

**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 nibs 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 4.8m² 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 ≤ 45m ²	2.0m ²	1.2m x 1.8m x 3.0m
75m ² ≥ GFA > 45m ²	2.4m ²	1.2m x 2.1m x 3.0m
140m ² ≥ GFA > 75m ²	3.2m ²	1.5m x 2.4m x 3.0m
GFA > 140m ²	4.0m ²	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)

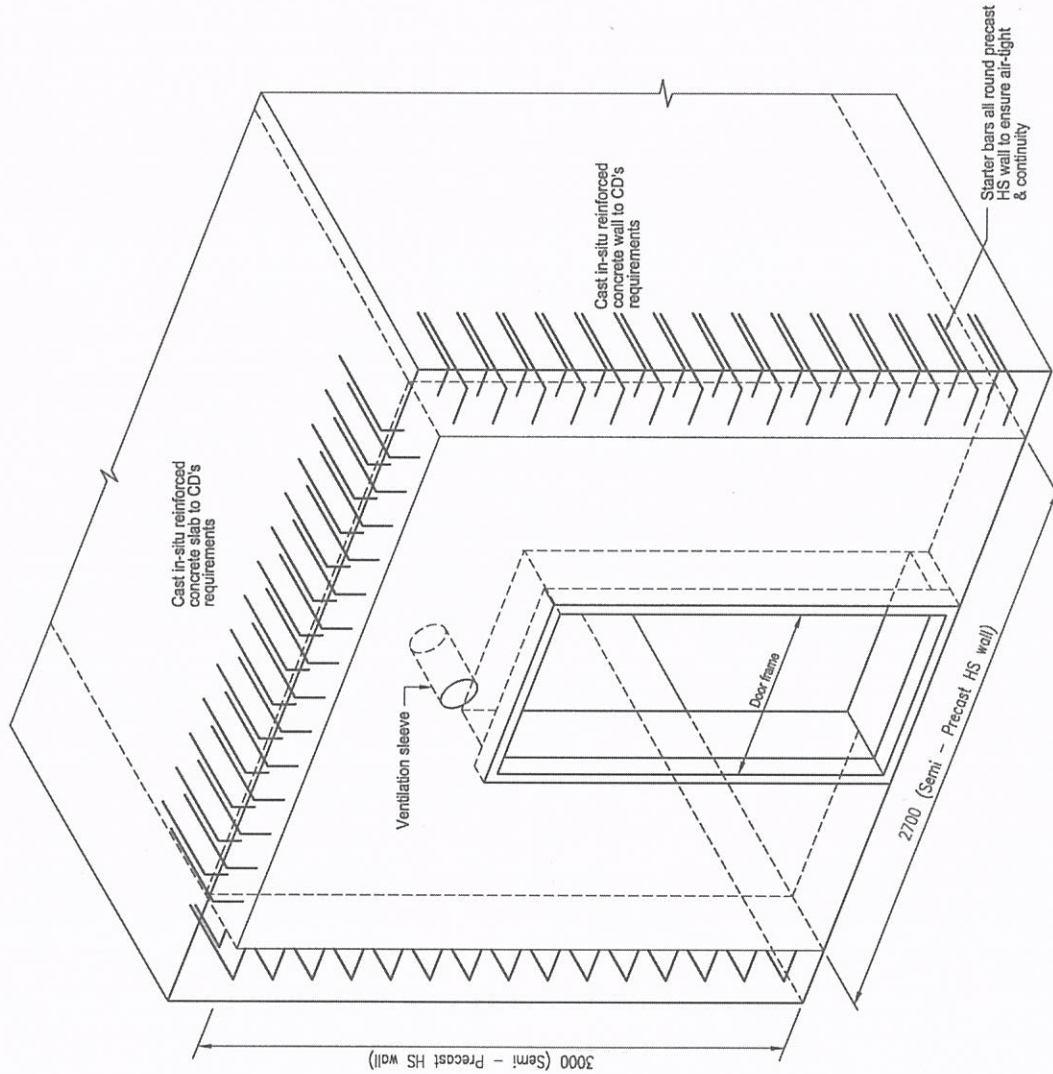
5.5 Reference Sheets

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 ³)
HSW/1800x3000	GFA ≤ 45m ²	1.2m x 1.8m x 3.0m	2.7 Tonnes
HSW/2100x3000	75m ² ≥ GFA > 45m ²	1.2m x 2.1m x 3.0m	3.3 Tonnes
HSW/2400x3000	140m ² ≥ 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 :

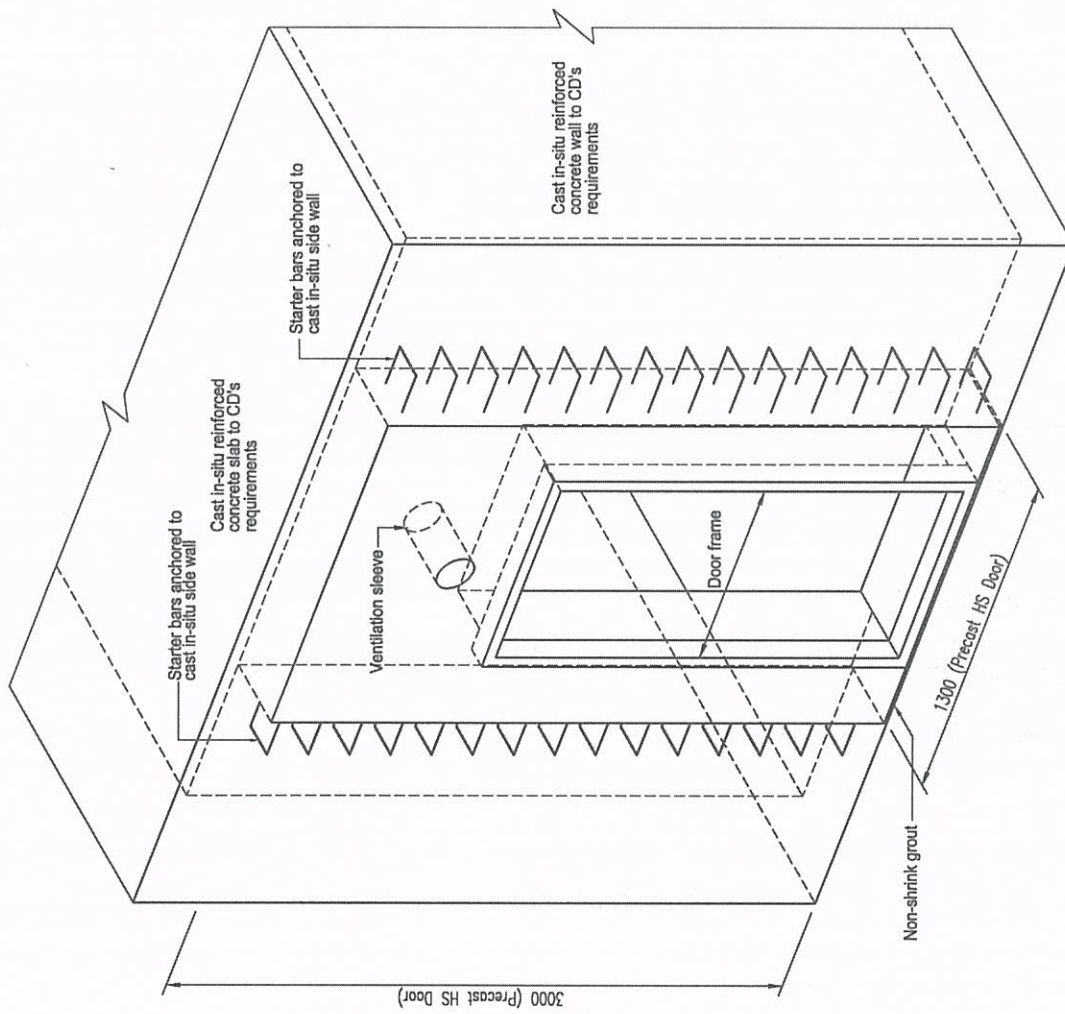
1. Semi-precast HS wall shall be erected before casting the base slab.
2. Semi-precast HS wall shall be propped to ensure stability before and after casting the base slab and walls.
3. Shear keys and reinforcement of cast in-situ walls and slab are not shown in drawing

**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 ³)
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 :

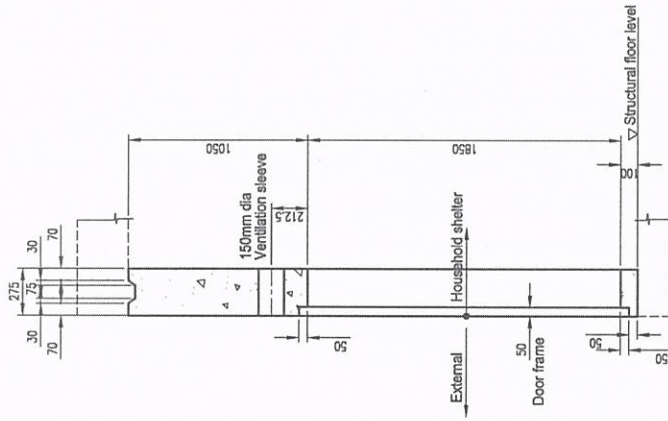
1. Precast HS door frame shall be erected after the completion of reinforced floor slab.
2. Precast HS door frame shall be propped to ensure stability before casting the adjoining base slab and walls.
3. Shear keys and reinforcement of cast in-situ walls and slabs are not shown in drawing.
4. Precast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

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

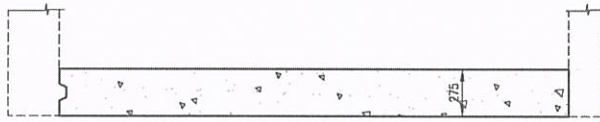
1. Currently, the maximum panel clear of precast household shelters approved by the relevant Authorities is 3m. Henceforth, not all the precast shelters approved for public housing are automatically suitable for private housing as the floor to floor height are usually higher. Greater heights may be permitted 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 4.8m² 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

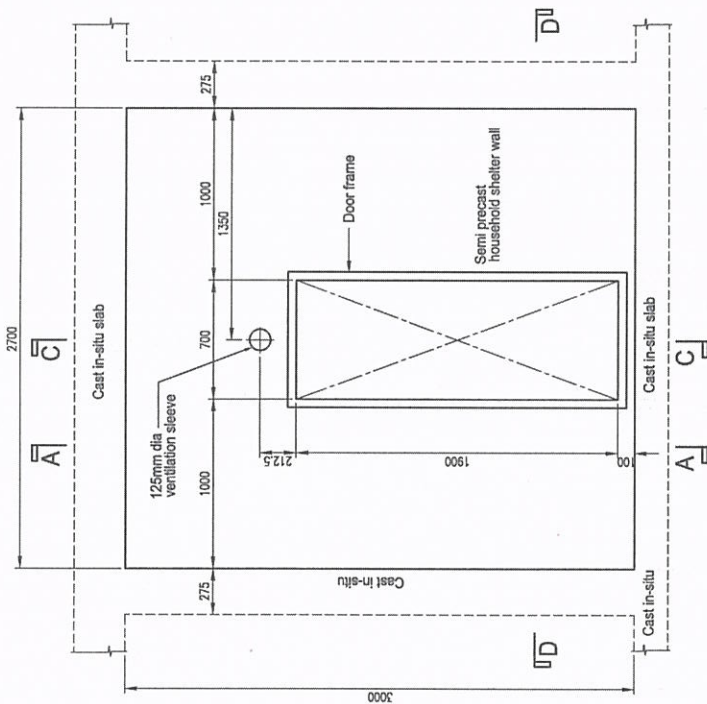
TYPE: HSW/2700 X 3000



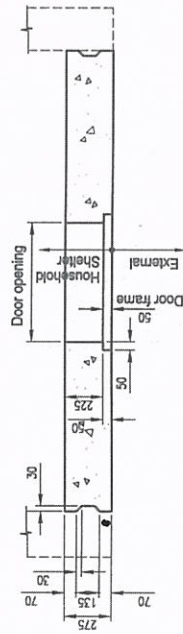
SECTION C-C



SECTION A-A

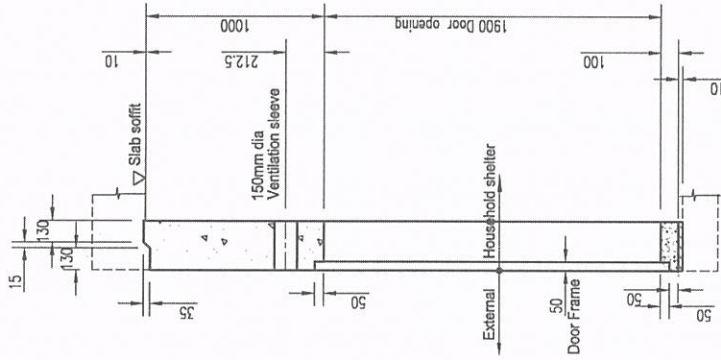


PRECAST HOUSEHOLD SHELTER WALL
HSW/2700X3000

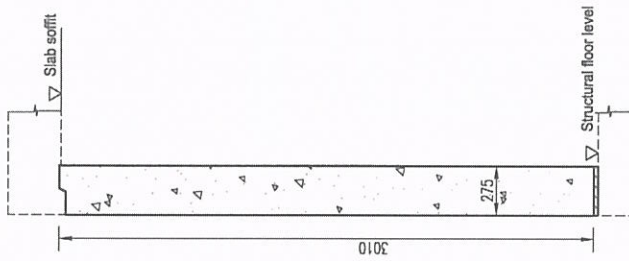


SECTION D-D

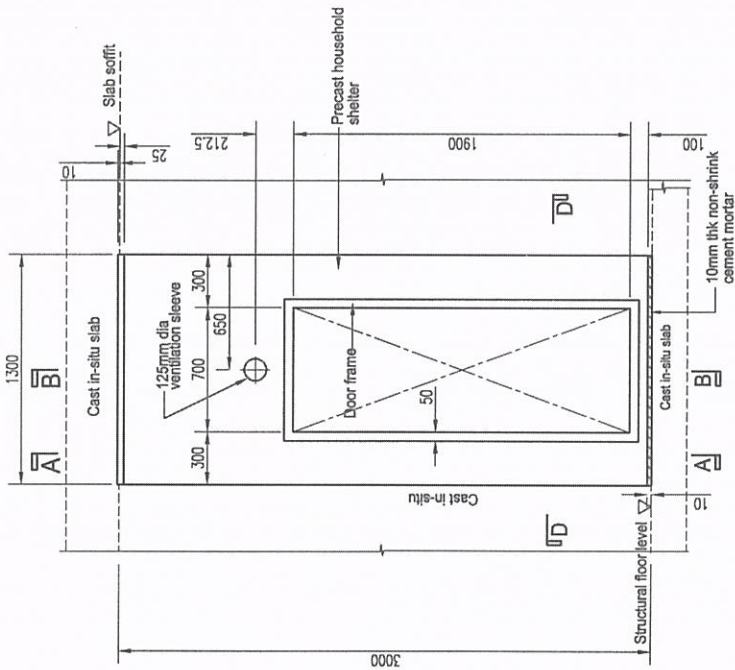
PRECAST HOUSEHOLD SHELTER DOOR FRAME DETAILS
TYPE: HSD/1300 X 3000



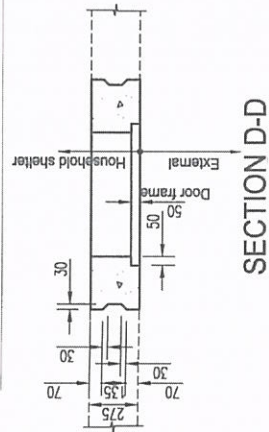
SECTION C-C



SECTION A-A



PRECAST HOUSEHOLD SHELTER
DOOR FRAME HSW/1300x3000



SECTION D-D

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/mm² high yield deformed bar, Type 2
 - R - Denotes 250N/mm² for mild steel bars
2. All steel fabric shall conform to the latest BS4483 with a minimum yield stress of 485N/mm².
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.

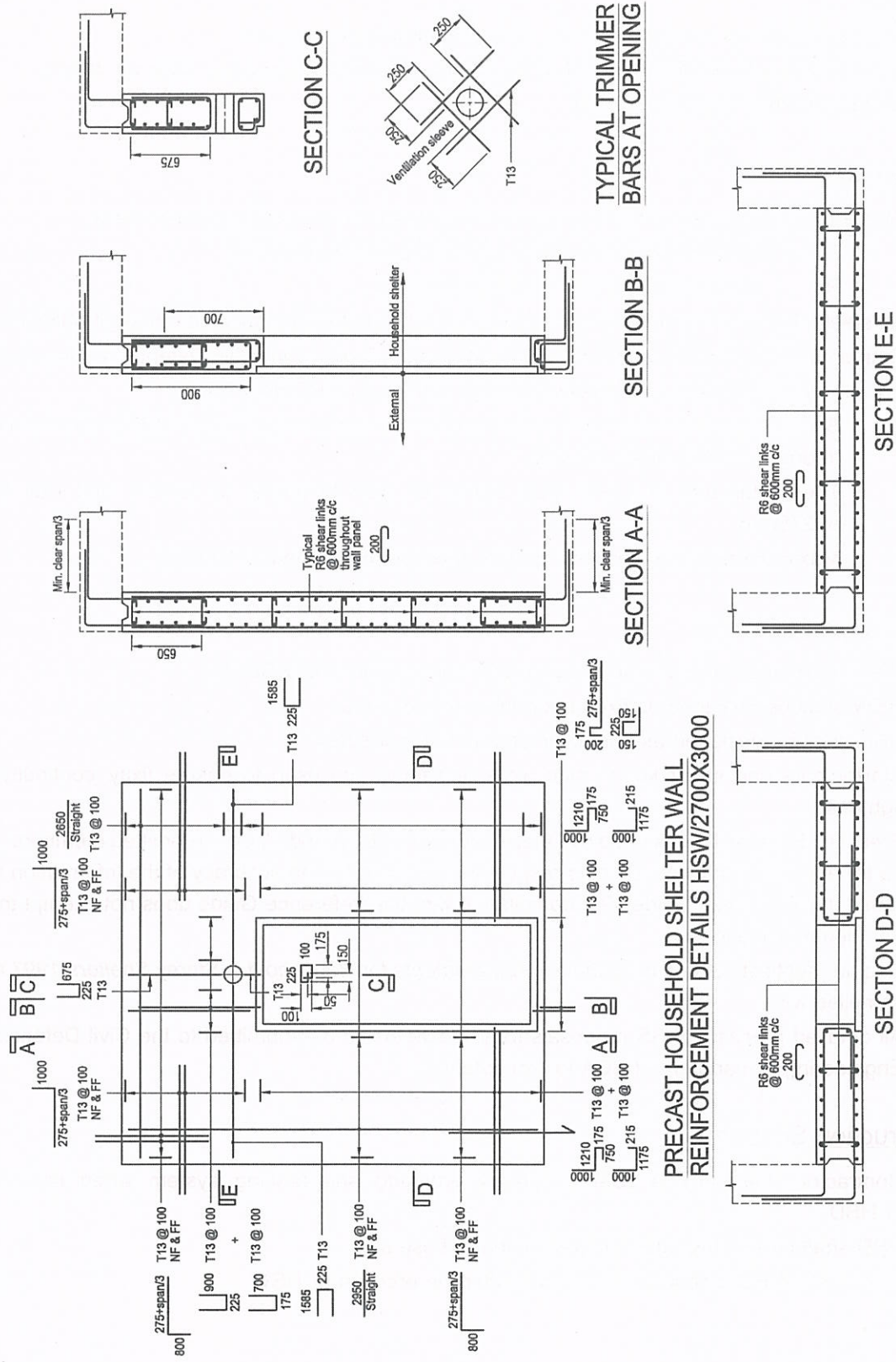
Design Considerations

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.

SEMI-PRECAST HOUSEHOLD SHELTER WALL REINFORCEMENT DETAILS
TYPE: HSW/2700 X 3000



TYPICAL TRIMMER BARS AT OPENING

SECTION B-B

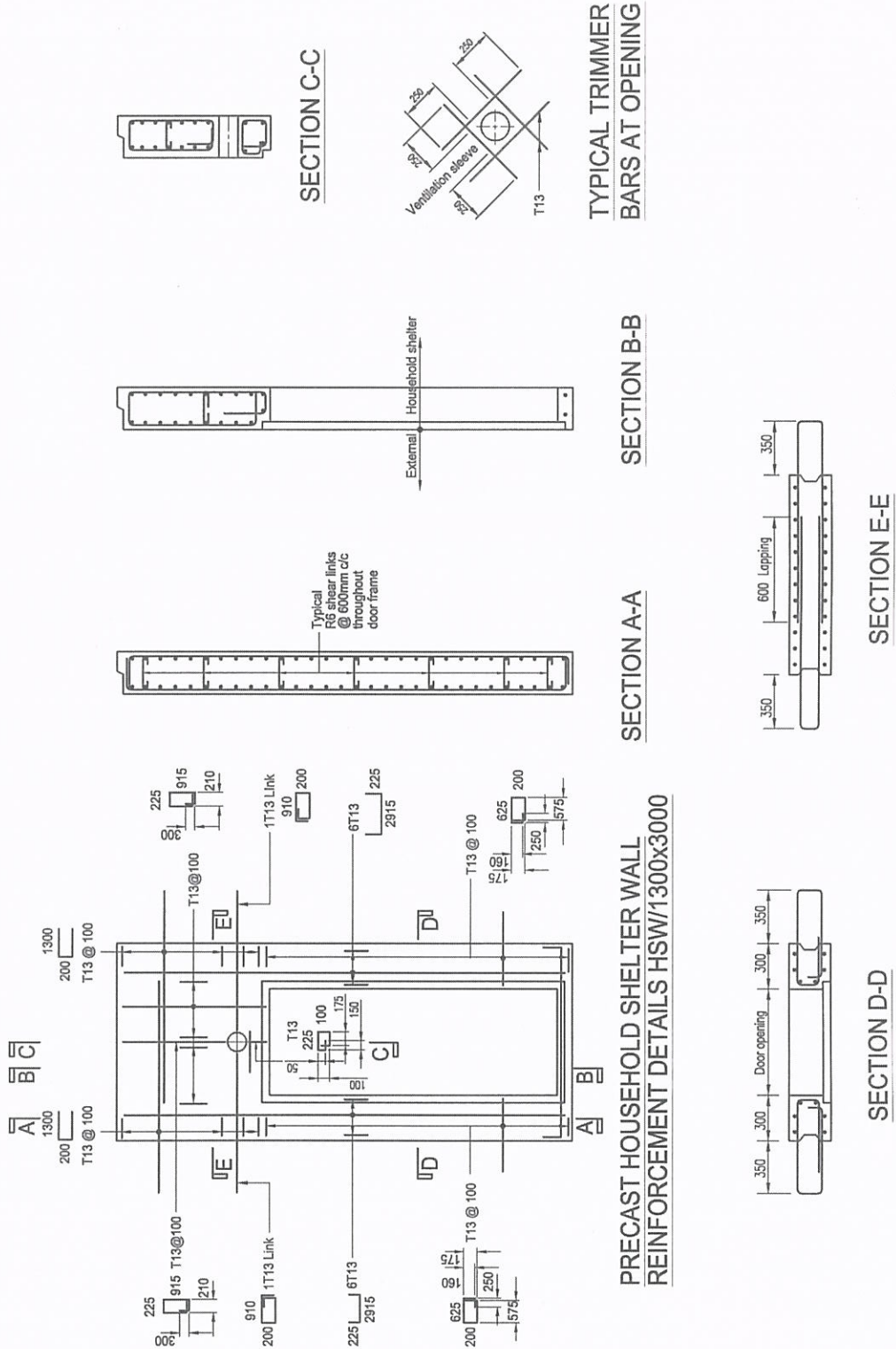
SECTION A-A

SECTION E-E

SECTION D-D

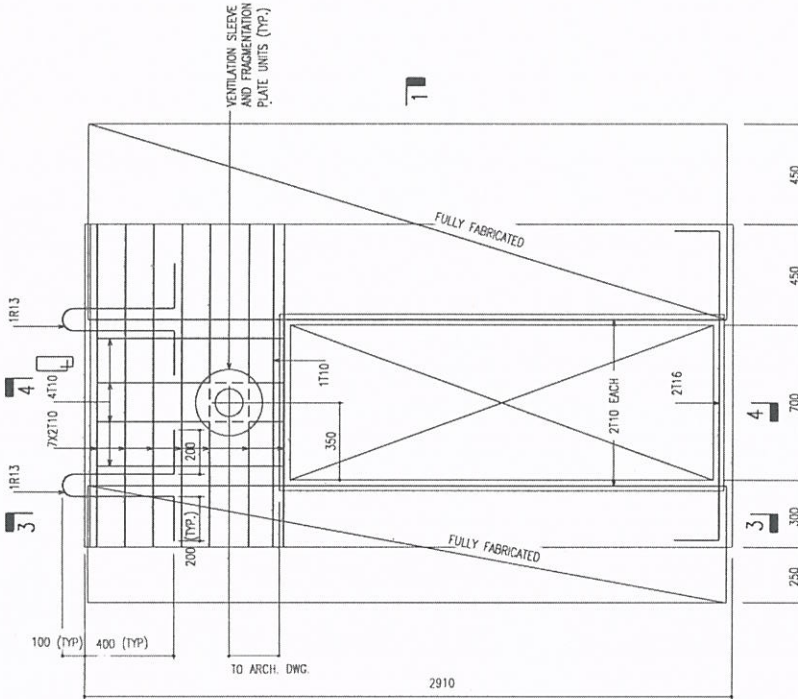
PRECAST HOUSEHOLD SHELTER WALL REINFORCEMENT DETAILS HSW/2700X3000

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

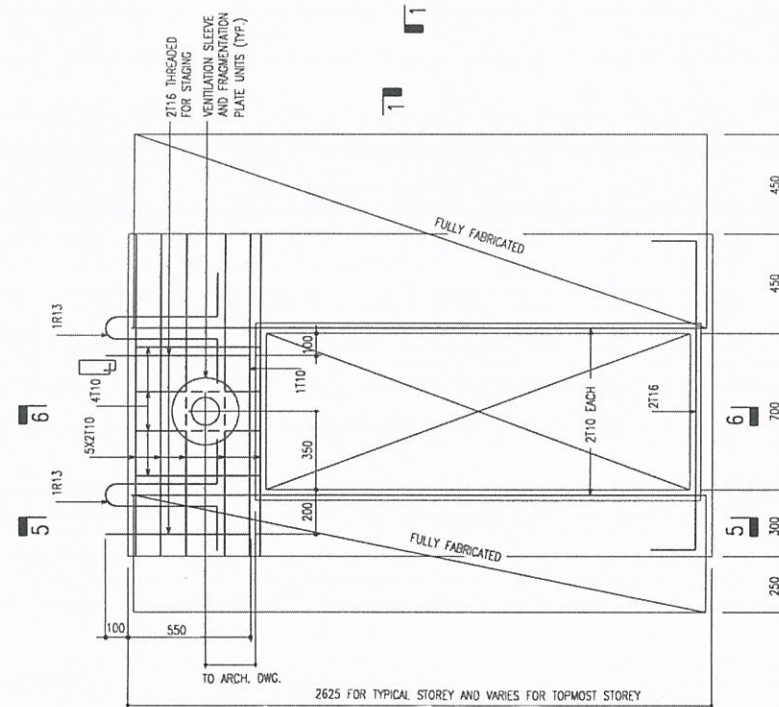


**HDB'S PRECAST HOUSEHOLD SHELTER DOOR FRAME
REINFORCEMENT DETAILS**

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

