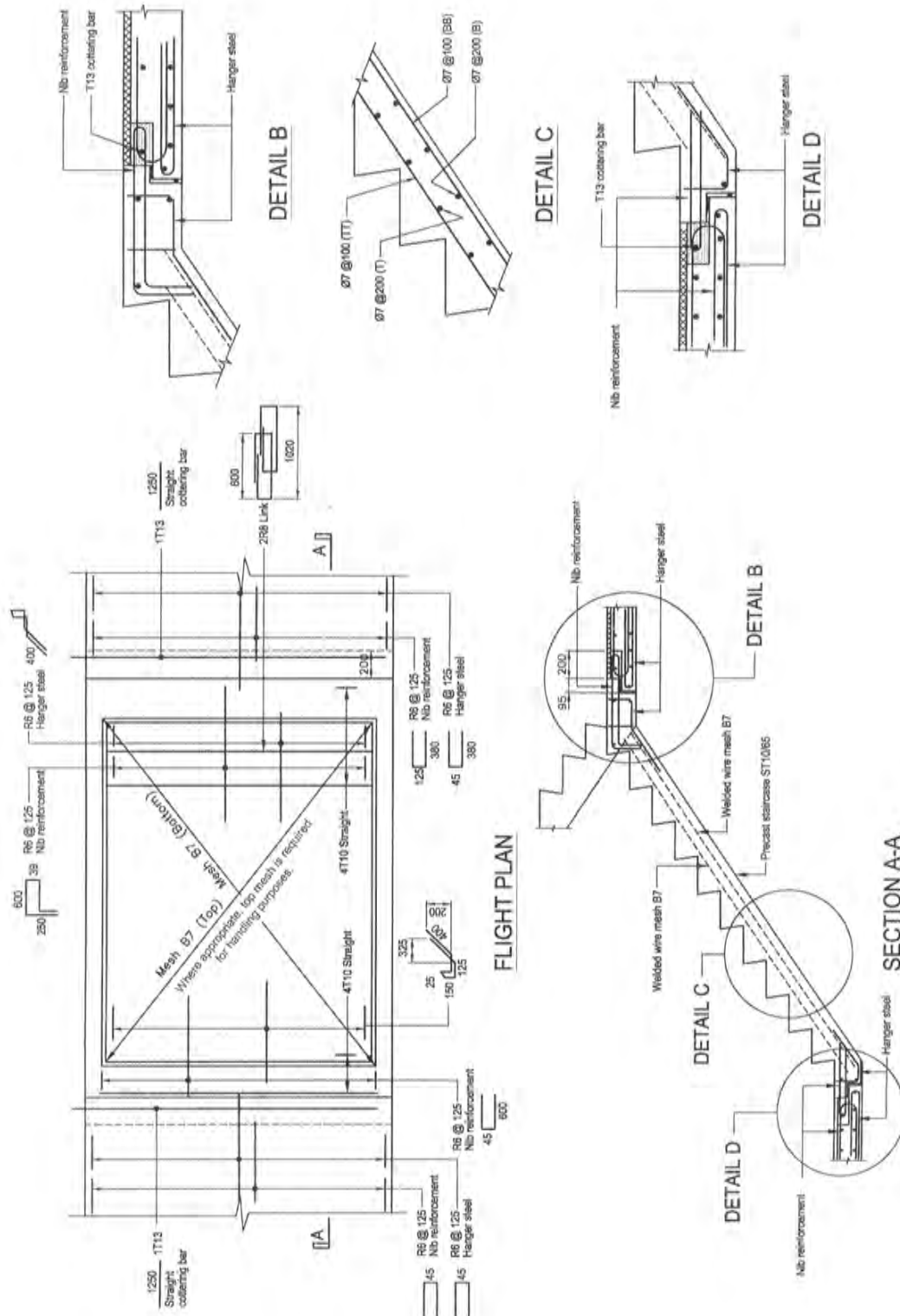
### Wet Joint Construction Sequence

1. Landings shall be cast in-situ before the placement of precast stair flights.
2. Levelling timber or steel section shall be used, to ensure flushed soffit when completed.
3. The cast in-situ strip will prevent water seeping through the joint, suitable for staircases subjected to wetting and drying. (Architectural Reference Sheet ST03)
4. Temporary props / levelling timber or steel sections shall be used to ensure cast in-situ concrete infill achieve the required strength during installation.
5. Nominal stair flight / landing contact bearing shall be 75mm.

**STANDARD PRECAST STAIRCASE REINFORCEMENT DETAILS (DRY JOINT)**  
**TYPE: ST10/I65**



## STANDARD PRECAST STAIRCASE REINFORCEMENT DETAILS (WET JOINT) TYPE: ST10/165

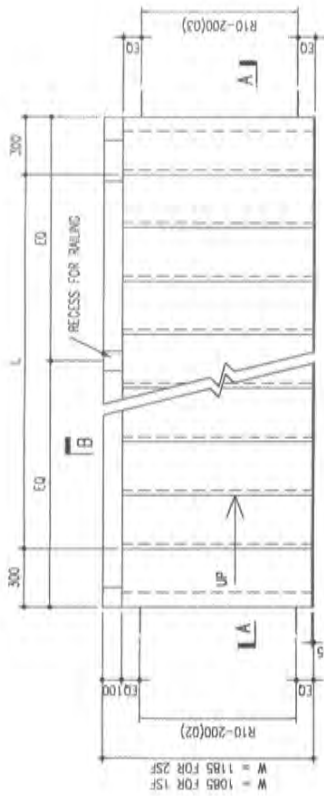


HDB'S PRECAST STAIRCASE REINFORCEMENT DETAILS

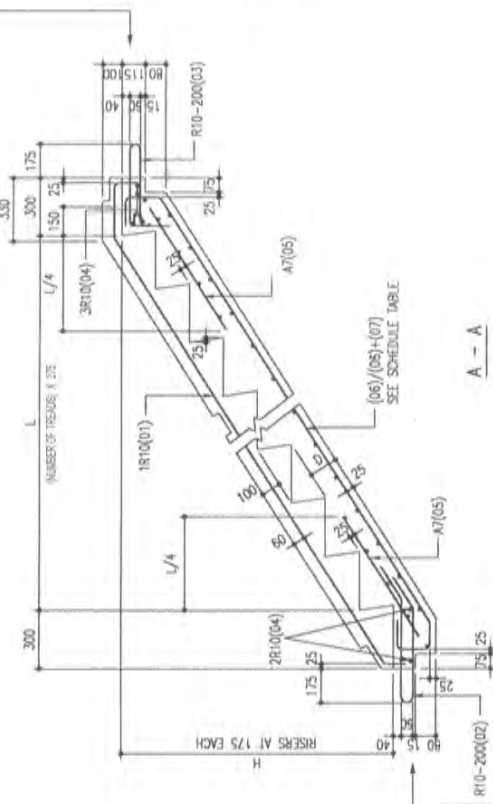
BAR SCHEDULE TABLE				
WAST(D)	BAR MARK	BAR SIZE	SHAPE	QTY.
100	05	188	MESH	1
	07	—	—	—
125	06	810	MESH	1
	07	—	—	—
150	06	812	MESH	1
	07	T10	X2	5
175	06	812	MESH	1
	07	T10	X2	5

BAR SCHEDULE TABLE				
BAR MARK	BAR SIZE	SHAPE	QTY.	
01 (FOR 1SF)	R10	X1 280	140	1
		X1 280		
		X1 280		
02 (FOR 2SF)	R10	525 / 200	60/100	5
		525 / 200		
		525 / 200		
03 (FOR 1SF)	R10	150	60/100	5
		150		
		150		
04 (FOR 2SF)	R10	1035	1135	5
		1035		
		1035		
05 (FOR 2SF)	A7	MESH	—	2
		MESH		
		MESH		

TYPE	No. OF RECESS	FLIGHT DIMENSIONS (mm)				BAR LENGTH (mm)	
		LENGTH (L)	No. OF TREADS (T)	HEIGHT (H)	WAST (D)	X1	X2
1SF 2SF	3	3375	5	1050	—	1710	—
		1850	6	1225	100	2035	—
		1975	7	1400	—	2360	—
		2200	8	1575	—	2685	—
		2475	9	1750	125	3010	—
	4	2750	10	1925	—	3335	—
		3025	11	2100	—	3660	—
		3300	12	2275	150	3985	3855
		3575	13	2450	—	4310	4180
		3850	14	2625	175	4635	4505
		4125	15	2800	—	4960	4830



DETAIL APPLICABLE FOR CONNECTION TO 150 THK SLAB/170 & 195 THK PRECAST SLAB  
FOR CONNECTION TO 200/250 THK SLAB SEE DETAIL B



DETAIL APPLICABLE FOR CONNECTION TO 150 THK SLAB/170 & 195 THK PRECAST SLAB  
FOR CONNECTION TO 200/250 THK SLAB SEE DETAIL C



**DESIGN TABLE - PRECAST STAIRCASE FLIGHT AND NIB****Live Load = 2.5kN/m<sup>2</sup> and 3.0kN/m<sup>2</sup>**

Type	Main Reinforcement		Nib Reinforcement	Main Reinforcement		Nib Reinforcement
	Live Load (2.5kN/m <sup>2</sup> )	Live Load (2.5kN/m <sup>2</sup> ) + Finishes		Live Load (3.0kN/m <sup>2</sup> )	Live Load (3.0kN/m <sup>2</sup> ) + Finishes	
ST10/150	-	-	R6 @ 150	-	-	R6 @ 125
	B8	B9		B9	B9	
ST11/150	B6	B6	R6 @ 125	B6	B7	R6 @ 125
	B9	B10		B10	B10	
ST12/150	B8	B8	R6 @ 125	B8	B8	R6 @ 100
	B10	B12		B12	B12	
ST10/165	-	-	R6 @ 150	-	-	R6 @ 150
	B6	B7		B7	B7	
ST8/175	-	-	R6 @ 150	-	-	R6 @ 150
	B6	B6		B6	B6	
ST9/175	-	-	R6 @ 150	-	-	R6 @ 150
	B6	B7		B7	B7	
ST10/175	-	-	R6 @ 150	-	-	R6 @ 150
	B7	B7		B7	B7	
ST11/175	-	-	R6 @ 150	-	-	R6 @ 125
	B7	B8		B8	B8	
ST12/175	-	-	R6 @ 125	-	-	R6 @ 125
	B9	B10		B10	B10	

Note:

1. Design parameters:  $f_{cu}=40\text{N/mm}^2$ ;  $f_y=485\text{N/mm}^2$ (mesh);  $f_y=460\text{N/mm}^2$ (T-bars);  $f_y=250\text{N/mm}^2$ (mild steel); Cover=35mm

2. Finishes are taken as 1.2kN/m<sup>2</sup>.

3. 

B9
B10

 - Denotes Top reinforcement using B9 mesh  
 - Denotes Bottom reinforcement using B10 mesh

4. The proposed standard precast concrete staircase is designed for peacetime use. Nevertheless, where there is only one staircase leading to household shelters, the Professional Engineer or Qualified Person would have to carry out a detailed design in compliance with Civil Defence requirements.



**DESIGN TABLE - PRECAST STAIRCASE FLIGHT AND NIB****Live Load = 4.0kN/m<sup>2</sup> and 5.0kN/m<sup>2</sup>**

Type	Main Reinforcement		Nib Reinforcement	Main Reinforcement		Nib Reinforcement
	Live Load (4.0kN/m <sup>2</sup> )	Live Load (4.0kN/m <sup>2</sup> ) + Finishes		Live Load (5.0kN/m <sup>2</sup> )	Live Load (5.0kN/m <sup>2</sup> ) + Finishes	
ST10/150	-	-	R6 @ 150	-	-	R6 @ 100
	B9	B10		B9	B9	
ST11/150	B7	B6	R6 @ 100	B6	B7	R6 @ 100
	B10	B12		B12	B12	
ST12/150	B8	B8	R6 @ 100	B8	B8	R6 @ 100
	B12	B12 + T10@200		B12 + T10@200	B12 + T10@100	
ST10/165	-	-	R6 @ 125	-	-	R6 @ 125
	B7	B7		B7	B7	
ST8/175	-	-	R6 @ 150	-	-	R6 @ 150
	B6	B7		B6	B7	
ST9/175	-	-	R6 @ 150	-	-	R6 @ 125
	B7	B8		B7	B7	
ST10/175	-	-	R6 @ 125	-	-	R6 @ 125
	B7	B8		B8	B8	
ST11/175	-	-	R6 @ 125	-	-	R6 @ 100
	B8	B9		B9	B10	
ST12/175	-	-	R6 @ 100	-	-	R6 @ 100
	B10	B12		B12	B12	

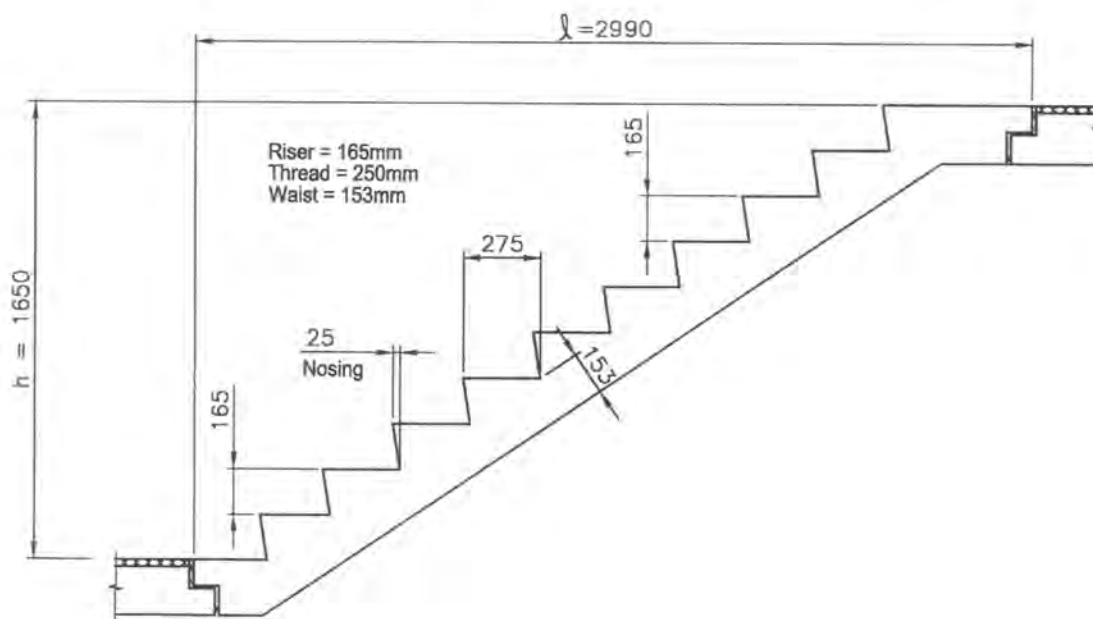
Note:

- Design parameters:  $f_{cu}=40\text{N/mm}^2$ ; Cover=35mm  
 $f_y=485\text{N/mm}^2$ (mesh);  $f_y=460\text{N/mm}^2$ (T-bars);  $f_y=250\text{N/mm}^2$ (mild steel)
- Finishes are taken as 1.2kN/m<sup>2</sup>.

- |     |
|-----|
| B9  |
| B10 |

- Denotes Top reinforcement using B9 mesh  
- Denotes Bottom reinforcement using B10 mesh

- The proposed standard precast concrete staircase is designed for peacetime use. Nevertheless, where there is only one staircase leading to household shelters, the Professional Engineer or Qualified Person would have to carry out a detailed design in compliance with Civil Defence requirements.

**DESIGN EXAMPLE - PRECAST STAIRCASE ST10/165****Design Data:****Material**

Concrete	$f_{cu}$	=	$40\text{N/mm}^2$
Welded Mesh	$f_y$	=	$485\text{N/mm}^2$
Mild Steel	$f_y$	=	$250\text{N/mm}^2$
Cover to reinforcement		=	25mm
Fire Rating		=	2 hours

**Loading**

Design Live Load		=	$4.0\text{kN/m}^2$
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Consider per metre width of staircase

$$\begin{aligned}
 \text{Slope length of stair} &= \sqrt{(1.65^2 + 2.99^2)} \\
 &= 3.415\text{m} \\
 \text{Weight of waist plus steps} &= (0.153 \times 3.415 + 0.275 \times 0.165 \times 10 \div 2) \times 24 \\
 &= 18.00\text{kN/m} \\
 \text{Live Load} &= 4.0 \times 2.99 \\
 &= 11.96\text{kN/m} \\
 \text{Ultimate Load, F} &= 1.4 \times 18.00 + 1.6 \times 11.96 \\
 &= 44.34\text{kN/m}
 \end{aligned}$$

**Bending Reinforcement**

Assuming no effective restraint at support.

$$\begin{aligned}
 \text{Ultimate BM at mid-span} &= \frac{F \times L}{8} \\
 M &= \frac{44.34 \times 2.99}{8} \\
 &= 16.57\text{kNm/m} \\
 \text{Effective depth, } d &= 153 - 25 - 10 \div 2 \\
 &= 123\text{mm} \\
 \text{Use } d &= 120\text{mm} \\
 z/d &= 0.5 + \sqrt{(0.25 - M \div (0.9bd^2f_{cu}))} \\
 &= 0.5 + \sqrt{(0.25 - (16.57 \times 10^6 \div (0.9 \times 1000 \times 120^2 \times 40))} \\
 &= 0.967 \\
 \text{Use } z/d &= 0.95 \\
 \text{Therefore } z &= 114\text{mm} \\
 A_s &= \frac{M}{0.95 \times f_y \times z} \\
 &= \frac{16.57 \times 10^6}{0.95 \times 485 \times 114} \\
 &= 315\text{mm}^2/\text{m}
 \end{aligned}$$

Use welded mesh type B7

(Main reinforcement 7mm dia. @100mm c/c, secondary reinforcement 7mm dia. @ 200mm c/c)

Therefore, provided  $A_s = 385\text{mm}^2/\text{m}$

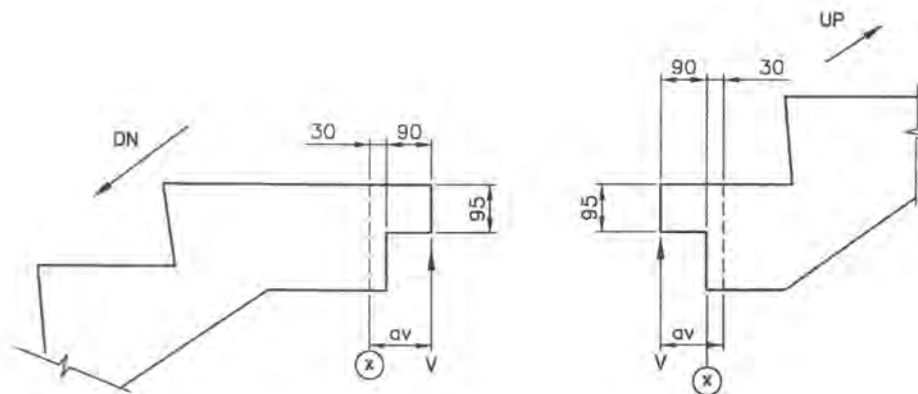
**Deflection**

$$\begin{aligned}\frac{M}{bd^2} &= \frac{16.57 \times 10^6}{1000 \times 120^2} \\ &= 1.15 \\ f_s &= \frac{2}{3} \times f_y \times \frac{A_{s \text{ reqd}}}{A_{s \text{ Prov}}} \\ &= \frac{2}{3} \times 485 \times \frac{315}{385} \\ &= 265 \text{ N/mm}^2\end{aligned}$$

$$\begin{aligned}\text{Tension modification factor, } \Phi &= 0.55 + \frac{(477 - f_y)}{120 \left(0.9 + \frac{M}{b \times d^2}\right)} \\ &= 0.55 + \frac{(477 - 265)}{120 (0.9 + 1.15)} \\ &= 1.41\end{aligned}$$

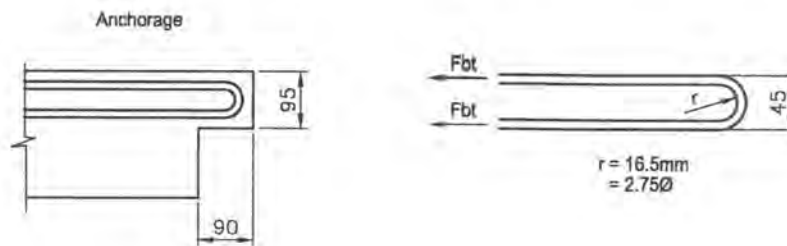
$$\begin{aligned}\text{Clause 3.10.2.2, Part 1, BS8110 (1997), basic span / depth ratio of staircase flight} \\ &= 20 \times 1.15 \\ &= 23\end{aligned}$$

$$\begin{aligned}\text{Minimum effective depth, } d &= \frac{L}{\Phi \times \text{Span/Depth Ratio}} \\ &= \frac{2990}{1.41 \times 23} \\ &= 92 \text{ mm} < 120 \text{ mm} \quad \text{Therefore, OK}\end{aligned}$$

**Design of Supporting Nibs**

Reaction at supporting nibs,	$V$	$=$	$44.34 \times 0.5$
		$=$	$22.17 \text{ kN/m}$
	$a_v$	$=$	$90 + 30$
		$=$	$120 \text{ mm}$
Bending Moment, (At Section X)	$M$	$=$	$V \times a_v$
		$=$	$22.17 \times 0.120$
		$=$	$2.66 \text{ kNm/m}$
Effective depth,	$d$	$=$	$95 \text{ mm} - 25 \text{ mm} - 5 \text{ mm}$
		$=$	$65 \text{ mm}$
	$z/d$	$=$	$0.5 + \sqrt{(0.25 - M \div (0.9bd^2f_{cu}))}$
		$=$	$0.5 + \sqrt{(0.25 - (2.66 \times 10^6 \div (0.9 \times 1000 \times 65^2 \times 40)))}$
		$=$	$0.98 \quad (< z/d = 0.95)$
Therefore,	$z$	$=$	$61.8 \text{ mm}$
Use mild steel,	$A_s$	$=$	$\frac{M}{0.95 \times f_y \times z}$
		$=$	$\frac{2.66 \times 10^6}{0.95 \times 250 \times 61.8}$
		$=$	$181 \text{ mm}^2/\text{m}$
Use R6 @ 150mm c/c,	$A_s$	$=$	$188 \text{ mm}^2/\text{m}$

### Check Anchorage



$$\begin{aligned}
 F_{bt} &= 0.95 f_y A_s \\
 &= 0.95 \times 250 \times 28 \times 10^{-3} \\
 &= 6.65 \text{ kN}
 \end{aligned}$$

$$\text{Minimum bending radius, } r \geq \frac{F_{bt}}{\phi} \times \frac{1 + 2(\phi \div a_b)}{2 f_{cu}}$$

$$\text{Where } \phi = 6 \text{ mm}$$

$$a_b = 150 \text{ mm}$$

$$f_{cu} = 40 \text{ N/mm}^2$$

$$\text{Therefore } r \geq \frac{6.65 \times 10^3}{6} \times \frac{1 + 2(6 \div 150)}{2 \times 40}$$

$$\geq 14.9 \text{ mm}$$

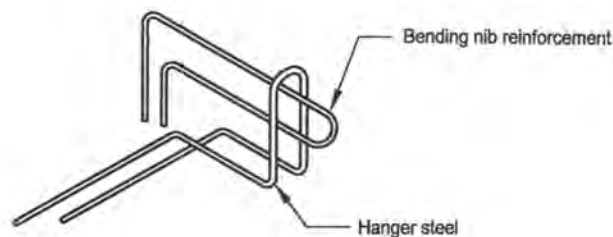
$$\geq 2.5 \phi$$

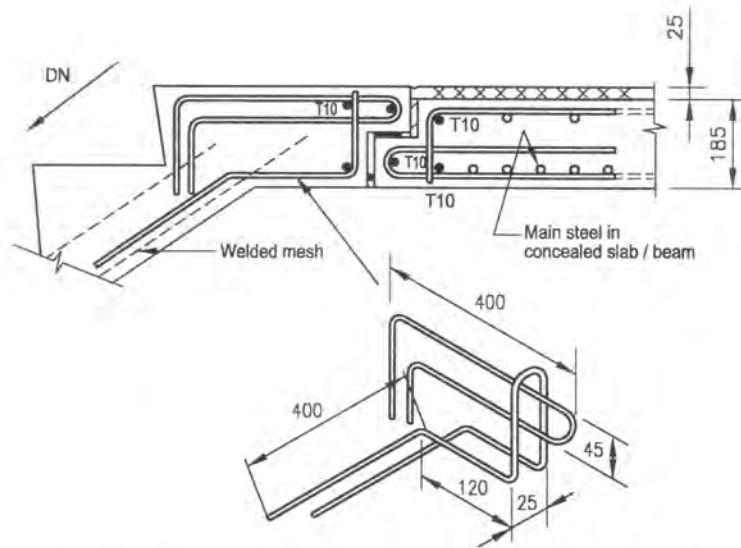
$$\text{Provide } r = 2.75 \phi > 2.5 \phi \quad \text{Therefore, OK}$$

### Check Hang-up Reinforcement

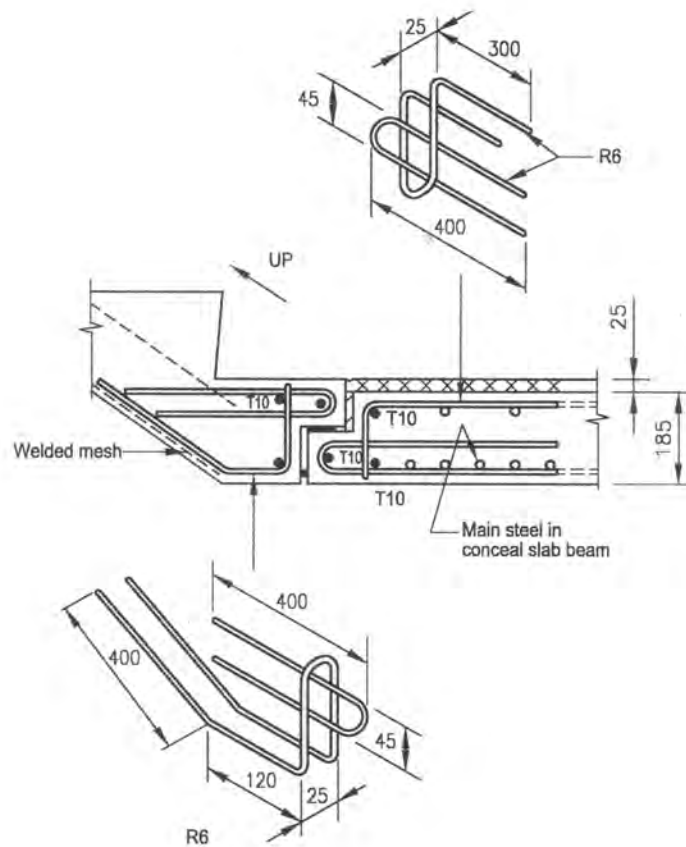
$$\begin{aligned}
 \text{Hang-up reinforcement, } A_{sh} &= \frac{V}{0.95 f_y} \\
 &= \frac{22.17 \times 10^3}{0.95 \times 250} \\
 &= 93 \text{ mm}^2/\text{m}
 \end{aligned}$$

For practical reason, provide at every R6 nib reinforcement a looped R6 as hanger steel, as below.





**TYPICAL REINFORCEMENT DETAILS AT UPPER FLIGHT**



**TYPICAL REINFORCEMENT DETAILS AT LOWER FLIGHT**

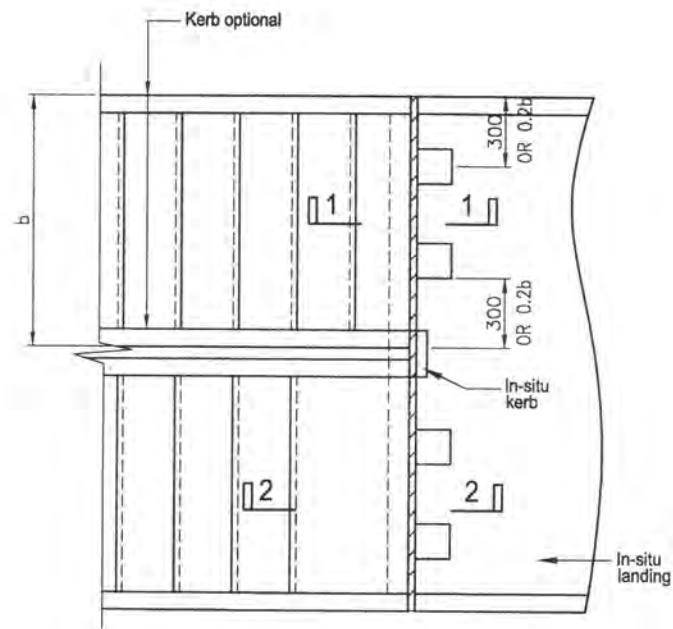
**Check Shear**

Shear force,

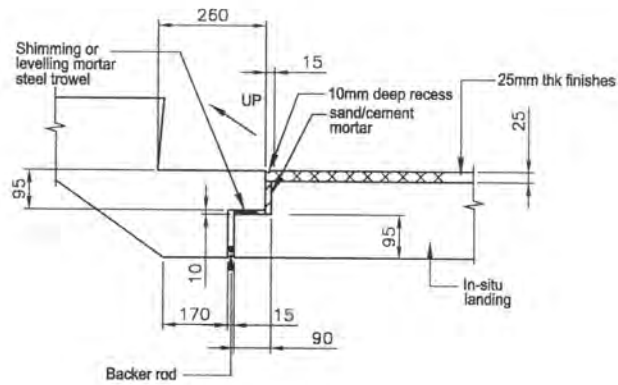
$$\begin{aligned}
 V &= 22.17 \text{ kN/m} \\
 v &= \frac{22.17 \times 10^3}{1000 \times 65} \\
 &= 0.34 \text{ N/mm}^2 \\
 r_s &= \frac{188 \times 100\%}{1000 \times 65} \\
 &= 0.29\% \\
 v_c &= \frac{0.79 (r_s)^{1/3} (400/d)^{1/4} (f_{cu}/25)^{1/3}}{\gamma_m} \\
 \gamma_m &= 1.25 \\
 v_c &= \frac{0.79 (0.29)^{1/3} (400/65)^{1/4} (40/25)^{1/3}}{1.25} \\
 &= 0.77 \text{ N/mm}^2 > 0.34 \text{ N/mm}^2
 \end{aligned}$$

Therefore, **OK**

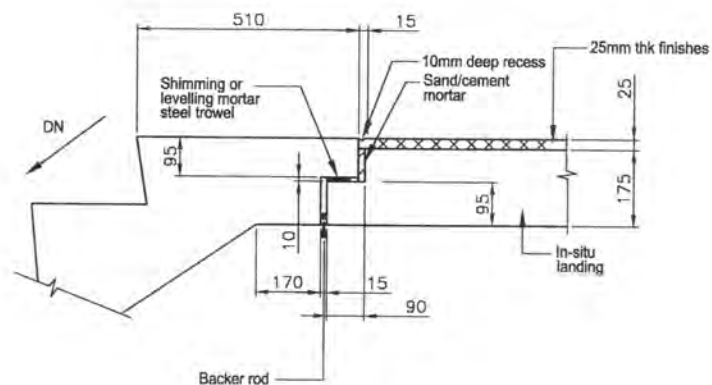




PLAN



SECTION 1-1



SECTION 2-2

# **PRECAST REFUSE CHUTES**

# CHAPTER 4

Refuse chute is an integrated component of a dwelling unit. Under the Building Plan for environmental health, refuse storage and collection system shall be designed such that there will be minimum nuisance to occupants and neighbouring premises, and no pollution to the environment. It also stated that refuse chutes shall be provided for high-rise buildings so that occupants need not have to take their refuse into lifts or walk down the stairs with it.

Refuse chutes shall meet the following requirements:

- (a) The internal cross-sectional area of the refuse chute shall not be less than  $0.3\text{m}^2$ .
- (b) It shall be cross-ventilated at the top with at least two openings of not less than  $0.1\text{m}^2$  each above roof level.
- (c) Refuse chutes shall be designed with a system to wash and flush the whole length of the chute. The control valve for the flushing system shall be located at the chamber level.

## 4.1 Architectural Design Considerations

Other than the functional requirements, architectural design considerations are the layout, shape and size, hopper opening and wall finishes.

The two types of refuse collection systems in use in high-rise residential developments are:

- (a) Localised collection system.
- (b) Centralised collection system.

Localised refuse collection system is usually located at the service balcony next to the kitchen for convenience reason. An internal diameter of 610mm would comply with the minimum size requirement under the environmental health and serve the intended usage.

A centralised refuse collection system is usually located in the common area. It has to be properly screened off to minimise nuisance and complaints from owners. With the use of centralised refuse collection system, the number of refuse stacks could be reduced. Therefore, the long term maintenance cost of bin chamber and refuse chutes could be reduced.

To encourage the wider use of standard building components, the Committee has recommended standard sizes for precast concrete refuse chutes suitable for private housing. Details are tabled in Architectural Reference Sheet RC01.

## **4.2 Structural Design Considerations**

Precast refuse chute is not a load bearing structure. Only minimal reinforcement would be required to prevent surface cracks. Most designers would normally suspend the unit from beams and slab above. The Committee recommends locating refuse chutes next to structural wall / column stump, so that (1) the stability of the component could be enhanced through tie bars and (2) the side wall or walls of the refuse chute could also be utilised as permanent formwork during the construction of wall / column stump. The effective anchorage provided between the precast refuse chute and the surrounding beams and slabs is ensured through the use of starter bars. With this arrangement, the load transfer in the vertical and lateral directions and the overall stability of the structural framing system are ensured.

## **4.3 Standard Precast Refuse Chutes**

Based on the clear internal dimensions, refuse chutes can be categorised into two main types, i.e., circular and square. Circular refuse chutes are commonly found in private projects. However, some designers also used HDB's square type of refuse chute.

Circular refuse chutes come with a 610mm internal diameter. However, the sizing of hopper openings is not standardised.

HDB's standard square refuse chute has internal dimensions 800mm x 800mm square with rounded corners. As the weight of each unit is approximately 2.4 tonnes, they can be transported easily from precast yards to sites, and lifted to their final positions via towers or mobile cranes.

Standardised dimensions and details for circular and HDB's square refuse chutes are included in the Reference Sheets.

#### 4.4 Prefabrication and Labelling

Precast concrete refuse chutes can be constructed using steel mould for both the external and internal surfaces. The length could vary according to specification. However, for repeated usage, the Committee recommends standardising the internal dimension, which could be circular or square with rounded corners.

With the use of standard precast concrete refuse chutes produced from precast yards, the end users would enjoy the benefit of quality product. In addition, the unit cost of standard concrete refuse chute is likely to be reduced as the standard moulds could be re-used from one project to another.

The Committee recommends designers to make use of the recommended dimensions and details presented in the Reference Sheets to specify precast refuse chute. The labelling system for precast refuse chute type, for example,

RC	/	600C
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is defined as:

RC	-	Standard Precast Refuse Chute
600	-	Internal diameter (in mm)
C	-	Circular internal dimension

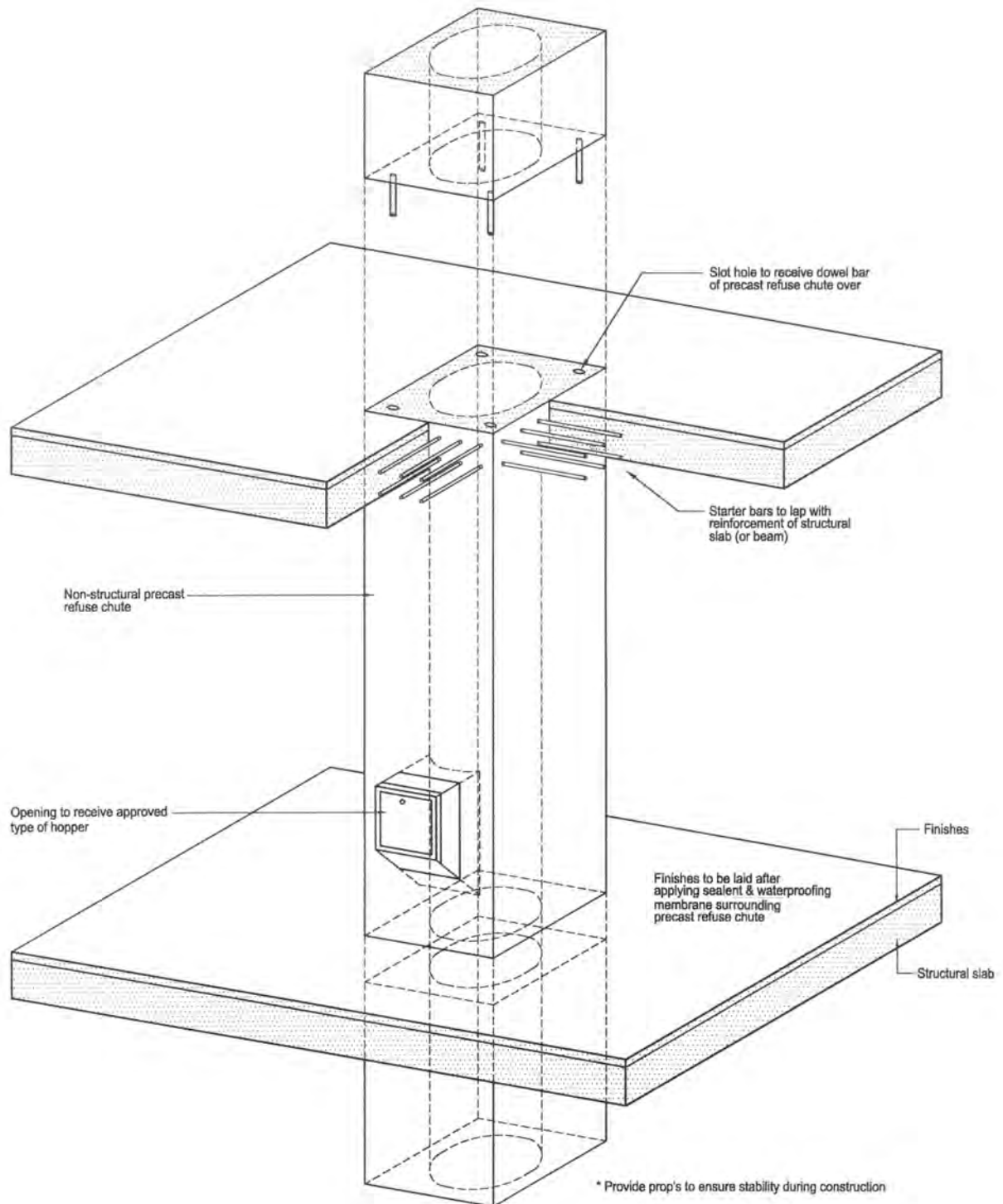
#### 4.5 Reference Sheets

**RECOMMENDED DIMENSIONS FOR STANDARD PRECAST REFUSE CHUTE**

Refuse Chute Type	Internal Shape	Internal Dimension	Recommended Component length *
RC/610C	Circular	610mm dia.	2790mm
			2990mm
			3140mm
			3290mm
			3490mm
			3590mm
			3840mm

Note: \* The length of the component takes account of 10mm joint gap between stack-up components at storey height.

## ISOMETRIC VIEW OF PRECAST REFUSE CHUTE

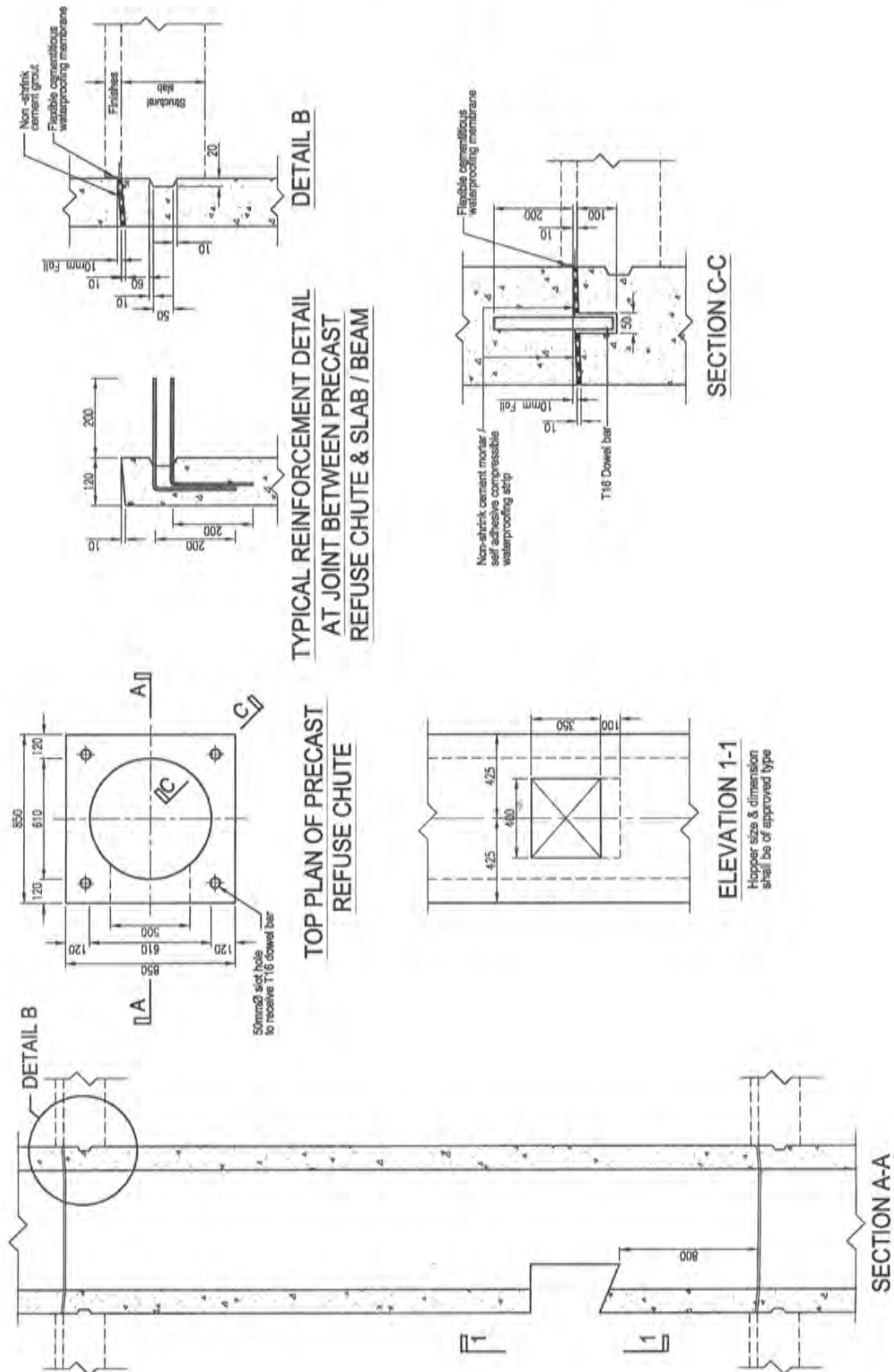


**GENERAL NOTES FOR PRECAST REFUSE CHUTE**

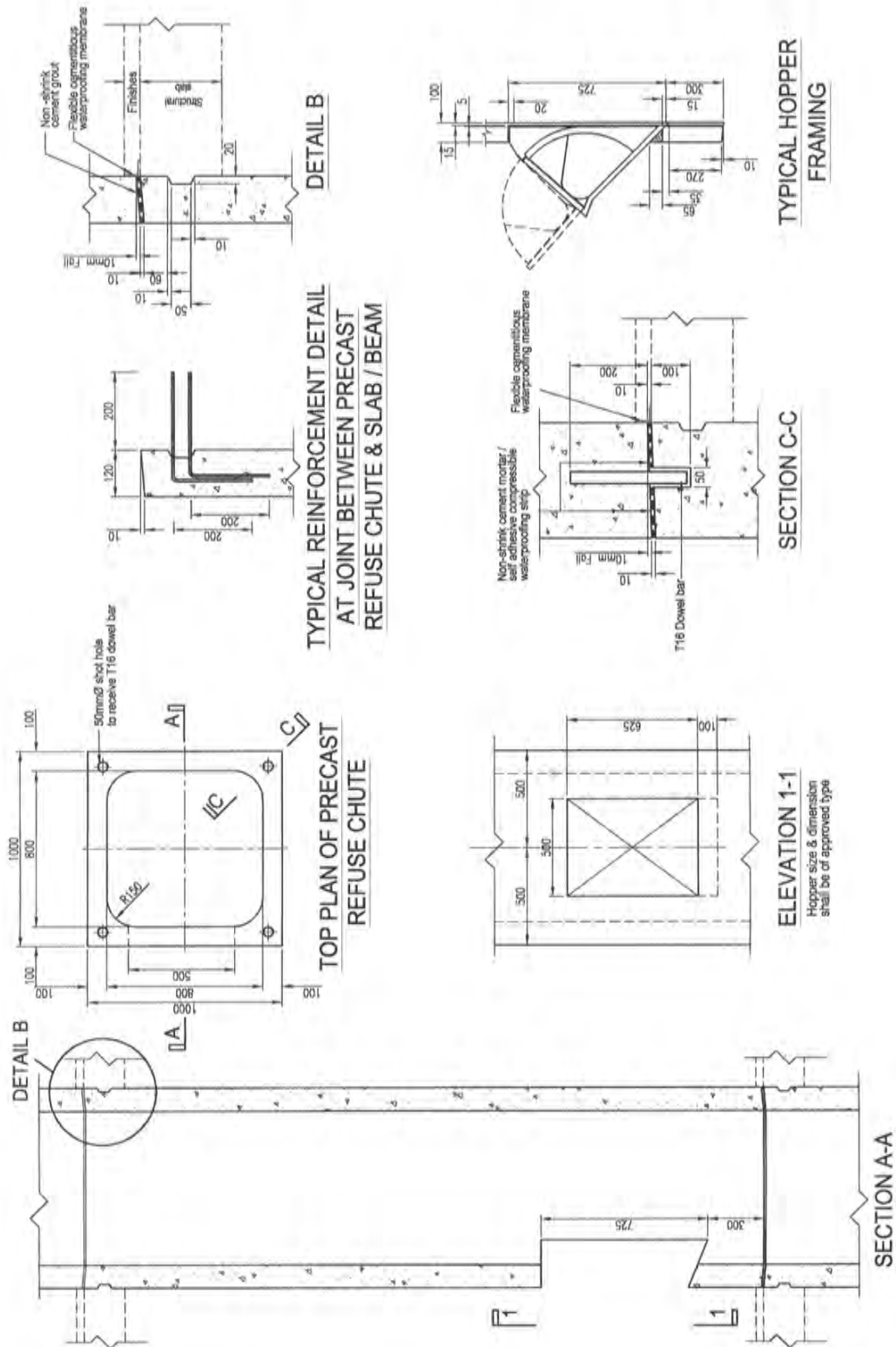
1. The two types of refuse collection system for high-rise residential developments are:
  - Localised collection system
  - Centralised collection system
2. Localised refuse collection system is usually located at the service balcony next to the kitchen for convenience reason.
3. Centralised refuse collection system is usually located in the common area. It has to be properly screened off to minimise nuisance and complaints from owners.
4. The number of refuse stacks for centralised collection system is less than localised collection system. The long term maintenance cost of bin chamber and refuse chutes could therefore be reduced.
5. The internal cross-sectional area of the refuse chute shall not be less than  $0.3\text{m}^2$ .
6. An internal diameter of 610mm would comply with the minimum size requirement under the environmental health.
7. HDB's standard square refuse chute has an internal dimension 800mm x 800mm square with rounded corners.
8. Hopper shall be of the approved type on size and material.



PRECAST REFUSE CHUTE DETAILS - TYPE: RC/610C



# HDB'S PRECAST REFUSE CHUTE DETAILS



## **GENERAL NOTES FOR PRECAST REFUSE CHUTE**

### General

1. Hopper shall be of the approved type on size and material.
2. The recommended length of precast refuse is tabled as in Architectural Reference Sheet RC01. 10mm joint gap between stack-up components at storey height was allowed for the adjustment of vertical and horizontal alignments.

### Concrete

1. Minimum concrete grade shall be C35, normal weight concrete.
2. Minimum cover to reinforcement shall be 35mm.
3. Surface finishes shall be off-form.

### Reinforcement

1. All reinforcement shall conform to the latest BS4449 with a minimum yield stress:
  - T - Denotes 460 N/mm<sup>2</sup> high yield deformed bar, Type 2
  - R - Denotes 250N/mm<sup>2</sup> for mild steel bars
2. Steel fabric shall conform to the latest BS4483 with minimum yield stress of 485N/mm<sup>2</sup>.

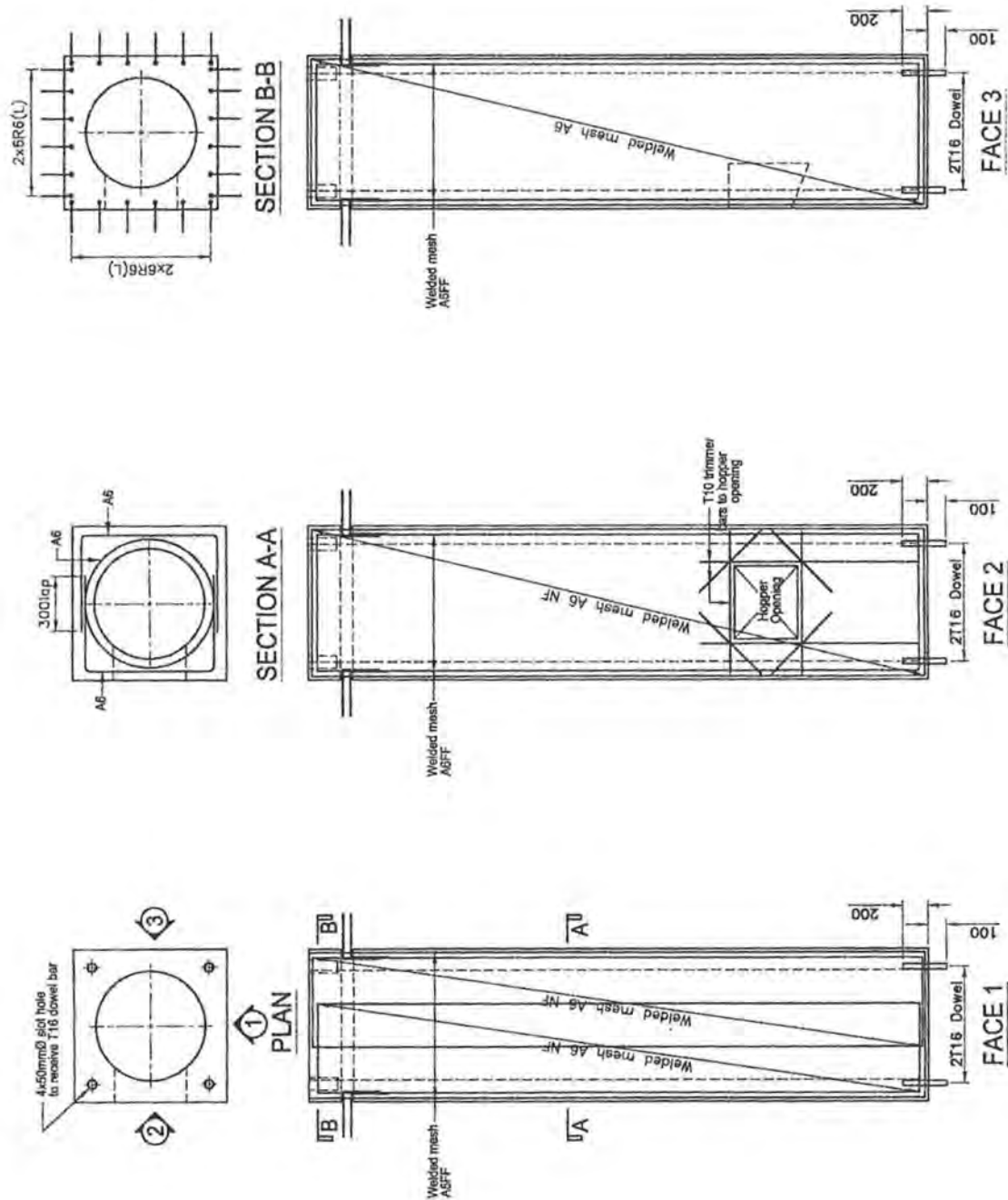
### Design Considerations

1. The recommended precast refuse chute was not designed as load bearing element.
2. Refuse chute shall be designed in accordance with the provisions of BS8110.
3. Precast refuse chute shall be suspended from beams and slab above.
4. Stability of precast refuse chute could be enhanced through tie bars anchored into structural wall or column.

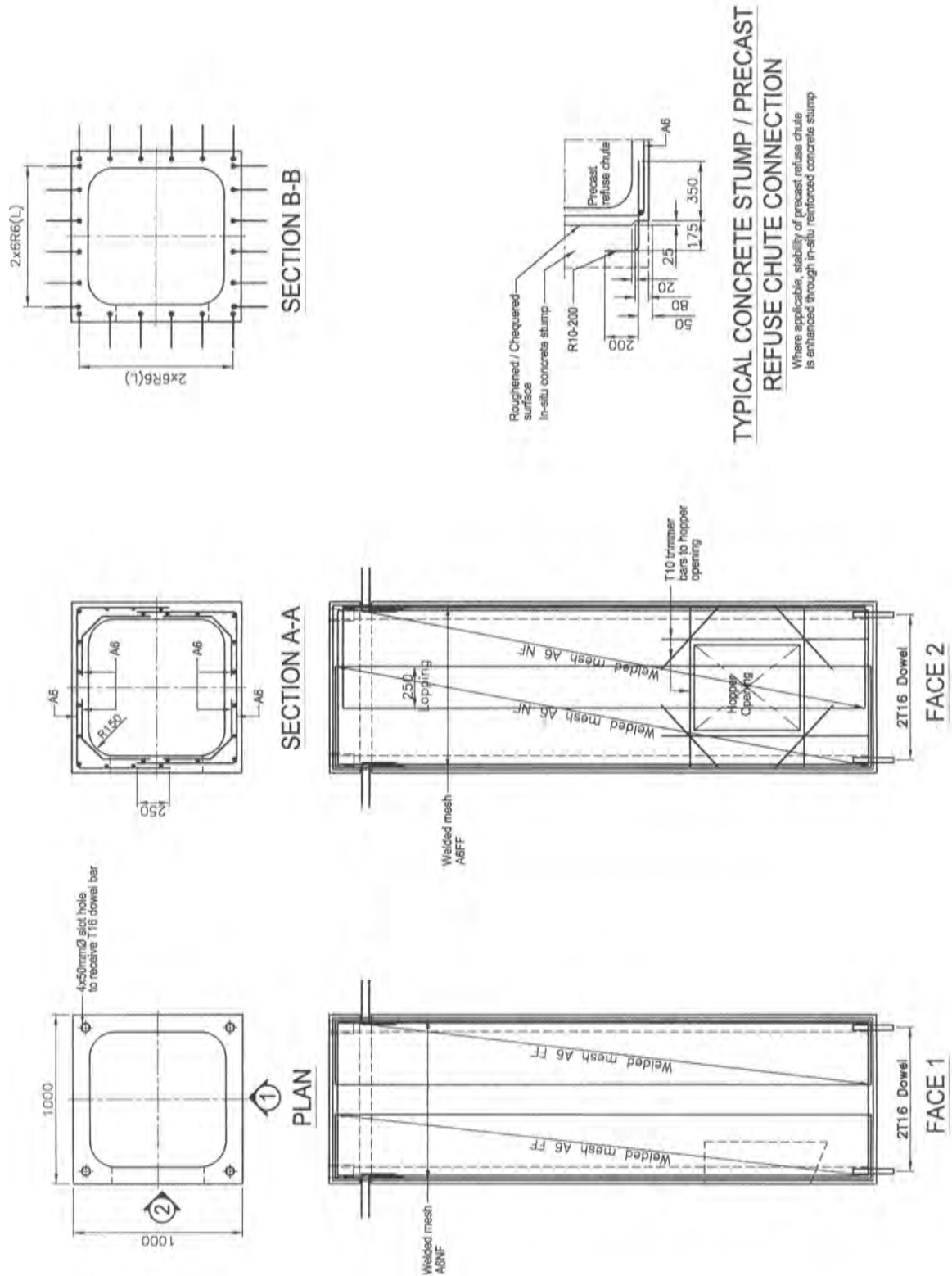
### Construction Considerations

1. Contractor shall provide safe temporary propping and bracing system when erecting precast refuse chute.
2. Precast refuse chute shall be stacked on top of each other after the completion of floor slab.
3. Starter bars projecting at top edges shall be cast together with the floor above.

PRECAST REFUSE CHUTE REINFORCEMENT DETAILS - TYPE: RC/601C



# HDB'S PRECAST REFUSE CHUTE REINFORCEMENT DETAILS



**PRECAST  
CIVIL DEFENCE  
SHELTERS**



## CHAPTER 5

Since the legislation of CD Shelter Act came into effect on 1 May 1998, all new flats and houses are required to be provided with either Household Shelters (HS) or Storey Shelters (SS).

The function of HS and SS is to protect people against weapon effects during emergencies. They are not designed for and should not be used as protection during other emergency situations such as fires. HS is located inside the individual dwelling unit for the convenience of its occupants. Whereas, SS is a shared facility located in a common property area at every storey of a residential building to serve the dwelling units of that storey.

Specifications for HS and SS are spelt out in the *Technical Requirements for Household and Storey Shelter 1997*, published by the Singapore Civil Defence Shelter Bureau. In which, the planning, design, M&E installation, construction, testing and commissioning requirements are stipulated. Information on precast CD shelters for public housing can also be obtained from the *Handbook on Architecture in Precast Concrete*, jointly published by BCA and the Singapore Institute of Architects as part of the BCA Buildability Series.

HDB has developed and implemented the construction of precast Household Shelters for public housing but the technology is not widely used in the private sector.

The Reference Guide only contains recommendations for precast HS panels as HS is commonly used in private residential developments. However, the concept used for HS could be applied to SS, subject to the approval of the Singapore Civil Defence Force and the Civil Defence Shelter Engineering Department of BCA. Actual precast HS/SS proposals for projects would have to be submitted to the Civil Defence Shelter Engineering Department of BCA for the relevant architectural and structural acceptance.

## 5.1 Architectural Design Considerations for Household Shelters

Currently, the maximum panel clear of precast household shelters approved by the relevant Authorities is 3m. Henceforth, not all the precast shelters approved for public housing are automatically suitable for private housing as the floor to floor heights are usually higher. Greater heights may be permitted in the near future.

The two types of precast approaches recommended in this Reference Guide are:

- **Semi-Precast HS Wall**  
Two long walls are precast and one of which is the wall with the blast door.
- **Precast HS Door Frame**  
Precast HS door frame is most suitable for multi-storey developments. It comes with 300mm concrete door ribs on both sides and the whole unit is 1300mm wide. Therefore, it could be located anywhere within the long wall.

It is recommended that the plan of HS be rectangular. The length to width ratio of the HS floor area shall always be less than 3:1. The minimum width (clear space excluding walls) of HS shall be 1200mm. The maximum HS size shall be 4.8m<sup>2</sup> unless otherwise approved by the Authority. The minimum clear height of the HS (measured from the finished floor level to the soffit of the concrete slab above) shall be 2.5m. The clear height of the HS can be increased to 4.0m (for cast in-situ construction), provided the setback distances, the wall thickness, reinforcement details and other protective requirements are satisfied.

For clear heights of up to 3.0m, the minimum internal clear floor area and the respective recommended internal dimensions of HS are tabled below:

Gross Floor Area of Dwelling Unit	Minimum Internal Clear Floor Area of HS	Recommended Internal Dimensions of HS (Width x Length x Height)
$GFA \leq 45m^2$	2.0m <sup>2</sup>	1.2m x 1.8m x 3.0m
$75m^2 \geq GFA > 45m^2$	2.4m <sup>2</sup>	1.2m x 2.1m x 3.0m
$140m^2 \geq GFA > 75m^2$	3.2m <sup>2</sup>	1.5m x 2.4m x 3.0m
$GFA > 140m^2$	4.0m <sup>2</sup>	1.5m x 2.7m x 3.0m

- Note:
1. Under CD's requirement, the wall thickness is a function of clear height.
  2. The wall thickness for the above HS shall be 275mm.
  3. Maximum height of Semi-Precast HS wall for above table shall be 3.0m.



Net opening dimensions of HS door is standardised to 700mm width x 1900mm height. The location of HS door shall be on a wall having a setback distance of at least 4.0m from the external building line and facing an interior structure of masonry construction. The door shall be on the wall that is longer on plan. At least 150mm concrete wall segments or door nibs shall be provided at both sides of the door. As HS has to be designed to withstand blast loads, HS doors have to be opened outwards. In addition, the hinges for the doors have to be exposed completely from outside.

Two ventilation openings are required for HS. One of the two openings must be kept opened at all times in peacetime to prevent anyone accidentally trapped in the HS from suffocating. However, during a wartime emergency, the two ventilation openings are to be closed and airtight.

## 5.2 Structural Design Considerations for Household Shelters

Owing to the close spacing of the reinforcement bars at both the inner and outer faces of the walls, there would be problems associated with the incorrect alignment and location of the door and ventilation sleeves. Thus, the Qualified Persons and contractors have to ensure that a high quality of workmanship is accorded in Household Shelter construction. As such, the Qualified Persons and contractors would have to ensure that the sequence of tying reinforcement and integrating the CD devices is carefully studied and co-ordinated during construction.

HS shall be designed in accordance with BS8110 under static loading conditions. However, there are additional requirements such as minimum reinforcement, specified in Chapter 3 on Structural Design, of the *Technical Requirements for Household Shelters 1997*.

### 5.3 Standard Precast Household Shelter

The entrance to HS is the weakest point in the protection envelope, and is protected by the approved type of light steel door. Besides fulfilling its function of shielding occupants from blast effects, HS doors would have to be designed to satisfy peacetime functional requirements, such as ease of operation and aesthetics.

Based on the minimum shelter technical requirements, Architectural Reference Sheet HS01 provides the recommended dimensions for Semi-Precast HS Walls and Architectural Reference Sheet HS03 provides the recommended dimensions for Standard Precast HS Door Frame. The objectives of standardisation are to:

- Ensure the quality and standard of workmanship, in order to fulfil the intended usage.
- Improve productivity and shorten construction period as fixing rebars at close spacing on site is time consuming.
- Better control in positioning the blast door and ventilation sleeves. The ventilation sleeves have to comply with the minimum clearances of the sleeves to the wall/ceiling soffit / door frame.

As compared with cast in-situ construction, using Semi-Precast HS Walls and Precast HS Door Frames would reduce defects in construction, which would otherwise result in extensive rectification works to meet protective requirements.

## 5.4 Prefabrication and Labelling

The fabrication and installation of the CD blast doors require experience and skill, from both the fabricator and contractor. Fabrication and construction tolerances have to be met to ensure that the doors function properly. HS door frames have to match the wall thickness. Designers and contractors are advised to obtain the list of approved suppliers for materials such as steel doors and ventilation sleeves from the Civil Defence Shelter Engineering Department of BCA.

The Committee recommends Qualified Persons to make use of the recommended dimensions and details presented in the Reference Sheets to specify precast Household Shelter components.

The labelling system for Semi-Precast Household Shelter Wall, for example,

HSW	/	1800	x	3000
-----	---	------	---	------

is defined as:

HSW	-	Semi-Precast Household Wall
1800	-	Length of the Semi-Precast Household wall (in mm)
3000	-	Height of the Semi-Precast Household wall (in mm)

Similarly, the labelling system for Precast Household Door Frame, for example,

HSD	/	1300	x	3000
-----	---	------	---	------

is defined as:

HSD	-	Precast Household Door Frame
1300	-	Length of the Precast Household Door Frame (in mm)
3000	-	Height of the Precast Household Door Frame (in mm)

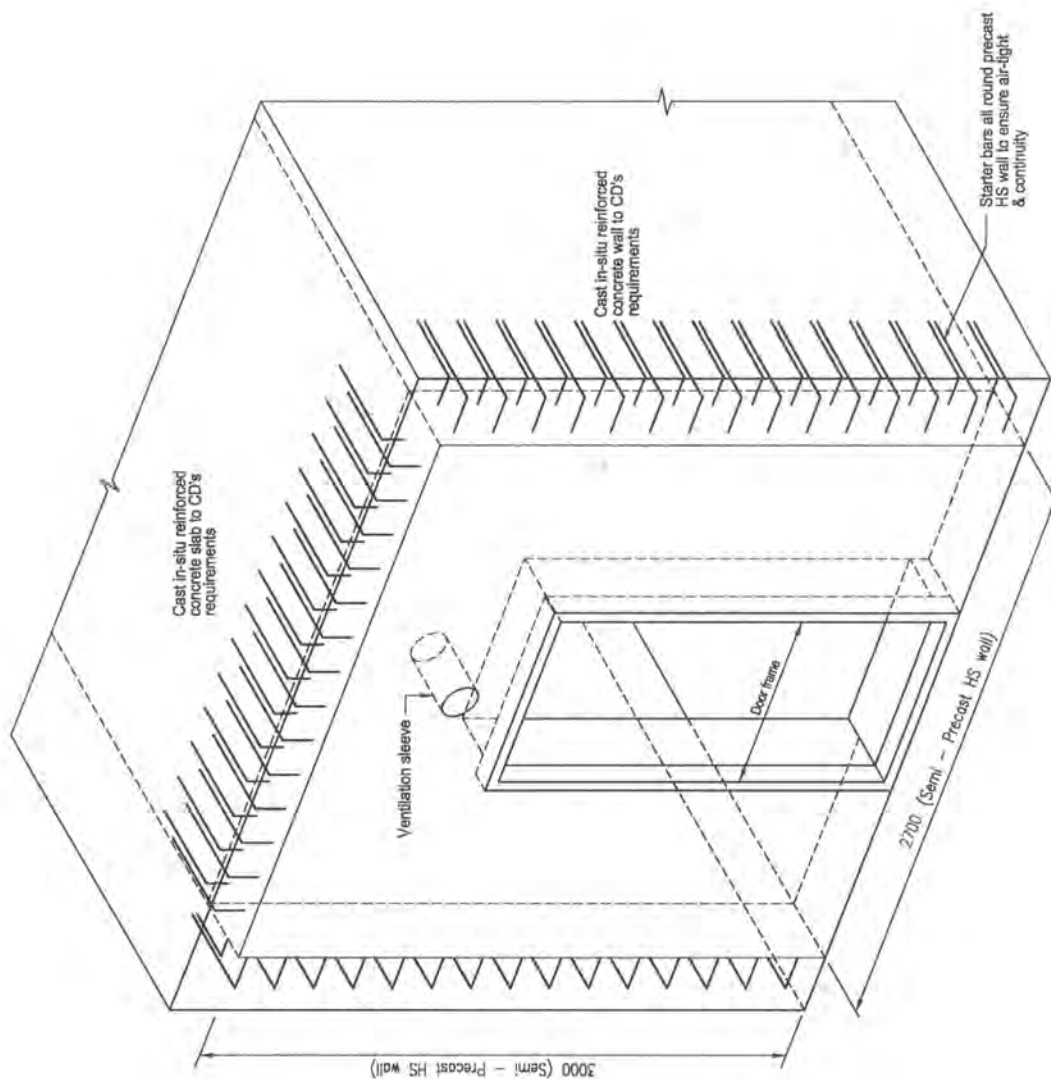
## 5.5 Reference Sheets

**RECOMMENDED DIMENSIONS FOR SEMI-PRECAST HOUSEHOLD  
SHELTER WALL (HSW)**

Semi-Precast HS Wall Type (HSW/Length x Height)	Gross Floor Area of Dwelling Unit	Recommended Internal Dimensions for HS (Width x Length x Height)	Weight (Tonnage based on 2.4 T/m <sup>3</sup> )
HSW/1800x3000	$GFA \leq 45m^2$	1.2m x 1.8m x 3.0m	2.7 Tonnes
HSW/2100x3000	$75m^2 \geq GFA > 45m^2$	1.2m x 2.1m x 3.0m	3.3 Tonnes
HSW/2400x3000	$140m^2 \geq GFA > 75m^2$	1.5m x 2.4m x 3.0m	3.8 Tonnes
HSW/2700x3000	$GFA > 140m^2$	1.5m x 2.7m x 3.0m	4.4 Tonnes

- Note:
1. Semi-Precast HS wall is suitable for single unit developments.
  2. Minimum wall thickness for Semi-Precast HS wall shall be 275mm.
  3. Maximum allowable height of Semi-Precast HS wall for the above table shall be 3.0m.
  4. Semi-Precast HS wall shall be positioned and propped prior to casting the base slab.
  5. Starter bars of Semi-Precast HS wall shall be lapped with the adjoining walls and slabs.

### ISOMETRIC VIEW OF SEMI-PRECAST HOUSEHOLD SHELTER WALL (HSW)



NOTE :

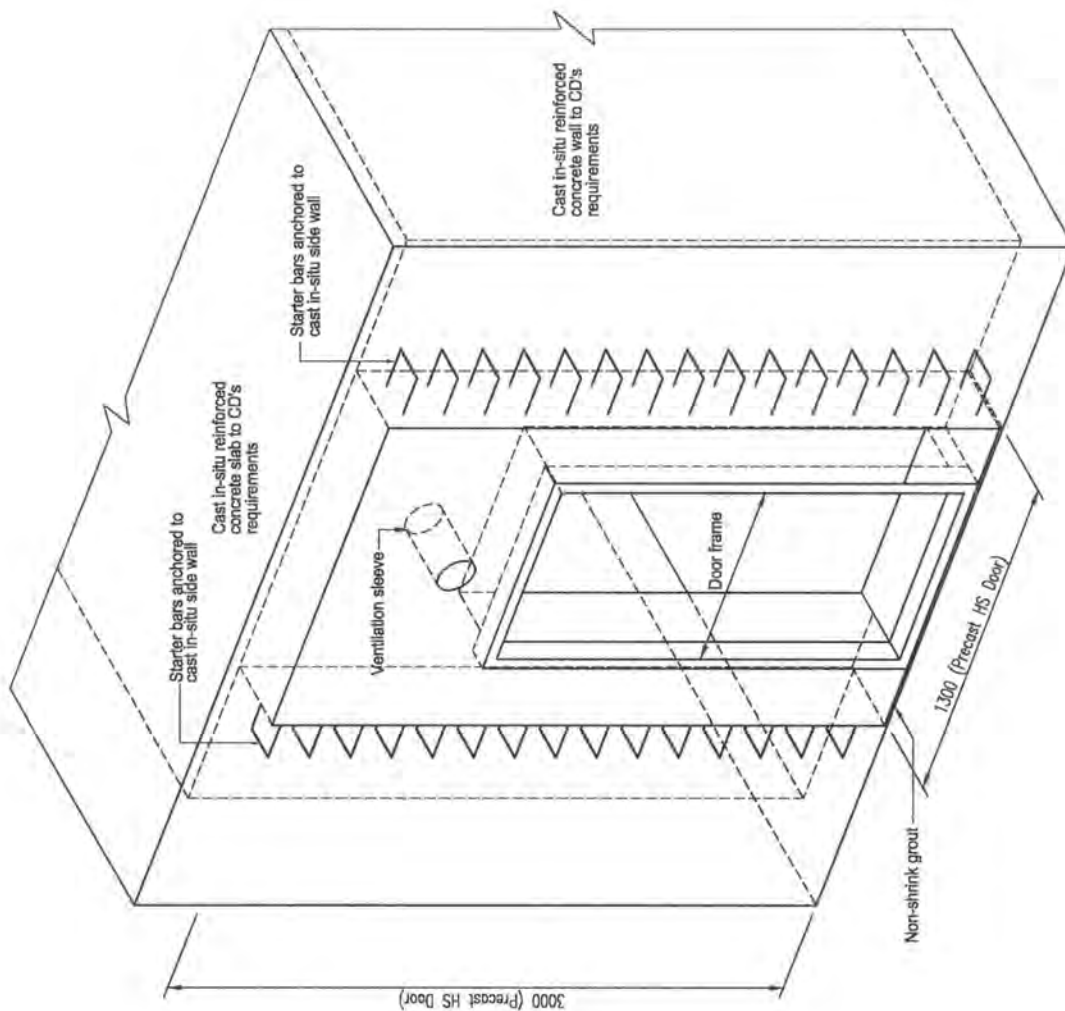
- NOTE.**
1. Semi-precast HS wall shall be erected before casting the base slab.
  2. Semi-precast HS wall shall be propped to ensure stability before and after casting the base slab and walls.
  3. Shear keys and reinforcement of cast in-situ walls and slab are not shown in drawing

### RECOMMENDED DIMENSIONS FOR STANDARD PRECAST HOUSEHOLD SHELTER DOOR FRAME (HSD)

HS Door Frame Type (HSD/Length x Height)	Gross Floor Area of Dwelling Unit	Recommended Internal Dimensions for HS (Width x Length x Height)	Weight (Tonnage based on 2.4 T/m <sup>3</sup> )
HSD/1300 x 3000	-	-	1.7 Tonnes

- Note:
1. HS Door Frame is suitable for single and multi-storey developments.
  2. Minimum wall thickness for HS Door Frame shall be 275mm.
  3. Maximum height of HS Door Frame for the above table shall be 3.0m.
  4. HS Door Frame shall be positioned and propped after casting the base slab.
  5. Starter bars shall be lapped & anchored into the two adjoining cast in-situ side walls.

## ISOMETRIC VIEW OF PRECAST HOUSEHOLD SHELTER DOOR FRAME (HSD)



### NOTES :

1. Precast HS door frame shall be erected after the completion of reinforced floor slab.
2. Precast HS door frame shall be propped to ensure stability before casting the adjoining base slab and walls.
3. Shear keys and reinforcement of cast in-situ walls and slabs are not shown in drawing.
4. Precast HS door frame is suitable for multi-storey development.

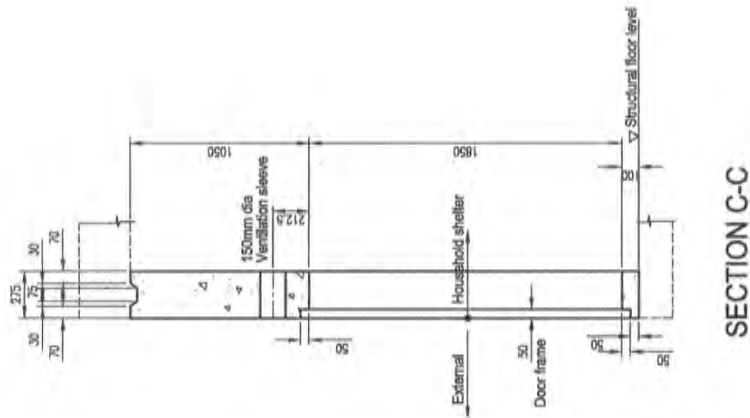
## **GENERAL NOTES FOR SEMI-PRECAST HOUSEHOLD SHELTER WALL AND PRECAST HOUSEHOLD SHELTER DOOR FRAME**

1. Currently, the maximum panel clear of precast household shelters approved by the relevant Authorities is 3m. Henceforth, not all the precast shelters approved for public housing are automatically suitable for private housing as the floor to floor height are usually higher. Greater heights may be permitted in the near future.
2. It is recommended that the plan of HS be rectangular. The length to width ratio of the HS floor area shall always be less than 3:1. The minimum width (clear space excluding walls) of HS shall be 1200mm. The maximum HS size shall be 4.8m<sup>2</sup> unless otherwise approved by the Authority.
3. The minimum clear height of the HS (measured from the finished floor level to the soffit of the concrete slab above) shall be 2.5m. The clear height of the HS can increase 4.0m (for cast in-situ construction) unless it satisfies the setback, wall thickness and reinforcement, and other protective requirements.
4. Blast door frame and ventilation sleeve shall be obtained from approved suppliers. The approved list could be obtained from Civil Defence Engineering Department of BCA.
5. HS door net opening dimensions shall be 700mm width x 1900mm height. Other dimensions at door opening shall be confirmed with approved blast door details.
6. The location of HS door shall be on a wall having a setback distance of at least 4.0m from the external building line and facing an interior structure of masonry construction.
7. At least 150mm concrete wall segments or door nibs shall be provided at both sides of the door. As HS has to be designed to withstand blast loads, HS doors have to be opened outwards. In addition, the hinges for the doors have to be exposed completely from the outside.
8. Two ventilation openings are required for HS.
9. Semi-precast HS wall, the two long walls are precast and one of which is the wall with the blast door.
10. Precast HS door frame is most suitable for multi-storey developments.
11. Precast HS door frame comes with 300mm concrete door nibs on both sides and the whole unit is 1300mm wide. Therefore, it could be located anywhere within the long wall.
12. Semi-precast HS wall is more suited for single unit developments.
13. Requirements stipulated in *Technical Requirements for Household & Storey Shelters 1997* are to be complied with.
14. All detailed precast HS/SS proposals for projects are to be submitted to the Civil Defence Shelter Engineering Department of BCA for acceptance.

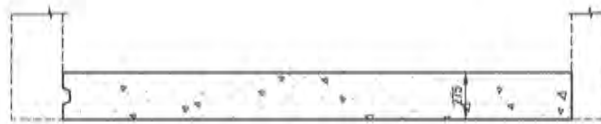


# SEMI-PRECAST HOUSEHOLD SHELTER WALL DETAILS

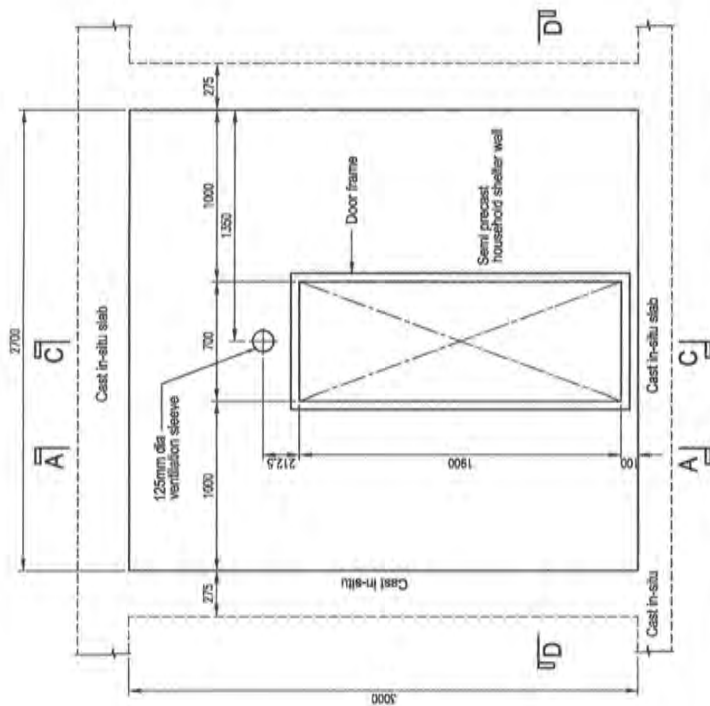
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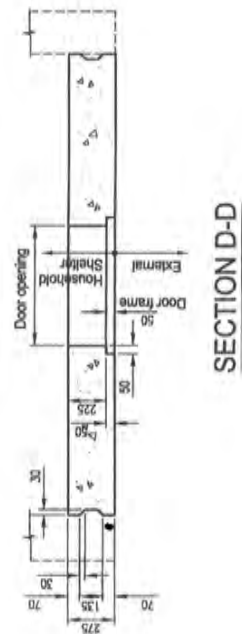
SECTION C-C



SECTION A-A

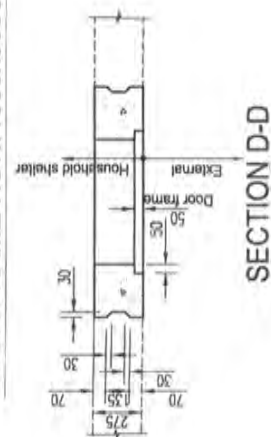
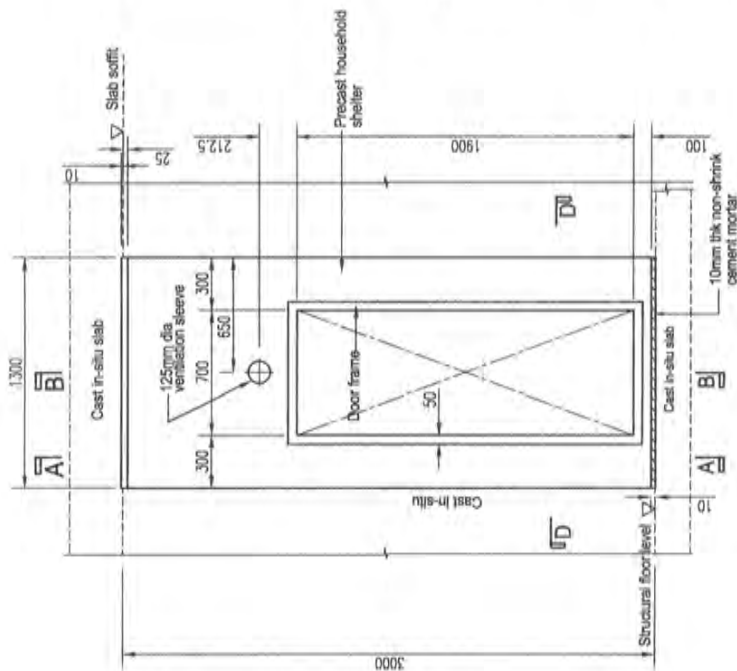
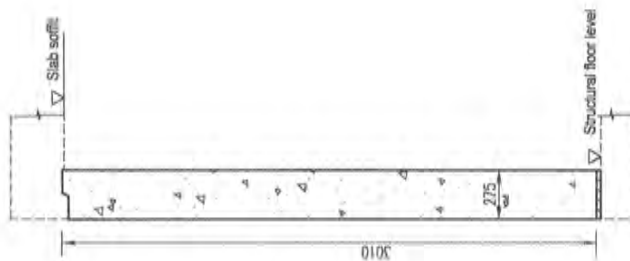
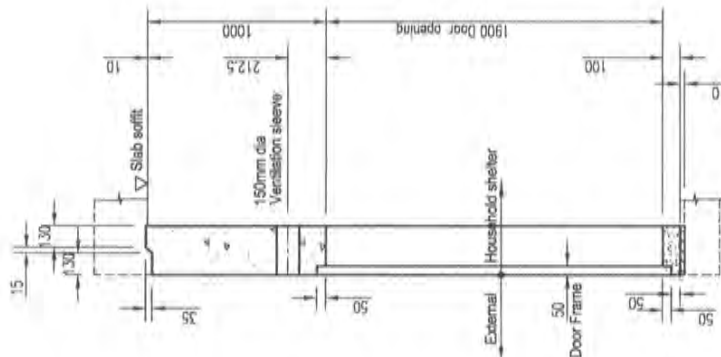


PRECAST HOUSEHOLD SHELTER WALL  
HSW/2700X3000



SECTION D-D

# PRECAST HOUSEHOLD SHELTER DOOR FRAME DETAILS TYPE: HSD/1300 X 3000



## GENERAL NOTES FOR SEMI-PRECAST HOUSEHOLD SHELTER WALL AND PRECAST HOUSEHOLD SHELTER DOOR FRAME

### Concrete

1. Minimum grade of concrete shall be C30, normal weight concrete.
2. Nominal cover to reinforcement shall be 25mm, while maximum cover shall be 40mm.
3. Surface finishes shall be off-form.

### Reinforcement

1. All reinforcement shall conform to the latest BS4449 with a minimum yield stress:
  - T - Denotes 460 N/mm<sup>2</sup> high yield deformed bar, Type 2
  - R - Denotes 250N/mm<sup>2</sup> for mild steel bars
2. All steel fabric shall conform to the latest BS4483 with a minimum yield stress of 485N/mm<sup>2</sup>.
3. Reinforcement provided is minimum quantity in compliance with Civil Defence requirements.
4. For the recommended semi-precast HS wall and Precast HS door frame:
  - Shear links connecting the two layers of reinforcement shall be R6 at 600mm c/c, both ways, throughout the precast HS wall.
  - The curtailment of starter bars based on slab thickness of 150mm and wall thickness of 275mm.
  - Maximum reinforcement bar spacing shall be maintained at 100mm.

### Design Considerations

1. Walls shall be designed in accordance with the provisions of BS8110.
2. HSW shall be designed as fixed restrained at four sides.
3. HSD shall be designed as partially restrained at four sides.
4. Starter bars and shear key to side walls and floors are used to ensure fixity, continuity and air tightness.
5. Precast HSD shall be designed by Qualified Persons. BCA and all the Committee members shall not, under any circumstances, be held responsible or liable for the accuracy of the information provided within the Reference Guide. The compliance with the Reference Guide does not exempt the users, from legal obligations.
6. Requirements stipulated in *Technical Requirements for Household & Storey Shelters 1997* are to be complied with.
7. All detailed precast HS/SS proposals for projects are to be submitted to the Civil Defence Shelter Engineering Department of BCA for acceptance.

### Construction Sequence

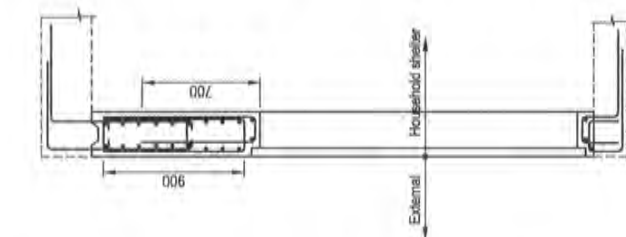
1. Contractor shall provide safe temporary propping and bracing system when erecting HSW or HSD.
2. HSD shall be erected after the completion of base slab.
3. Floor slab of HSW shall be cast in-situ after the erection of HSW.

Technical drawing of a mechanical part, showing a cross-section with a dimension of 67.5.

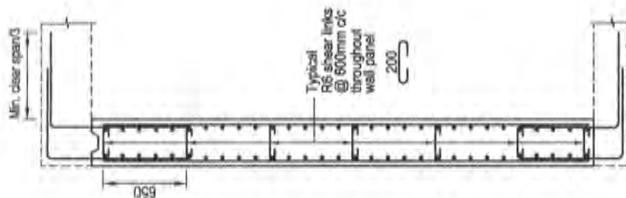
SECTION C-C



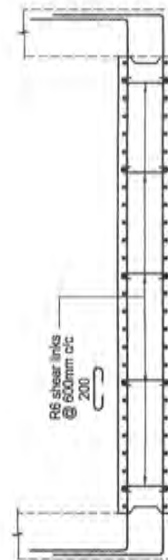
**TYPICAL TRIMMER  
BARS AT OPENING**



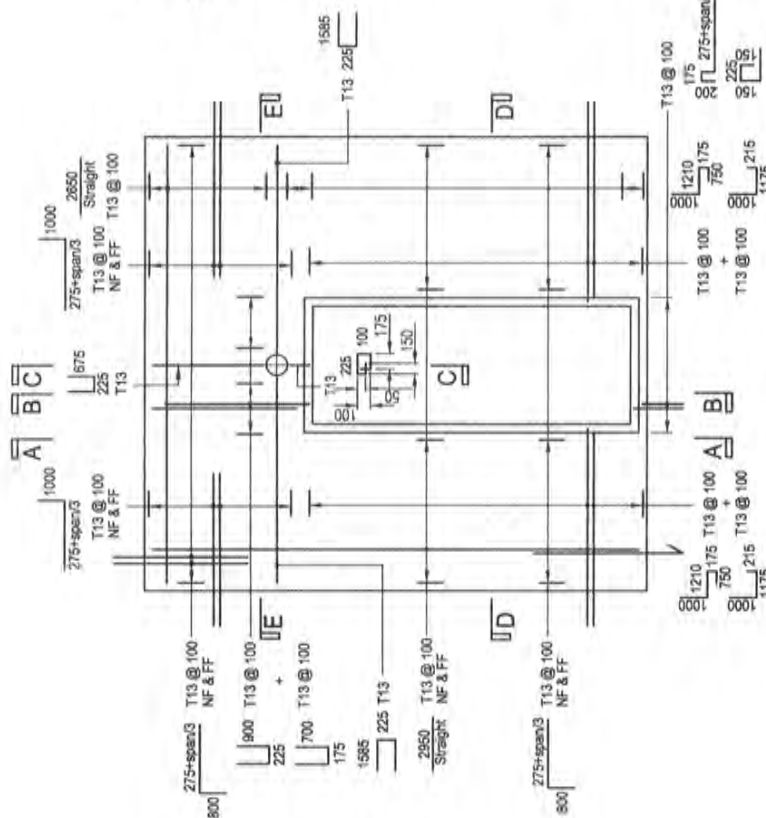
SECTION B-B



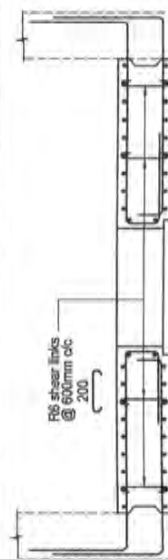
SECTION A-A



SECTION E-E

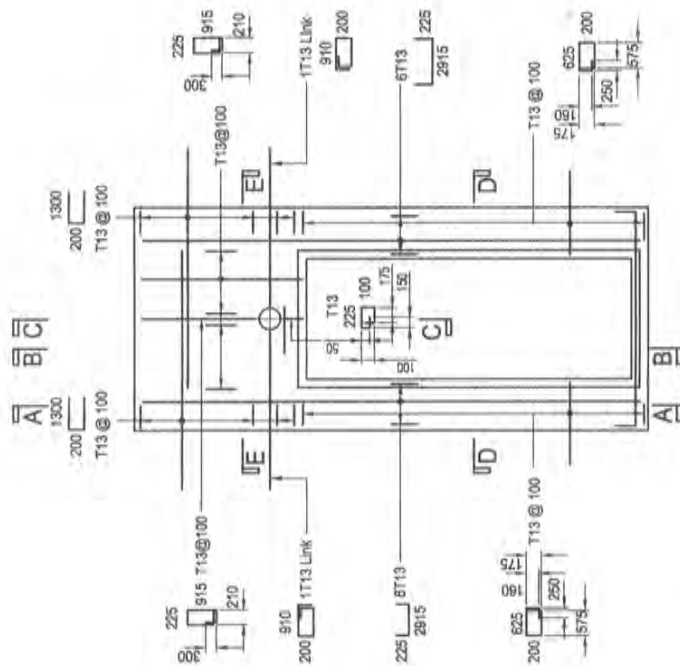


PRECAST HOUSEHOLD SHELTER WALL  
REINFORCEMENT DETAILS HSW/2700X3000

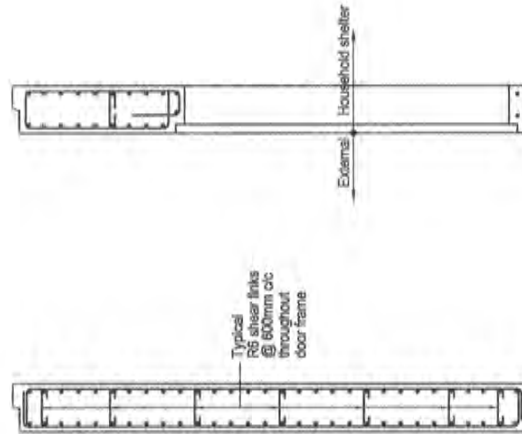


SECTION D-D

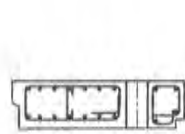
# PRECAST HOUSEHOLD SHELTER DOOR FRAME REINFORCEMENT DETAILS TYPE: HSD/1300 X 3000



PRECAST HOUSEHOLD SHELTER WALL  
REINFORCEMENT DETAILS HSW/1300x3000



SECTION A-A



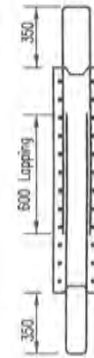
SECTION C-C



TYPICAL TRIMMER  
BARS AT OPENING



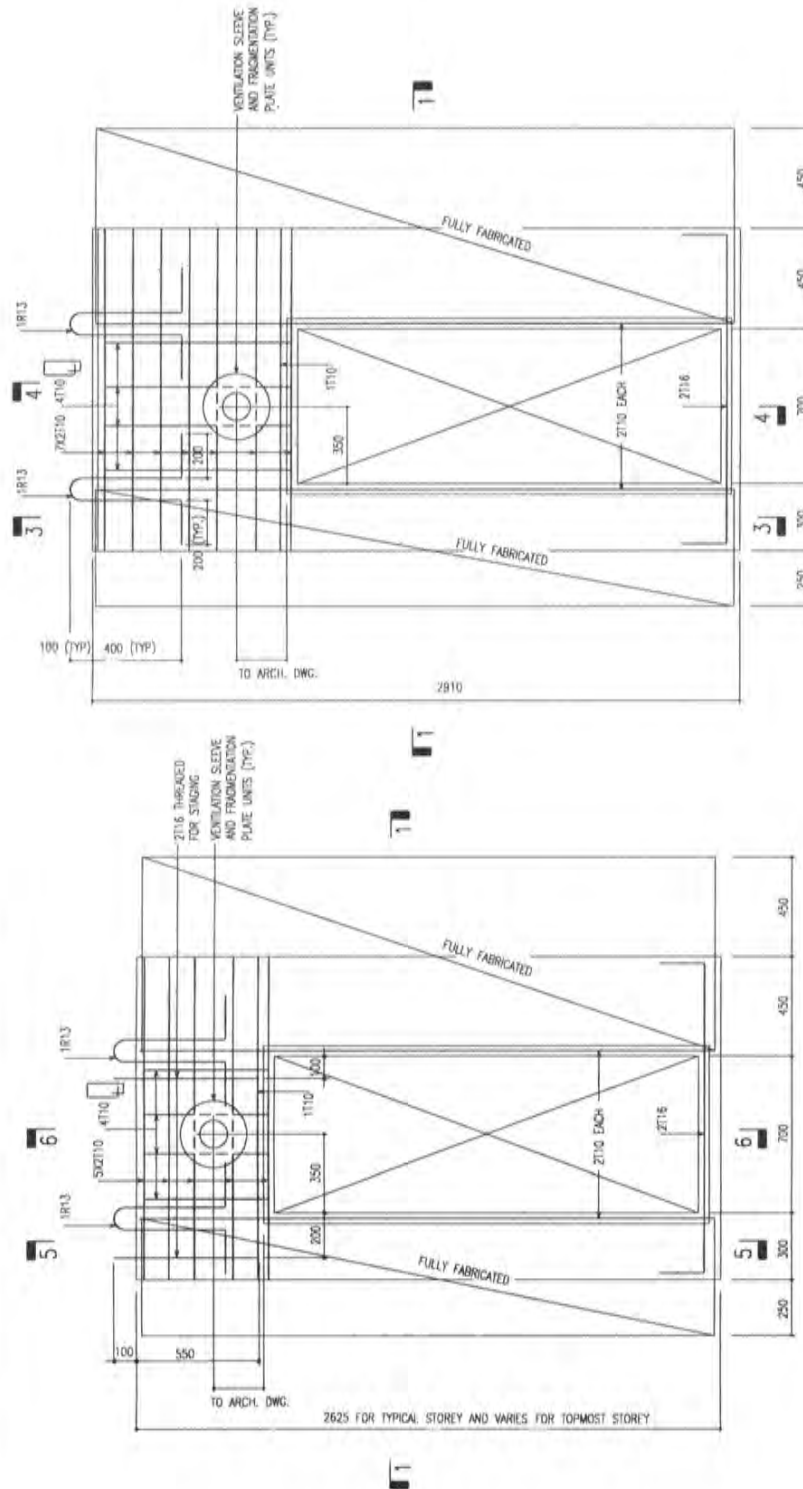
SECTION D-D



SECTION E-E

## HDB'S PRECAST HOUSEHOLD SHELTER DOOR FRAME REINFORCEMENT DETAILS

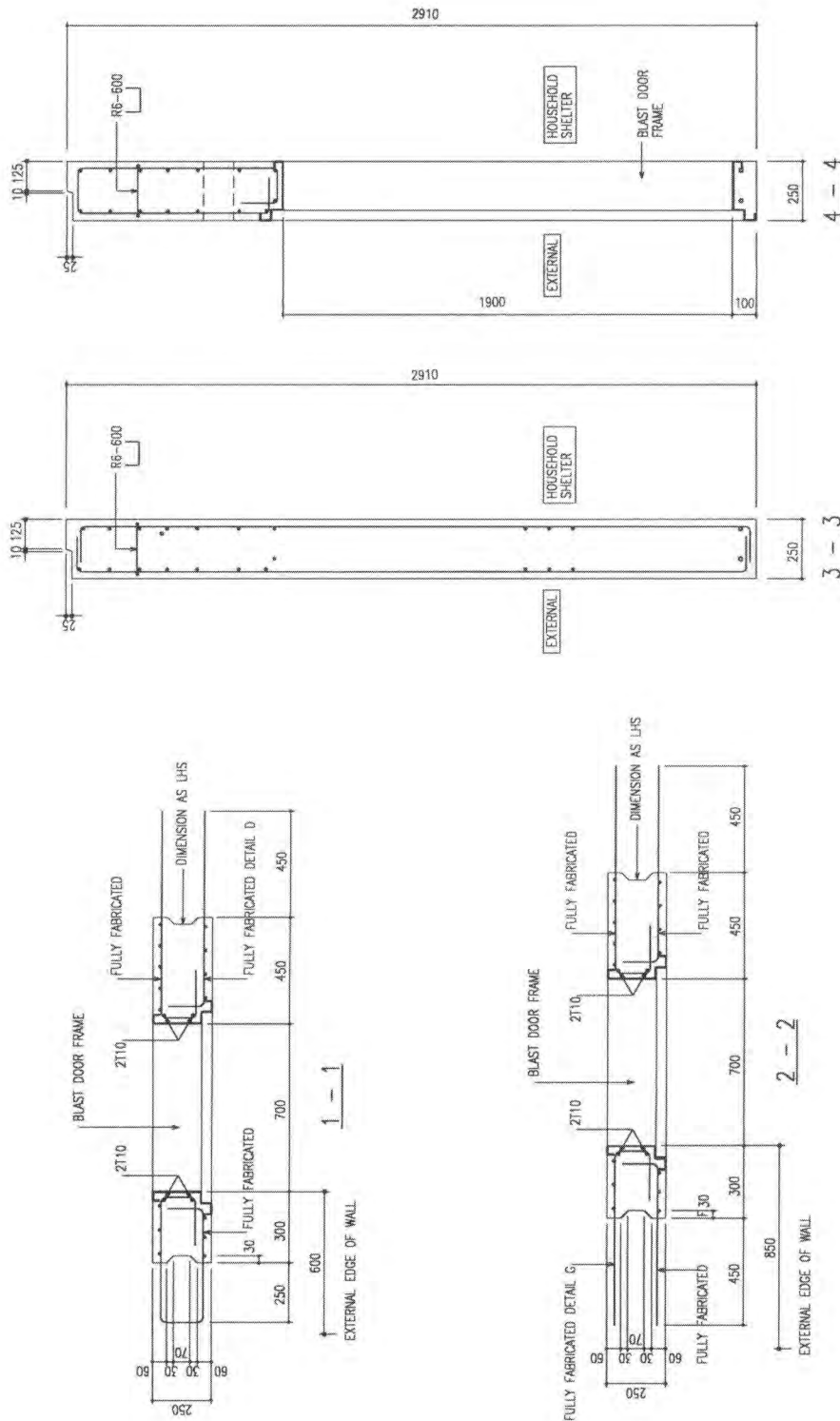
FOR DOOR LOCATED AT 600 FROM EXTERNAL EDGE OF WALL



TYPE DFP1 FOR HOUSEHOLD  
SHELTER AT 1ST STOREY

TYPE DFP2 FOR HOUSEHOLD SHELTER  
AT TYPICAL AND TOPMOST STOREY

## HDB'S PRECAST HOUSEHOLD SHELTER DOOR FRAME REINFORCEMENT DETAILS





**PRECAST /  
PREFABRICATED  
BATHROOM UNITS**



## CHAPTER 6

The bathroom is usually one of the smallest rooms in a dwelling unit. Nevertheless, it is one of the most labour intensive elements to be co-ordinated. It requires the involvement of almost all building trades such as waterproofing, finishes, accessories, sanitary wares / plumbing systems and M&E installations.

Being subjected to wetting and drying, the construction of a bathroom demands a very high standard of workmanship, especially in the area of waterproofing. Should there be a leak found in the floor slab, the amount of time, cost and inconvenience caused could be extensive, as it is often difficult to trace the source, such as defective workmanship or cracks through the structural slab. Rectification work may require hacking floor tiles, exposing substrate and re-applying waterproofing membrane.

The Committee recommends designers to integrate precast / prefabricated bathroom units (PBUs) in their design, which offers significant opportunities for improvement in terms of delivery, quality assurance and productivity.

## 6.1 Types of Precast / Prefabricated Bathroom Units

PBUs have been widely used in Japan and the western homes and hotels for many years. In recent years, both the HDB and private developers have explored the possibility of using prefabricated bathrooms. A trial implementation programme for the PBUs was carried out by HDB in some of the public housing projects. As feedback from homeowners was very encouraging, PBU is likely to become the new approach to public and private housing.

There are many proprietary systems available in the Singapore market. Nevertheless, PBUs could generally categories into the following systems:

### System 1

Precast concrete cell completed with finished wall and floor prior to delivery to site.

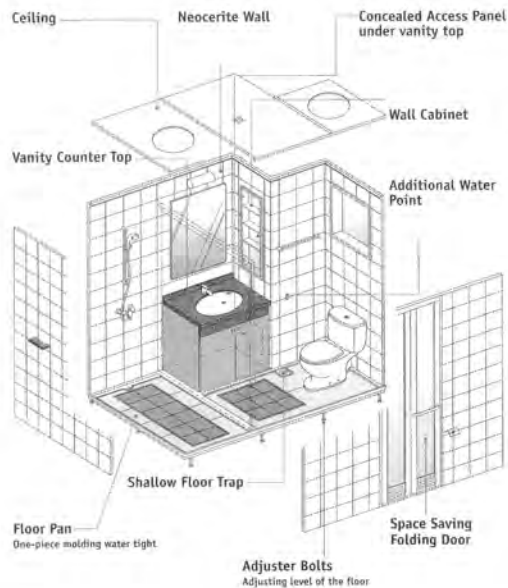


- Bathroom shall be cast as a volumetric concrete cell and pre-finished with floor and wall finishes prior to delivery to site.
- PBU shall be hoisted to location and the M&E services shall be connected to the mains of the building.

Figure 1 : Precast Concrete Cell with Finished Floor and Walls.

## System 2

Wall panels and floor tray separately lifted and assembled at site.



- Floor tray shall be lifted to position and set up accordingly.
- Wall panels shall be lifted and assembled at site.
- Finally, Ceiling and sanitary fittings shall be assembled accordingly.

Figure 2: Wall Panels and Floor Separately Lifted

## System 3

Wall panels and floor trays pre-assembled in factory prior to delivery to site.



- Wall panels and floor tray were pre-assembled in factory prior to delivery to site.
- PBU shall be hoisted to location and the M&E services shall be connected to the mains of the building.

Figure 3: Pre-assembled Bathroom Unit

Floor trays are usually made of reinforced concrete (RC), fibre reinforced polyester (FRP) or sheet moulding compound (SMC). Wall panels are commonly made of fibre reinforced polyester, special cement board, sheet moulding compound, galvanised metal sheet as well as sandwich panelling system. Lightweight ceiling materials such as PVC-coated alloy for rust resistance are available in the market.

Both the conventional "S-trap" and the new shallow "P-trap" system can be used for the sanitary plumbing system. The shallow "P-trap" and sanitary pipes have the advantage of being fully encased within the PBU floor tray / slab and connected horizontally to the main sanitary discharge stack in the service duct. This eliminates the exposure of unsightly sanitary pipings under the slab in conventional bathrooms. It also eases the maintenance process. As no pipes are protruding out of the ceiling of the unit below, all maintenance/repairing works can be carried out within the affected unit itself, avoiding the need to disturb the neighbours.

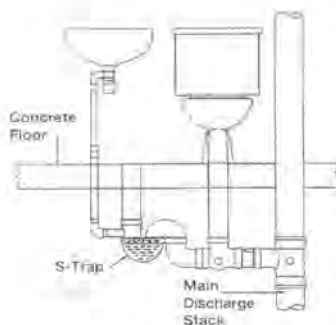


Figure 4 : Conventional Floor Trap

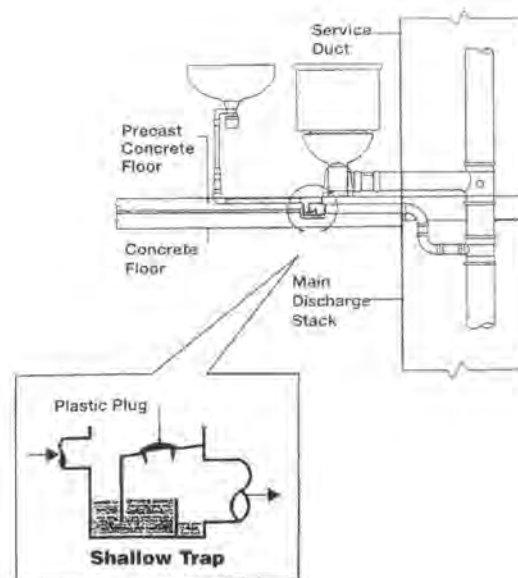


Figure 5 : New 'Shallow' Floor Trap

## 6.2 Benefits of Precast / Prefabricated Bathroom Units

The foremost benefits of precast / prefabricated bathroom units are:

- Higher quality finishes and low wastage of materials.
- Improved productivity of labour on site.
- Reduced wet work especially in the bathroom and less cleaning up work on site.
- Better quality control in waterproofing works in the factory environment.
- Maintenance can be carried out within the unit rather than from neighbouring unit.
- Higher buildability score.

These benefits translate into substantial savings in cost for developers, high and consistent quality product for designers and simpler quality control for contractors.

## 6.3 Architectural Design Considerations

Besides knowing the types of system available in the market, designers could consider the following factors and guidelines during the development stage of a project.

### Treatment to external surfaces of PBUs' wall panels

Some PBU systems come with complete wall panels ready to receive skim coat and painting. Others would require external finishing panels (brickwall, block wall, dry wall, etc.) for the architectural treatment.

### Treatment to the drop in soffit level of the slab

In most private residential developments, a drop at the entrance of bathroom is incorporated to contain water within the bathroom. Designers are therefore advised to consider the drop at the soffit level of the slab in the bathroom area. Alternatively, a designer may choose to provide a kerb at the bathroom's entrance to avoid creating a separate floor level.

### Location of service ducts and access panel for maintenance

The location of the access panel is critical to suppliers, as the routing and connection of services have to be predetermined and co-ordinated with the appointed supplier prior to delivery.

### Sanitary plumbing system

The "P-trap" system refers to "horizontal outlet" (or wall outlet) type of WCs and floor traps. The P-trap WC and floor trap are separately connected horizontally to the main discharge stack at floor level. P-trap system is normally used where the provision of a common discharge pipe below the slab is not feasible.

The conventional "S-trap" (i.e. vertical outlet) type of WC and floor trap are to pass through the floor slab and connect to a common discharge pipe below the floor slab (i.e. this pipe is within the lower unit) for the connection to the main discharge stack. Access for maintenance of the common discharge pipe is to be provided.

The P-trap system can be used in PBUs for the whole construction industry. However, the Qualified Person is advised to pre-consult the Sewerage Department of the Ministry of the Environment (ENV) on the design and layout of the sanitary plumbing system for the PBU and the whole building.

### Location of PBU on floor plan

The location of PBU is important to the engineer who is responsible for the hoisting of the unit into the building. A detailed study into the building layout, site boundary, constraints, etc., is a pre-requisite.

### Performance of wall panel

Some developers and designers are particular in some of the wall panelling systems such that they may sound hollow. However, many suppliers in the market have confirmed that they can reduce it.

### Types of finishes for the wall and floor

Some PBU systems do not encourage the use of tiled finishing. It is therefore essential that designers discuss their requirements with suppliers before choosing a PBU system.

## 6.4 Structural Design Considerations

Precast concrete floor trays can be designed as a structural slab and integrated into the structural system. This design concept will make the construction of bathroom unit a critical path of building project.

It is therefore a preferred choice to leave the prefabricated bathroom unit a strictly architectural precast element. The floor tray would then be designed as a secondary slab, carrying its self-weight with some live load from the sanitary fittings and human movement. This approach will make the bathroom unit a secondary operational component, giving more time for the designer, supplier and contractor to finalise the sanitary fittings as well as the finishes.

Other design factors to be considered when using PBUs are:

### Weight of the precast / prefabricated bathroom unit

When carrying out the structural design of the bathroom tray, the structural engineer would have to consider the weight of the PBU, which could be obtained from the supplier. As a rough guide, the weight of PBU available in the market can range from 0.5 to 3 tonnes.

### Method of hoisting

Occasionally, the method of hoisting PBUs into a building and the points of lifting are influenced or restrained by the final location of PBUs. As such the structural framing system of PBUs may have to be strengthened or modified to suit.

### Type of floor trap

There are many methods to connect floor traps to main discharge stacks depending on PBU suppliers. Designer will need to liaise with the supplier and design the connection details accordingly. For example, if the conventional S-trap is to be used, it will be necessary to box out the structural floor slab.



The suppliers shall seek approval from the Sewerage Department (ENV) on the shallow floor trap. Shallow floor traps shall comply with the following basic requirements:

- (a) Depth of water seal shall not be less than 50mm and the parts / partition forming the water seal trap shall be of an integral part of the trap.
- (b) Depth of passage clearance shall not be less than 25mm.
- (c) Diameter of waste pipe connection shall not be less than 40mm (or 2 nos. of 25mm waste pipe connection).
- (d) Diameter of outlet pipe shall not be less than 75mm.
- (e) Floor trap grating shall incorporate with an anti-mosquito device.

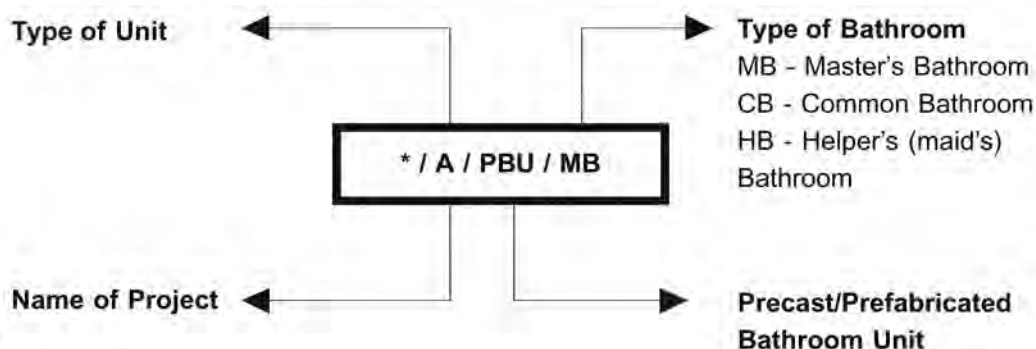
## 6.5 Dimensioning and Labelling System

A wide variety of proprietary PBU systems are available in the market. Most suppliers can produce PBUs to designers' specifications, including the size of the bathroom.

It is imperative that designers use the internal coordinating dimensions in multiples of 0.5M (where M is equivalent to 100mm) for the length, breadth and width of the bathroom, when designing the bathroom layout.

To support the application of modular system, the size and layout of the PBUs should be standardised in specific incremental dimension. The productivity and quality of PBUs would certainly be enhanced with the use of more industrialised materials and methods. More cost competitive PBUs could also be achieved through economics of scale.

There are many systems available in the market, the development of unit modular standardisation for the local PBU market is therefore essential. Standardised PBU label format may be adopted. A proposed example would be as follow:



## 6.6 Reference Sheets



## **INSTALLATION OF PRECAST / PREFABRICATED BATHROOM UNITS**

The installation procedures for precast / prefabricated bathroom units varies from system to system. Designers are encouraged to liaise with suppliers for specifying PBUs in their projects.

The general rules are:

1. All loose concrete and debris such as loose timber and nails shall be removed. Surfaces shall be prepared and made good before receiving the unit.
2. Contingency discharge pipe should be cast in the structural slab as an outlet pipe for seepage of water through the PBU, even though most PBUs are waterproofed prior to delivery.
3. Debris in pipes shall be removed to avoid choking sanitary discharge pipes / stacks.
4. With the preparation works complete, care should be taken to prevent damage to PBUs when hoisting the unit to the respective floor level.
5. Palletiser could be used to transport PBUs. Final position shall be adjusted using pneumatic jacks and levelling shims.
6. Sanitary discharge pipes shall be connected to the main discharge stack in the service duct in accordance with the manufacturer's specifications.
7. Electrical service shall also be connected to the main switch of the building.
8. The gap between the bottom of the PBU and the structural slab shall be packed with non-shrink grout around the perimeter or treated in accordance with manufacturer's specifications.
9. If one of the PBU's wall panels is exposed or formed part of the external wall or façade, much care should be taken to prevent water seepage or migration.

**LIST OF SUPPLIERS FOR PRECAST / PREFABRICATED BATHROOM UNITS**

Name of PBU Suppliers	Tel / Fax No	Model	System
Eastern Pretech (Pte) Ltd 15 Sungei Kadut St 2, Singapore 729234	368 1366 368 2256 (Fax)	'Parma'	3
Eng Seng Cement Products Pte Ltd 45 Kallang Pudding Road #10-01 Alpha Building, Singapore 349317	746 4333 743 4085 (Fax)	'YES'	2 & 3
Fermold Pte Ltd 3 Tuas Basin Close, Singapore 638798	861 8836 861 2909 (Fax)	INAX 'KW'	3
Framework Building Products Pte Ltd 58 Tuas Basin Link, Jurong Town Singapore 638774	861 5838 861 3387 (Fax)	'Unilav'	3
G & W Precast Pte Ltd 21 Sungei Kadut St 2, Singapore 729238	368 2221 365 3927 (Fax)	House brand	3
Hong Leong Asia Ltd 7A Tuas Avenue 13, Singapore 638979	862 3501 861 0674 (Fax)	House brand	3
Keppel Sea Scan Pte Ltd 31 Shipyard Road Singapore 628130	262 6100 262 4231 (Fax)	'Keppel Sea Scan'	3
National Matsushita Electric Works (Asia Pacific) Pte Ltd 101 Thomson Road #25-03/05, United Square, Singapore 307591	255 5473 253 5689 (Fax)	'National'	2 & 3
Plus Link Industries Pte Ltd 40 Tuas West Road, Singapore 638389	269 0708 269 2808 (Fax)	'Plus Link Series'	3
Prefab Technology Pte Ltd 66 Sungei Kadut St 1, Singapore 729367	368 3233 365 8316 (Fax)	'P-Cube'	3

Note: The list of Suppliers for Precast / Prefabricated Bathroom Units is not exhaustive.

## PRECAST / PREFABRICATED BATHROOM UNIT SUPPLIER



### Eastern Pretech Pte Ltd

15 Sungei Kadut Street 2  
Singapore 729234

Tel : (65) 3681366

Fax : (65) 3682256



### Product Features "PARMA"

- Walls and ceilings consist of plastic-coated hot-dipped galvanised steel sheet cassettes jointed together with mechanical connection.
- Walls are 50mm thick and tiles or marble are applied to the walls with a special adhesive.
- Reinforced concrete floor slab shall be 100mm thick, laid to fall with waterproofing membrane.
- Patented PVC sanitary piping and shallow floor trap system concealed within floor slab structure. No sanitary pipes need to penetrate the floor slab, thus cutting down the possibility of leakage into the apartment below.
- Fully furnished with all sanitary wares, fittings, electrical and services within the unit in the factory.
- Quality of workmanship under controlled ideal factory conditions. Quality control includes tests on water proofing, plumbing and electrical wiring.
- PBU would be ready for use after hoisting it into final position and connecting its plumbing and electrical services. M&E connections are all done from outside of the unit.
- Unit weight approximately 2 tonnes.

### Project Reference

- HDB Public Housing (3184 units)
- Redevelopment of Gurkha Camp (848 units)
- NTU Student Hostels (421 units)
- Malaysia projects: Pudu Hotel (168 Units), Kemayan Hotel (208 Units), Ambassador Hotel (368 Units)



## PRECAST / PREFABRICATED BATHROOM UNIT SUPPLIER



### Eng Seng Cement Products (Pte) Ltd

45 Kallang Pudding Road  
#10-01 Alpha Building  
Singapore 349317

Tel : (65) 7464333  
Fax : (65) 7434085  
Email : sales@engseng.com.sg  
URL : www.engseng.com.sg

The New Yes Bathroom Unit



Part of Interior Finishes

Model: Yes0001



External View

### Product Features

- Standard FEcon Unit 2.4 X 1.7 with accessories weighs 2,500Kg (Option for lightweight GRP unit >450Kg)
- Preformed one-piece concrete/GRP floor tray with FEcon wall panel system
- Whole unit is cast/assembled with quality finished and sanitary wares in controlled factory environment. Alternatively, due space constraint, individual panels may be assembled at construction sites
- Flexible custom-design units allow solutions for all applications according to building structures and architectural design. Many styles, colours and finishing materials can be chosen from our wide collection to suit individual tastes.
- High structural strength, long lasting, good sound insulation value, maintenance-free, quick and easy installation are some of the advantages that come with YES bathroom unit.

## PRECAST / PREFABRICATED BATHROOM UNIT SUPPLIER



**FERMOLD PTE LTD**

3 Tuas Basin Close  
Singapore 638798

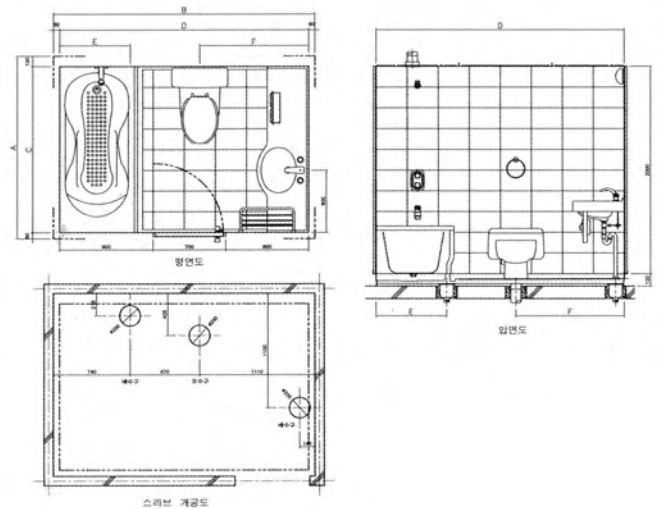
Tel : (65) 8618836

Fax : (65) 8612909

E-mail : fermold@pacific.net.sg



**FERMOLD  
DAELIM-INAX UBR**



### Product Features

- Variety of quality components
- Easy maintenance for services within unit
- Established UBR system in Japan and Korea
- Design with drawing details package
- Weight less than 2.5 tonnes
- Flexibility for alteration

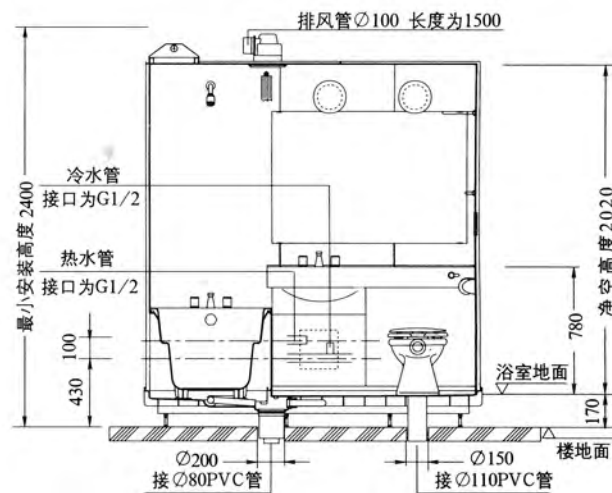
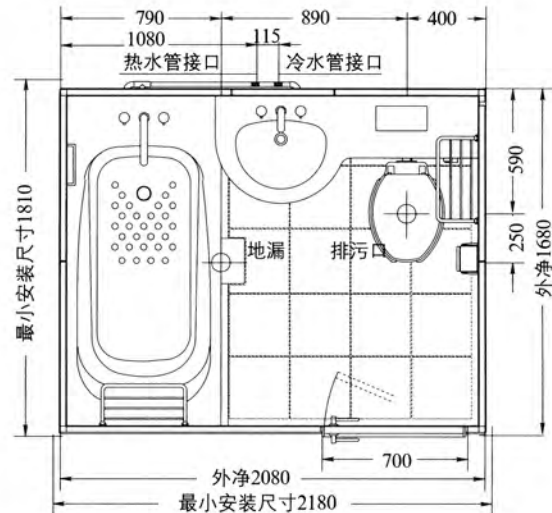


## PRECAST / PREFABRICATED BATHROOM UNIT SUPPLIER



**FRAMEWORK**  
**Building Products Pte Ltd**  
 58 Tuas Basin Link  
 Singapore 638774

Tel : (65) 8615838  
 Fax : (65) 8613387  
 Website : <http://www.framework.com.sg>



### Product Features

- Use lightweight, strong and impact resistant Sheet Moulding Compound (SMC), commonly used in aerospace and marine industries.
- SMC is durable, environmentally safe, corrosion and thermal resistant, with bending and compressive strength much greater than alloy and cast iron.
- Available in different sizes, configuration and colour choice with finishes.
- Fabricated in factory environment with systematic quality control and stringent tests.
- One piece machine moulded floor plan ensured waterproofed requirement.
- Ease of installation and complete with bathroom fittings and fixtures.
- On-time and one trade installation, save time, labour and money.

## PRECAST / PREFABRICATED BATHROOM UNIT SUPPLIER



### G & W Precast Pte Ltd

21 Sungei Kadut St 2  
Singapore 729238

Tel : (65) 3682221

Fax : (65) 3653927



### Product Features

- PBU are lightweight but very sturdy so as to ensure durability and easy handling.
- Reinforced Concrete floor incorporating UPVC pipings and P-trap within the slab.
- Body made up either of steel sheet cassette or galvanised angle sections assembled to form the shell. Building boards are then secured onto the cassettes or angles being the wall of BTU - to replace the conventional use of concrete wall / brickwall.
- Pipings for water installation are fixed onto the external of the shell. All other pipings within the unit are carefully concealed so that is aesthetically pleasing.
- BTU comes complete with accessories ranging from basin mixer, bath and shower mixer to frameless mirror.
- Accommodate flexible varying design in layouts with different fittings and accessories to requirements.
- Versatile choice of finishing preference from ceramic tiles, marble to granite.



## PRECAST / PREFABRICATED BATHROOM UNIT SUPPLIER



### Hong Leong Asia Ltd

7A Tuas Avenue 13  
Singapore 638979

Tel : (65) 8623501

Fax : (65) 8610674

Email : hlasales@hlasia.com.sg

### Cubic System

Where the prefab bathroom is completely factory assembled, with all the necessary sanitary fittings, and delivered to site in a cubic form.



### Knock-down System

Where only the base tray, with water proofing & tiling (marble), is installed first. Wall panel modules, ceiling & sanitary fittings are site installed later. This system gives a freedom to change the wall panels at any future time.



### Product Features

- Floor tray is made of waterproof reinforced concrete. It can be either the structural floor or an elevated secondary floor.
- Walls are made of PVC laminated steel plates with plaster board backing or fibre cement boards with hand laid wall tiles. All vertical joints are made waterproof.
- Ceiling is made of PVC laminated steel plates or fibre cement boards with access opening.
- Wash basins are wall mounted with or without pedestal bases.
- Water closet can be of either the 'P' type or the 'S' type. All other fittings such as long baths, shower roses, towel racks, etc. can be included. Fitted with hot and cold water plumbing.
- All plumbing and electrical wiring are preformed and, when the Units arrive on site, all that is necessary is to roll them to their places and provide the simple connections.
- Developed PBU with technical consultancy from TOTO Ltd of Japan - a company internationally renowned for its sanitary fittings and unit baths.
- Enhance buildability, save cost (and time) and offer superior quality products, possibility to change the wall panels (tile/marble type) at any given future time.

### Project Reference:

- HDB Hougang Contract N1 C11 (1995).
- TOTO Japan has produced & installed thousands of Unit Baths - as they are called in Japan- for over 30 years. Projects ranging from residential housings to star class hotels.



**PRECAST / PREFABRICATED BATHROOM UNIT SUPPLIER**



**Keppel Sea Scan Pte Ltd**

31 Shipyard Road  
Singapore 628130

Tel : (65) 2626100  
Fax : (65) 2621231, (65) 2624403  
E-mail : [sscan123@seascan.com.sg](mailto:sscan123@seascan.com.sg)



**Product Features**

- Used precast concrete flooring with steel wall panels.
- Good sound insulation using wall elements with air gap in between.
- Weighing about 1.5 to 2.0 tonnes, 2m(L) x 2m(B) x 2.4m(Ht).
- Lightweight construction and easy installation without compromising on sound proofing and solid feel of a private bathroom.
- Wall and floor could be delivered with completed marble, tiles, PVC or paint finishes. Only require to connect the services to the main building.
- Capable to complete 3000 to 4000 PBU units per year.
- PSB approved waterproofing materials to be used.
- Manufactured under controlled environment.
- Design to meet client's requirements.

**Project Reference**

- Worked closed with Wartsila - Principals in Finland
- Hotels, offices and residential housing projects in Finland, Germany and Korea

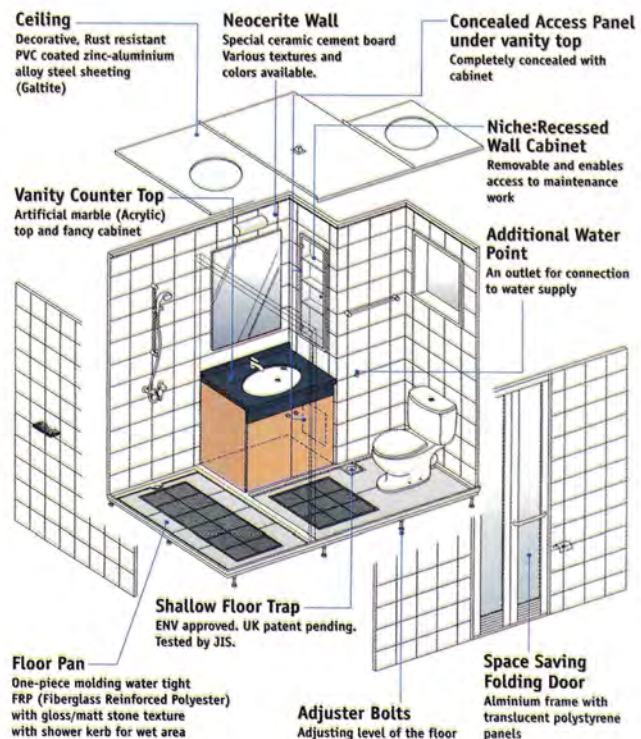
## PRECAST / PREFABRICATED BATHROOM UNIT SUPPLIER

### National Matsushita Electric Works (Asia Pacific) Pte Ltd

101 Thomson Road, #25-03/05  
United Square, Singapore 307591

Tel : (65) 2555473

Fax: (65) 2535689



### Product Features

- Weighing only 350kg.
- Used one-piece moulding watertight fiberglass reinforced polyester with gloss/matt stone texture.
- Neocerite wall panels finished with ceramic surface cement boards. Wide range of textures, colours and designs are available.
- Concealed access panel under vanity top.
- Ceiling made of zinc-aluminium alloy steel sheeting, coated with decorative PVC, for rust resistant.
- ENV approved type of shallow floor trap, UK patent obtained.
- 100% waterproof guarantees long life of property.
- Assembly chiefly by fastening bolts from inside therefore making dismantle and remodeling easy.
- Undertake complicated installation of toilet as a package.
- Guaranteed quality assurance of the product.
- Design to meet client's requirements.
- Various designs also available for selection.

### Project Reference

- 1996 - 1st HDB public housing project at Hougang (1216 units).
- 1999 - 1st private condominium project in Singapore - Trellis Towers (686 units).
- Current 35% market share of PBUs in Japan, accumulated more than 3,000,000 units installed.



**PRECAST / PREFABRICATED BATHROOM UNIT SUPPLIER**



**Plus Link Industries Pte Ltd**

40 Tuas West Road  
Singapore 638389

Tel : (65) 2690708

Fax : (65) 2692808

E-mail : Pluslink@mbox5.singnet.com.sg



INTERIOR



EXTERIOR

**Product Features**

- To facilitate easy handling at site, PBU is of lightweight construction, using concrete as floor and steel cassettes as walls and ceiling panels. A typical unit weights approximately 2 tonnes.
- Installation on site is easy, fast and simple. Typically, a 4-man team, with the use of a crane, is able to install a single unit at the designated position in just 30 minutes.
- Concealed services and pipings.
- In-house design team capable of producing fast and flexible solutions to meet design and engineering requirements.
- Products manufactured and installed with total care and precision. QC team on each stage of manufacturing process.
- 10 years warranty on waterproofing.

## PRECAST / PREFABRICATED BATHROOM UNIT SUPPLIER

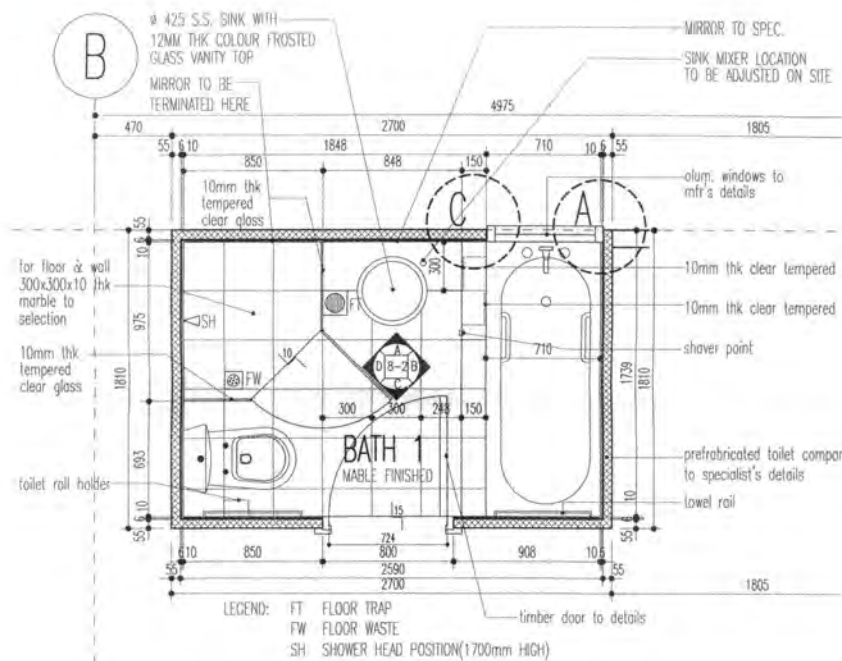


**Prefab Technology Pte Ltd**

66 Sungei Kadut Street 1  
Singapore 729367

Tel : (65) 3683233

Fax : (65) 3658316



### Product Features

- Used prefabricated waterproof reinforced concrete slab.
- Used sandwich wall system that completes with fully concealed piping, wiring and finished external walls, thus requiring only skim coating and painting on site.
- Other features include built-in sound buffers that eliminate the 'hollow' sound effect, and doing away with the need to erect a brick wall on site.
- Finished wall is thinner than conventional brickwall, thus increasing usable GFA.
- Used ceiling board with light fittings.
- Cast in door frame, window frame and glass panel.
- Manufacturing process thoroughly tested at stages. Achieved the requirement of ISO9000 standard.
- M&E maintenance works carried out within the unit rather than servicing from the neighbouring unit.
- Water tightness warranty from fabricator.
- Shop drawings to be provided by fabricator.
- Prefabrication reduces site coordination of many trades.

### Project Reference

- 10 storey flat comprising 17 apartment units at 27 Ewe Boon Road.



**LIST OF SUPPLIERS  
FOR PRECAST  
CONCRETE  
BUILDING  
COMPONENTS**

# LIST OF SUPPLIERS FOR PRECAST CONCRETE BUILDING COMPONENTS

Name of Precasters	Tel / Fax No
Bolsen Cement Products Pte Ltd 7 Sungei Kadut St 5, Singapore 728954	269 3822 366 1979 (Fax)
Construction Technology Pte Ltd 50 Admiralty Road West, Singapore 759946	759 3833 752 6923 (Fax)
Eastern Pretech Pte Ltd 15 Sungei Kadut St 2, Singapore 729234	368 1366 368 2256 (Fax)
Econ Industries Pte Ltd 21 Kranji Way, Singapore 739432	368 9223 269 6367 (Fax)
Excel Precast Pte Ltd 531 Yishun Industrial Park A, Singapore 768739	863 0895 863 4182 (Fax)
Fermold Pte Ltd 3 Tuas Basin Close, Singapore 638798	861 8836 861 2909 (Fax)
G & W Precast Pte Ltd 21 Sungei Kadut Drive, Singapore 729238	368 2221 365 3927 (Fax)
Hanson Concrete Innovators Co Pte Ltd 42 Pioneer Sector 2, Singapore 628393	861 6262 862 2342 (Fax)
Hong Leong Asia Ltd 7A Tuas Avenue 13, Singapore 638979	862 3501 861 0674 (Fax)
Hua Kok Precast Pte Ltd 32 Sungei Kadut Way, Singapore 728787	368 5993 368 5994 (Fax)
L&M Precast (Tuas) Pte Ltd 28 Tuas Crescent, Singapore 638719	861 3988 861 2284 (Fax)
Poh Cheong Concrete Product Pte Ltd 48 Sungei Kadut St 1, Singapore 729377	269 1447 368 5604 (Fax)
Prefab Technology Pte Ltd 66, Sungei Kadut St 1, Singapore 729357	368 3233 365 8316 (Fax)
Singapore Precast Pte Ltd 6 Sungei Kadut Drive, Singapore 729559	365 9043 365 9042 (Fax)
Spandek Engineering (S) Pte Ltd 5 Tuas Avenue 13, Singapore 638977	862 3922 861 5389 (Fax)
Sunway Concrete Products (S) Pte Ltd 4 Tampines Industrial St 52, Singapore 528817	582 8089 581 0482 (Fax)
Syscon Pte Ltd 17 Tuas Avenue 18, Jurong, Singapore 638900	862 3238 861 1439 (Fax)

Note: The list of suppliers for Precast Concrete Building Components is not exhaustive.