

SINGAPORE CIVIL DEFENCE FORCE

Our Ref. : CD/FSSD/12/01/03/01

Your Ref. :

Date : 25 November 2013



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President, Institution of Engineers, Singapore (IES)

President, Association of Consulting Engineers, Singapore (ACES)

President, Real Estates Developers' Association of Singapore (REDAS)

Dear Sir/Mdm,

AMENDMENT TO TECHNICAL REQUIREMENTS FOR DESIGN AND CONSTRUCTION OF PRECAST HOLLOW CORE HOUSEHOLD SHELTERS 2013

A circular dated 25 Jan 2013 was issued by SCDF on the permissible variations for technical requirements for precast household shelter designs. SCDF and BCA have gathered feedback from the building industry and made amendments to the precast household shelter technical requirements for greater clarity and design flexibility.

2 The amendments to the technical requirements include a common modular increase in the length and width of the precast HS; dimensions between the core and the nearest fixtures; details of closed link at the starter bar level for the cast in-situ joint between two HS; shear key design on HS for precast plank or cast in-situ slab construction and the details of tapered hollow cores for ease of production; etc. The key amendments are summarised in **Annex A**. The amended technical requirements for design and construction of the precast hollow core household shelters are attached in **Annex B** for easy reference.



3 The amended technical requirements shall take immediate effect. Please convey the contents of this circular to members of your Institution/Association/ Board. The circular is also available in CORENET-e-Info: <http://www.corenet.gov.sg/einfo>. For any inquiry or clarification, please contact the undersigned at 68481478.

Yours faithfully,

MAJ ANG GUAN HOCK
SSO SHELTER DEVELOPMENT
FIRE SAFETY & SHELTER DEPARTMENT
FOR COMMISSIONER
SINGAPORE CIVIL DEFENCE FORCE

cc

CEO, BCA

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**SUMMARY OF AMENDMENTS TO TECHNICAL REQUIREMENTS
FOR DESIGN AND CONSTRUCTION OF PRECAST HOUSEHOLD SHELTERS 2013**

S/No	Topic And Reference	Amendment
1	Dimensions of Precast Hollow Core Household Shelters. Refer to page B-8 to B-11, figure 1 to 9.	Modular increment in length and width of the precast hollow core HS for all the 7 types of the precast HS designs to allow for more flexibility in terms of dimensions between the hollow core and the nearest fixtures.
2	Reinforcement Bar Requirements. (a) Refer to page B-12, figure 10. (b) Refer to page B-13 to B-15, figure 11 to 16. (c) Refer to page B-17, figure 18. (d) Refer to page B-19, figure 22.	Additional information on the hollow core dimensions with 15mm tapering all round from the bottom to the top of the core to provide clarity on the dimensions and the required clearance for the tapering design. Additional details on the shear link and starter bar for cast-in-situ joint between two HS. Additional details for the shear key designs and the dimensions for precast plank or cast-in-situ joint construction. Additional notes to reinforce the requirements of rebar size; no. of rebar and its clear space arrangement.
3	Connection Between Precast Hollow Core Household Shelters. Refer to page B-20, figure 23.	Additional notes on the requirements of structural safety and technical requirements for HS to be fulfilled and designed by qualified person.
4	Blocked-Out at Precast Hollow Core Household Shelters. Refer to page B-24 and B-25, figure 29 and 30 respectively.	Additional notes on the shear key requirements between two precast hollow core HS.



**TECHNICAL REQUIREMENTS
FOR DESIGN AND
CONSTRUCTION
OF PRECAST
HOLLOW CORE
HOUSEHOLD SHELTERS
2013**

(AMENDED ON 25 NOVEMBER 2013)



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Technical Requirements for the Design and Construction of Precast Hollow Core Household Shelters (HS)**A General**

1. Precast hollow core household shelter shall comply with the latest Technical Requirements for Household Shelters unless otherwise specified in this part of technical requirements for precast hollow core household shelters.

B Dimensions of Precast Hollow Core Household Shelters

2. Precast hollow core household shelters (hereafter known as precast household shelters) must be designed to meet the area and volume requirements. The internal length and width of the household shelter (HS) walls shall be modular in size with an increment of 50mm. Precast household shelters including the dimensions and spacing of modular hollow cores (See Tables A & B, Annex B), location of shear key on wall above HS door, ventilation sleeves, blast door and electrical fixtures are shown in Figures 1 to 10 of Annex B :

- | | | | |
|----|-----------|---|---|
| a) | Figure 1 | : | Precast HS with HS door on longer wall and one of ventilation sleeve above the door (Type 1). |
| b) | Figure 2 | : | Precast HS with HS door on shorter wall and one of ventilation sleeve above the door (Type 2). |
| c) | Figure 3 | : | Precast HS showing ventilation sleeve and internal electrical fixtures on the same wall (Type 3). |
| d) | Figure 4 | : | Precast HS and C-shaped Precast HS connected at the shorter wall and with HS Doors on long walls (Type 4). |
| e) | Figure 5 | : | Precast HS and C-shaped Precast HS connected at the longer wall and with HS doors on long walls (Type 5). |
| f) | Figure 5A | : | Precast HS and C-shaped Precast HS connected at the longer wall and with HS door each on long wall and short wall (Type 5A). |
| g) | Figure 6 | : | Precast HS and C-shaped Precast HS with connection between longer and shorter walls respectively and with HS doors on long walls (Type 6). |
| h) | Figure 6A | : | Precast HS and C-shaped Precast HS with connection between longer and shorter walls respectively and with HS door each on long wall and short wall (Type 6A). |
| i) | Figure 7 | : | Precast HS adjoining Cast in-situ Walls/ Columns (Type 7). |

- | j) Figure 8 : Shear Key formed on wall above HS Door.
 - | k) Figure 9 : Blocked-out at Precast HS for beam connection.
 - | l) Figure 10 : Hollow Core Shape.
3. To facilitate de-moulding of the precast household shelter, the hollow cores shall be tapered all round throughout its height as shown in Figure 10.
 4. Where possible, hollow core of maximum 500mm long shall be adopted to achieve lighter precast household shelter for ease of handling.

C Reinforcement Bar Requirements

5. The reinforcement of precast household shelter shall be welded steel fabric mesh and hot rolled steel bars. Reinforcement bars specified for precast slab, walls and hollow cores of the precast household shelter refer to minimum bar diameters and maximum spacing in both directions.
6. In the precast HS walls, reinforcement bars shall be welded steel fabric mesh of minimum T10 at 100mm spacing or minimum T13 at 100mm spacing depending on the clear height of household shelter as given in the Technical Requirements for Household Shelters.
7. The details of reinforcement bars for precast HS, C-shaped Precast HS, the rib of precast HS, connection to precast HS, door frame, electrical fixtures, trimmer bars around ventilation sleeve and at door recess, and hollow cores are shown in Figures 11-23 of Annex B :
 - a) Figure 11 : Reinforcement Bar Details of Wall and Rib for Precast HS (Type 1).
 - b) Figure 11A : Plan and Section of Rib with Shear Links.
 - c) Figure 12 : Reinforcement Bar Details of Wall and Rib for Precast HS (Type 2).
 - d) Figure 13 : Reinforcement Bar Details of Wall and Rib for C-Shaped Precast HS (Type 5).
 - | e) Figure 14 : Reinforcement Bar Details of Wall and Rib for C-Shaped Precast HS (Type 6).
 - | f) Figure 15 : Connection Details Between Two-Precast HS.
 - | g) Figure 16 : Connection Details Between Precast HS and Cast in-Situ Wall/Column.
 - h) Figure 17 : Reinforcement Bar Details of Rib.

- i) Figure 18 : Details of Reinforcement Bars near Door Frame and at Electrical Fixtures on Internal Face of Precast HS.
 - j) Figure 19 : Details of Trimmer Bars for Ventilation Sleeve.
 - k) Figure 20 : Details of Trimmer Bars for Wall Recess for HS Door Handle.
 - l) Figure 21 : Cage Reinforcement Bars in Hollow Cores.
 - m) Figure 22 : Reinforcement Bars in Hollow Cores of Precast HS with and without adjacent Ventilation Sleeve, Door and Internal Electrical Fixtures.
 - n) Figure 23 : Reinforcement Bars Lapping in Hollow Cores.
8. For the rib between two hollow cores, its top and bottom portion shall be provided with closer shear links of at least 6 number of R6 at 100mm spacing. For area between these top and bottom portions, minimum shear link of at least R6 at 600mm spacing shall be provided. (See Figure 17). The hook of the shear link must be anchored around the outermost bars of the internal face of precast HS wall.
9. The reinforcement bars for the HS door frame, ventilation sleeves and wall recess for electrical fixtures on internal face of HS wall are shown in Figures 18 to 20. As shown in the Figures, the wall recess for electrical fixtures on internal face of HS wall shall be located next or near to the HS door.
10. The modular length of the hollow cores shall vary from minimum 200mm to maximum 500mm with increment of 100mm whereas the modular width of hollow cores shall be minimum 150mm and maximum 200mm with increment of 25mm as shown in Table C. In these hollow cores, minimum cage reinforcement bars and links shall be provided and installed as shown in Figures 21 and 22, Tables D and E. Higher reinforcement bars and links shall be provided if they are required to meet the structural safety and stability requirements.
11. All reinforcement bars must be designed and detailed with tension anchorage or lapped length. The cage reinforcement bars for hollow cores of precast household shelter wall shall be cranked at their upper parts to facilitate placing of the reinforcement bars at lapping level (See Figure 23).

D Connection Between Precast Hollow Core Household Shelters

12. The connections between hollow cores are shown in Figures 24, 24A and 25 of Annex B :
- a) Figure 24 : Splice Sleeve Connection Details Between Precast HS and Cast In-Situ Element and Bolt Connection Details Between Two Precast HS.
 - b) Figure 24A : Splice Sleeve Connection Details for Precast HS Tower

c) Figure 25 : Connection Details Between Lower and Upper Precast HS.

13. Where precast household shelter is supported on cast in-situ elements (beam, or wall), T28 dowel bars shall be cast in the in-situ elements for splice sleeve connection between the precast household shelter and the cast in-situ elements. These dowel bars must be properly secured in position such that they are in line with the splice sleeve of the precast hollow core household shelter as shown in Figure 24 and Figure 24A. The splice sleeve shall be pressure-grouted with minimum Grade 70 grout to design and manufacturer's specification.
14. The lower and upper precast household shelters can be connected by bolt and steel plate connection or splice sleeve connection as shown in Figure 25 of Annex B. To facilitate installation, T28 bars required for these two types of connection shall be properly secured in position at 4 top corners of lower precast household shelter wall with a template such that they are aligned with the bolt holes or splice sleeve provided at the base or lower part of the upper precast household shelter respectively.

E Precast Slab of Household Shelter

15. The minimum reinforcement bars to be provided for precast plank and structural concrete topping shall be as shown in Figure 26, Annex B. Table E shows the thickness of slab, precast plank and in-situ concrete topping.
 - a) Figure 26 : Details of Precast Plank (marked as PS) and Concrete Topping.
16. The shear links shall be cast in the precast plank. The hook of the shear link must be anchored around outermost layer of bottom reinforcement bars of the precast plank. The bend of the shear link shall be anchored round the outermost layer of top reinforcement bars in the concrete topping.

F External Electrical Fixtures

17. Where there are electrical fixtures on external face of HS wall, a recess shall be formed on the rib of the precast household shelter wall. The reinforcement bars around the recess shall be as shown in Figure 27 of Annex B.
 - a) Figure 27 : Electrical Fixtures on External Face of Precast HS.

G Ventilation Sleeves

18. One of the two ventilation sleeves shall be located above the shelter door.
19. Ventilation sleeve shall not be located at the connection joint between two precast shelter walls.

H Door Recess on HS Wall

20. A recess shall be formed on the external face of the precast HS wall to accommodate the HS door handle when the HS door is open in 180°. The recess shall not be larger than 160 mm (length) x 80 mm (height) x 40 mm (depth).

I Blocked-Out at Precast Hollow Core Household Shelters

21. Reinforcement bar details for the blocked out at the bottom part of the outer wall of hollow cores are shown in Figures 17 and 23. In the blocked-out area where the cast in vertical reinforcement bars are exposed, horizontal reinforcement bars and shear links are to be installed at site.
22. Where the blocked-out is required for supporting in-situ beam, it shall be limited to outer wall of hollow core or outer part of precast household shelter wall. Blocking out any part of the inner wall of the hollow core for in-situ construction works is not allowed. The isometric views of precast HS showing blocked-out areas and exposed reinforcement bars are in Figures 28 and 29 of Annex B.
- a) Figure 28 : Isometric View of Precast HS with bolt and steel plate connection (without blocked out for Beam).
- b) Figure 29 : Isometric View of Precast HS with bolt and steel plate connection (with blocked out for Beam).
23. For a beam with more than one support, the end of a beam that is supported on the household shelter wall shall be designed and detailed as simply support.
24. Figure 30 shows Isometric View of Precast HS with Splice Sleeve Connection (Reinforcement Bar Details)

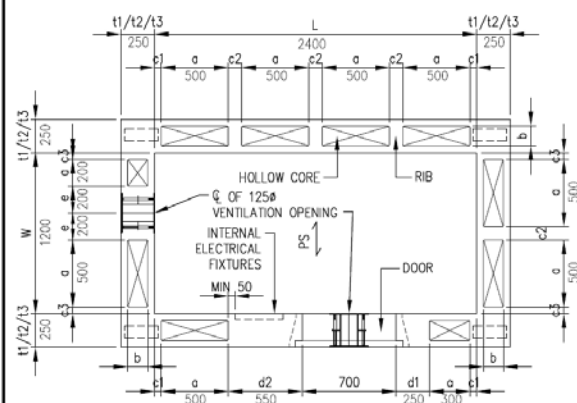


FIGURE 1: PRECAST HS WITH HS DOOR ON LONGER WALL AND ONE OF VENTILATION SLEEVE ABOVE THE DOOR (TYPE 1)
(HS DENOTES HOUSEHOLD SHELTER AND PS DENOTES PRECAST PLANK)

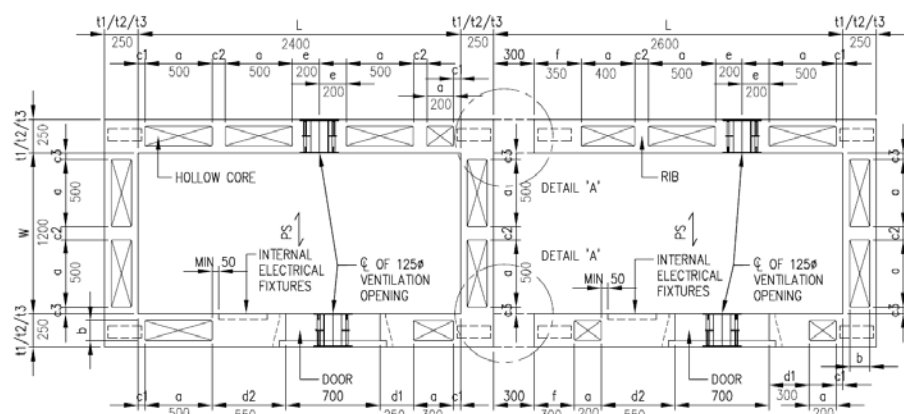


FIGURE 4: PRECAST HS AND C-SHAPED PRECAST HS CONNECTED AT THE SHORTER WALL AND WITH HS DOORS ON LONGER WALLS (TYPE 4)
(FOR JOINT DETAILS 'A', REFER TO FIGURE 15)

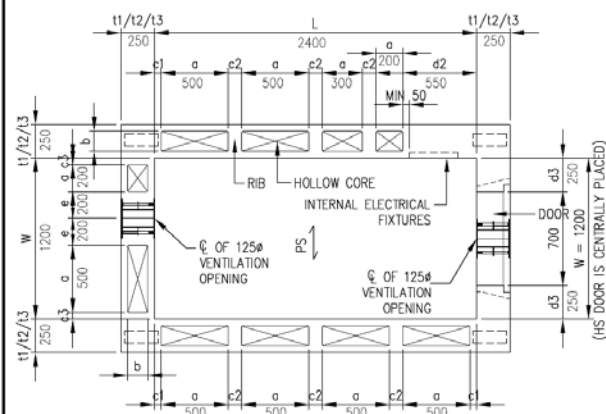


FIGURE 2: PRECAST HS WITH HS DOOR ON SHORTER WALL AND ONE OF VENTILATION SLEEVE ABOVE THE DOOR (TYPE 2)

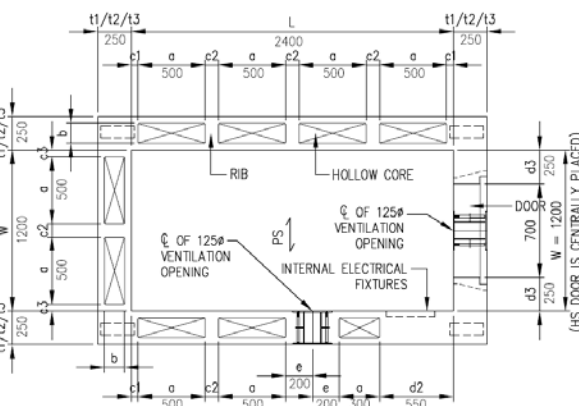
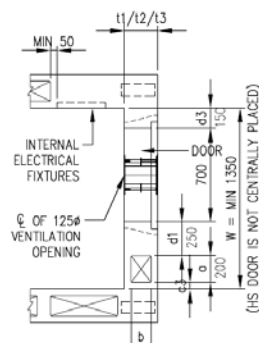


FIGURE 3: PRECAST HS SHOWING VENTILATION SLEEVE AND INTERNAL ELECTRICAL FIXTURES ON THE SAME WALL (TYPE 3)

DIMENSIONS OF HOLLOW CORES, RIBS & SERVICES

TABLE A

SYMBOLS	DIMENSIONS	
	MIN. (mm)	MAX. (mm)
a*	200	500
b***	150	200
d3**	150	300
e***	150	200
f***	250	350
c1**/c3***	25	50
d1***	250	300
d2***	525	550

* DIMENSIONS WITH INCREMENT OF 100 mm
** DIMENSIONS WITH INCREMENT OF 50 mm
*** DIMENSIONS WITH INCREMENT OF 25 mm

TABLE B

SYMBOLS	FIXED DIMENSIONS (mm)
c2	100
t1	250
t2	275
t3	300

NOTES:

1. THE INTERNAL LENGTH (L) AND WIDTH (W) OF THE HS WALLS SHALL BE MODULAR IN SIZE WITH AN INCREMENT OF 50 mm.
2. FOR ILLUSTRATION, MODULAR SIZE AND ARRANGEMENT OF HOLLOW CORES SHOWN ARE INDICATIVE ONLY.
3. BUILDING PLAN SHALL INDICATE PRECAST HS LAYOUT SHOWING ARRANGEMENT OF HOLLOW CORES WITH DIMENSION AND SPACING.
4. HOLLOW CORES SHALL BE MODULAR IN SIZE WITH INCREMENT OF 100 mm FOR LENGTH (a) AND 25 mm FOR WIDTH (b).
5. HOLLOW CORES SHALL BE 500 mm LONG WHERE POSSIBLE TO ACHIEVE A LIGHTER PRECAST HS FOR EASE OF HANDLING.
6. OTHER SIZES OF HOLLOW CORE CAN BE USED TO FILL UP THE WALL AREA WHERE 500 mm LONG HOLLOW CORE CANNOT BE FORMED.

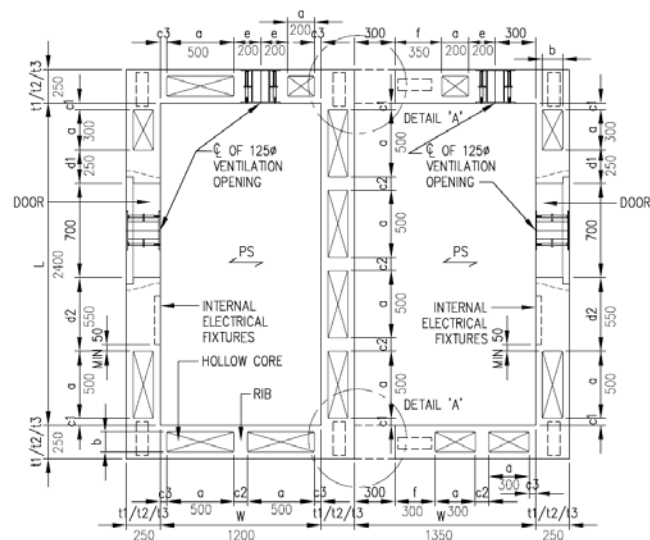


FIGURE 5: PRECAST HS AND C-SHAPED PRECAST HS CONNECTED AT THE LONGER WALL AND WITH HS DOORS ON LONG WALLS (TYPE 5)

(FOR JOINT DETAILS 'A', REFER TO FIGURE 15)

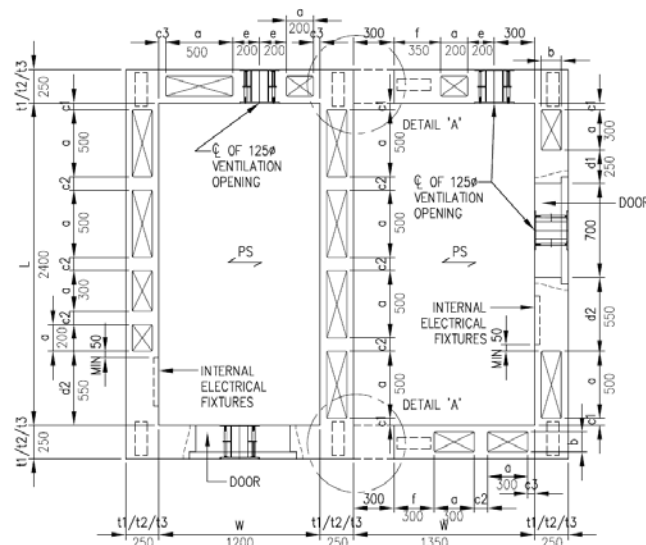


FIGURE 5A: PRECAST HS AND C-SHAPED PRECAST HS CONNECTED AT THE LONGER WALL AND WITH HS DOOR EACH ON LONG WALL AND SHORT WALL (TYPE 5A)

(FOR JOINT DETAILS 'A', REFER TO FIGURE 15)

DIMENSIONS OF HOLLOW CORES, RIBS & SERVICES

TABLE A

SYMBOLS	DIMENSIONS	
	MIN. (mm)	MAX. (mm)
a*	200	500
b***	150	200
d3**	150	300
e***	150	200
f***	250	350
c1***/c3***	25	50
d1***	250	300
d2***	525	550

* DIMENSIONS WITH INCREMENT OF 100 mm

** DIMENSIONS WITH INCREMENT OF 50 mm

*** DIMENSIONS WITH INCREMENT OF 25 mm

TABLE B

SYMBOLS	FIXED DIMENSIONS (mm)
c2	100
t1	250
t2	275
t3	300

NOTES:

1. THE INTERNAL LENGTH (L) AND WIDTH (W) OF THE HS WALLS SHALL BE MODULAR IN SIZE WITH AN INCREMENT OF 50 mm.
2. FOR ILLUSTRATION, MODULAR SIZE AND ARRANGEMENT OF HOLLOW CORES SHOWN ARE INDICATIVE ONLY.
3. BUILDING PLAN SHALL INDICATE PRECAST HS LAYOUT SHOWING ARRANGEMENT OF HOLLOW CORES WITH DIMENSION AND SPACING.
4. HOLLOW CORES SHALL BE MODULAR IN SIZE WITH INCREMENT OF 100 mm FOR LENGTH (a) AND 25 mm FOR WIDTH (b).
5. HOLLOW CORES SHALL BE 500 mm LONG WHERE POSSIBLE TO ACHIEVE A LIGHTER PRECAST HS FOR EASE OF HANDLING.
6. OTHER SIZES OF HOLLOW CORE CAN BE USED TO FILL UP THE WALL AREA WHERE 500 mm LONG HOLLOW CORE CANNOT BE FORMED.

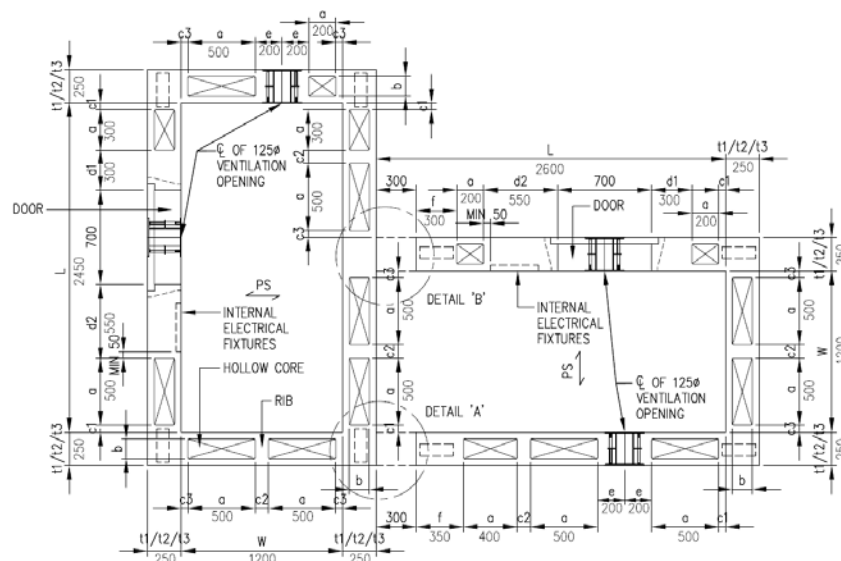


FIGURE 6: PRECAST HS AND C-SHAPED PRECAST HS WITH CONNECTION BETWEEN LONGER AND SHORTER WALLS RESPECTIVELY AND WITH HS DOORS ON LONG WALLS (TYPE 6)

(FOR JOINT DETAILS 'A' AND 'B', REFER TO FIGURE 15)

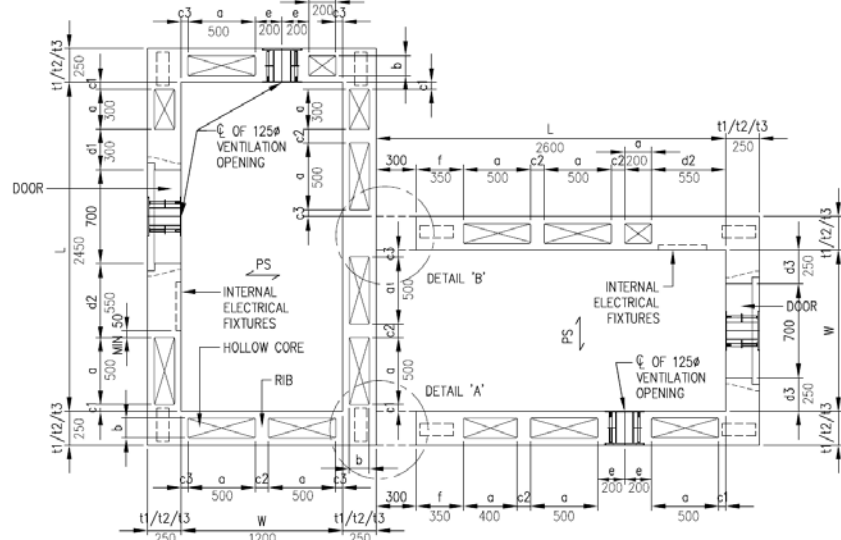


FIGURE 6A: PRECAST HS AND C-SHAPED PRECAST HS WITH CONNECTION BETWEEN LONGER AND SHORTER WALLS RESPECTIVELY AND WITH HS DOOR EACH ON LONG WALL AND SHORT WALL (TYPE 6A)

(FOR JOINT DETAILS 'A' AND 'B', REFER TO FIGURE 15)

DIMENSIONS OF HOLLOW CORES, RIBS & SERVICES

TABLE A

SYMBOLS	DIMENSIONS	
	MIN. (mm)	MAX. (mm)
a*	200	500
b***	150	200
d3**	150	300
e***	150	200
f***	250	350
c1***/c3***	25	50
d1***	250	300
d2***	525	550

* DIMENSIONS WITH INCREMENT OF 100 mm

** DIMENSIONS WITH INCREMENT OF 50 mm

*** DIMENSIONS WITH INCREMENT OF 25 mm

TABLE B

SYMBOLS	FIXED DIMENSIONS (mm)
c2	100
t1	250
t2	275
t3	300

NOTES:

1. THE INTERNAL LENGTH (L) AND WIDTH (W) OF THE HS WALLS SHALL BE MODULAR IN SIZE WITH AN INCREMENT OF 50 mm.
2. FOR ILLUSTRATION, MODULAR SIZE AND ARRANGEMENT OF HOLLOW CORES SHOWN ARE INDICATIVE ONLY.
3. BUILDING PLAN SHALL INDICATE PRECAST HS LAYOUT SHOWING ARRANGEMENT OF HOLLOW CORES WITH DIMENSION AND SPACING.
4. HOLLOW CORES SHALL BE MODULAR IN SIZE WITH INCREMENT OF 100 mm FOR LENGTH (a) AND 25 mm FOR WIDTH (b).
5. HOLLOW CORES SHALL BE 500 mm LONG WHERE POSSIBLE TO ACHIEVE A LIGHTER PRECAST HS FOR EASE OF HANDLING.
6. OTHER SIZES OF HOLLOW CORE CAN BE USED TO FILL UP THE WALL AREA WHERE 500 mm LONG HOLLOW CORE CANNOT BE FORMED.

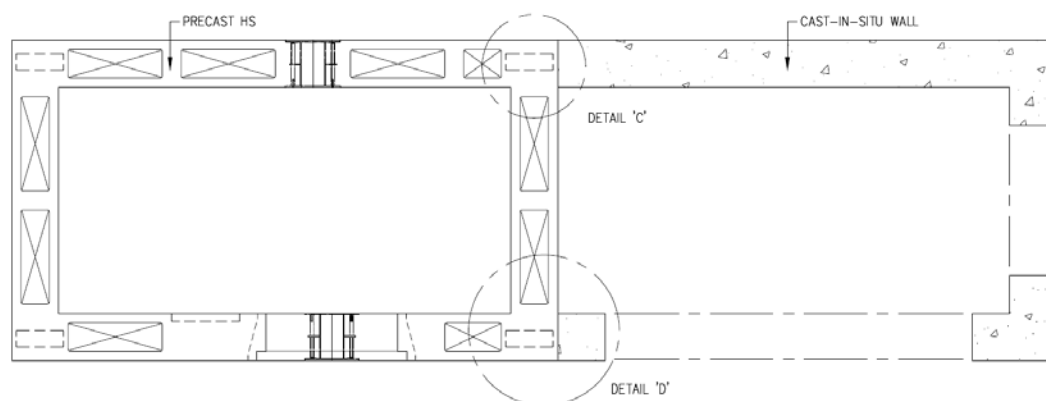


FIGURE 7: PRECAST HS ADJOINING CAST-IN-SITU WALLS/COLUMNS (TYPE 7)

(FOR JOINT DETAILS 'C' AND 'D', REFER TO FIGURE 16)

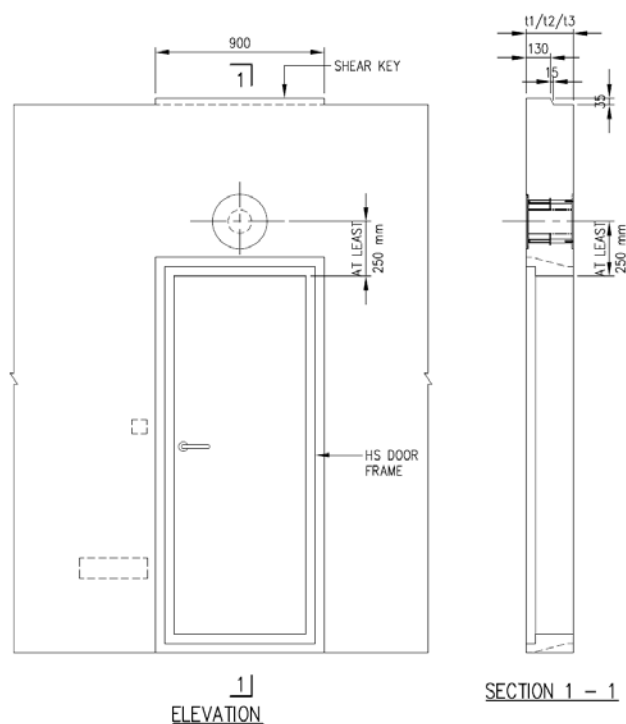


FIGURE 8: SHEAR KEY FORMED ON WALL ABOVE HS DOOR

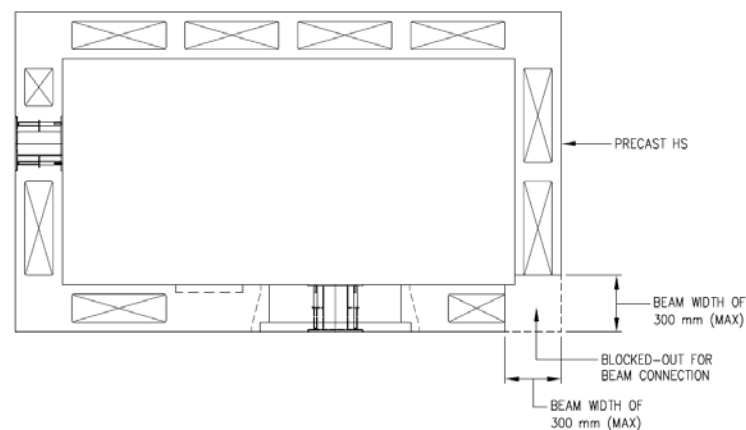


FIGURE 9: BLOCKED-OUT AT PRECAST HS FOR BEAM CONNECTION

NOTES:

1. FOR ILLUSTRATION, SIZE AND ARRANGEMENT OF HOLLOW CORES SHOWN ARE INDICATIVE ONLY.
2. FOR BEAM WITH MORE THAN ONE SUPPORTS, ONE END OF THE BEAM THAT IS SUPPORTED ON THE HS WALL SHALL BE DESIGNED AND DETAILED AS SIMPLY SUPPORT.

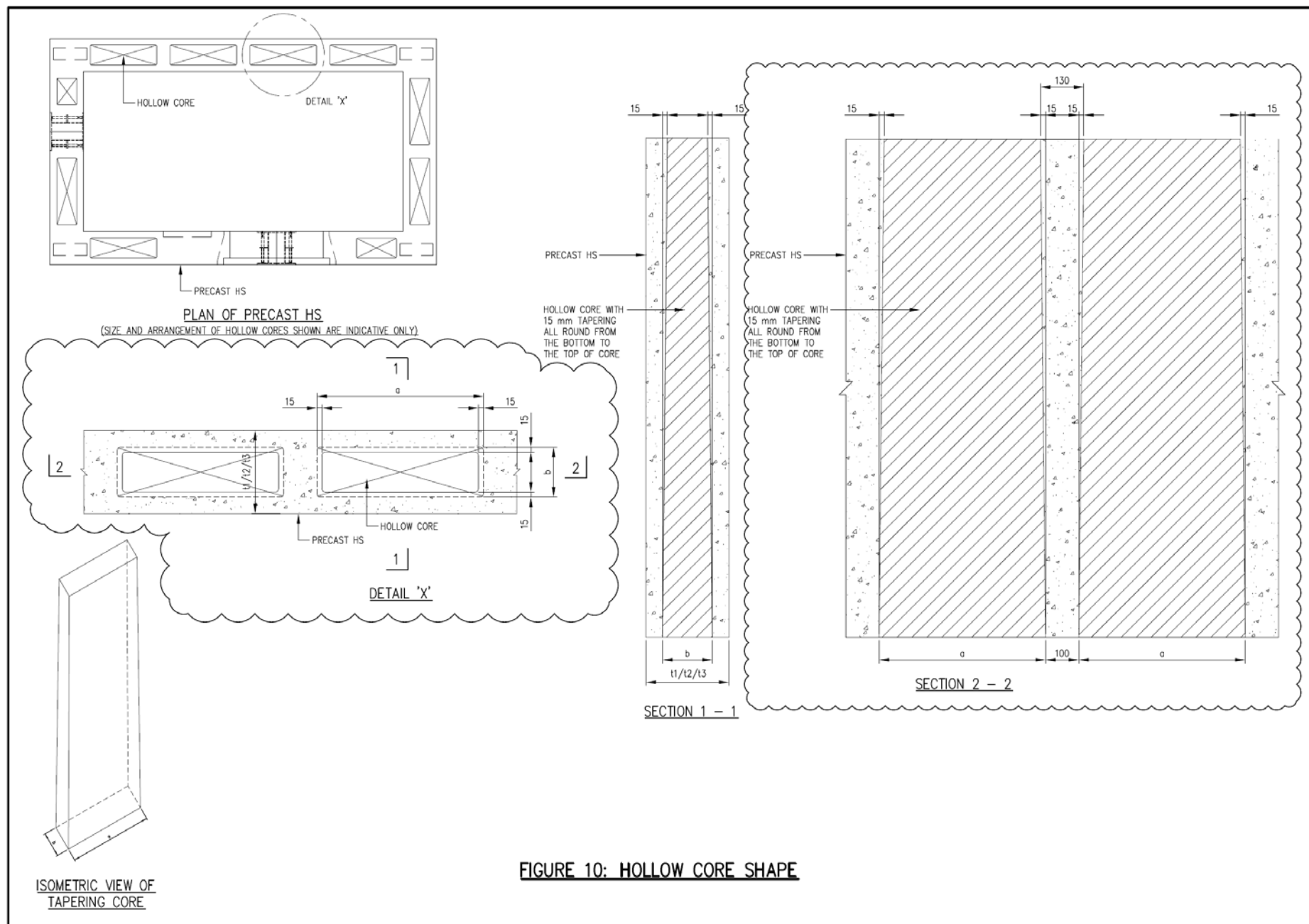
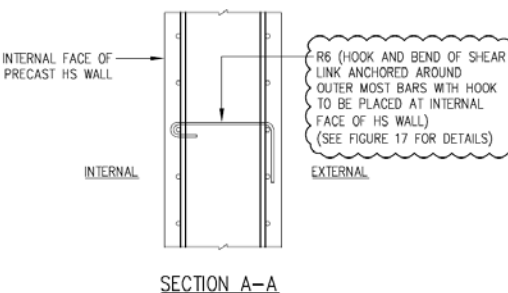
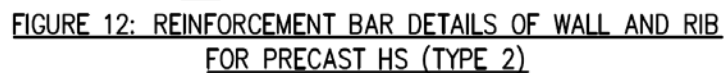


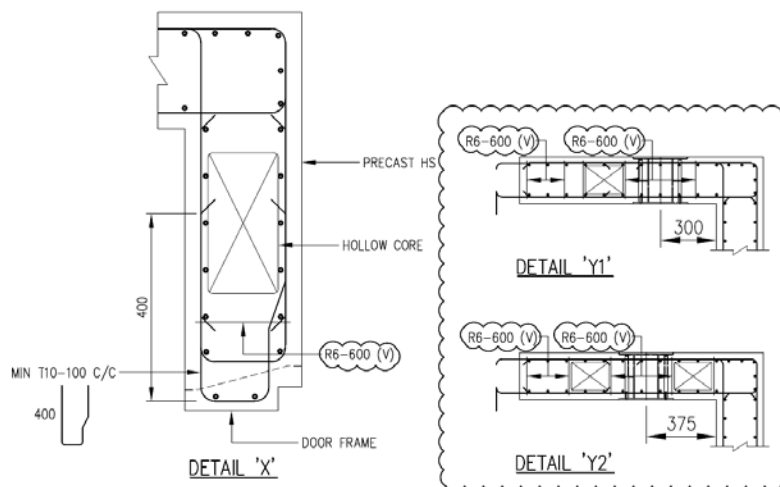
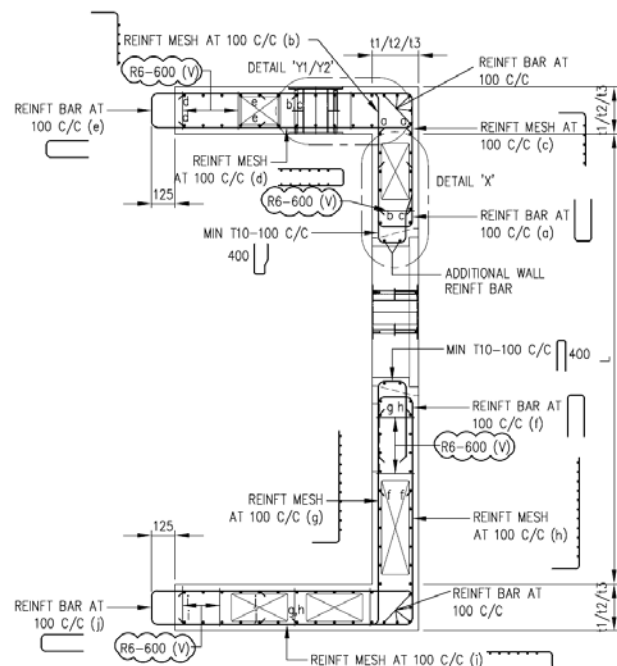
FIGURE 10: HOLLOW CORE SHAPE



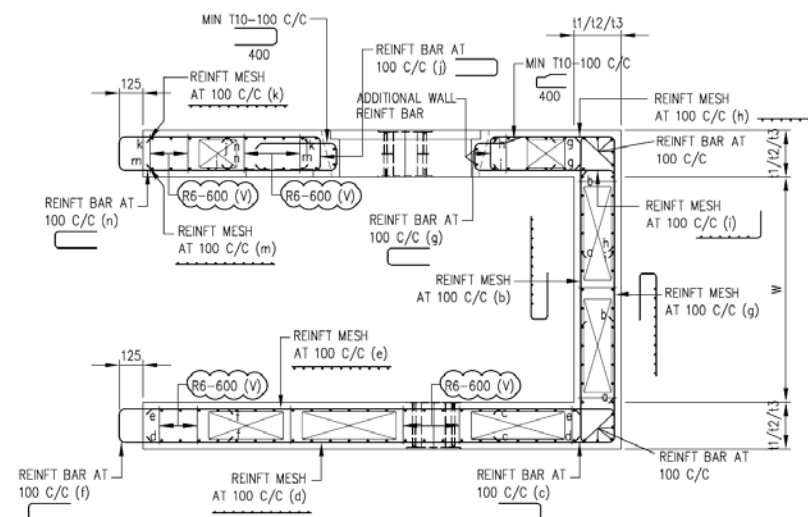
**FIGURE 11A: PLAN AND SECTION
OF RIB WITH SHEAR LINKS**

1. MINIMUM BAR SIZE OF WELDED STEEL FABRIC MESH AND HOT-ROLLED STEEL BARS FOR HOUSEHOLD SHELTER WALL AND SLAB SHALL BE PROVIDED IN COMPLIANCE WITH TECHNICAL REQUIREMENT FOR HOUSEHOLD SHELTERS.
2. MINIMUM BAR SIZE IN THE HOLLOW CORE OF PRECAST HOUSEHOLD SHELTER SHALL BE AS SHOWN IN TABLE C AND D OF THIS SET OF PLANS.
3. THE SPACING OF ALL REINFORCEMENT BARS FOR WALL OR SLAB SHALL BE MAXIMUM 100 mm IN BOTH DIRECTIONS.
4. ALL REINFORCEMENT BARS FOR WALL AND SLAB SHALL BE WITH TENSION LAP AND ANCHORAGE LENGTH.
5. THE MINIMUM CONCRETE GRADE SHALL BE 30N/mm².
6. THE MAXIMUM CONCRETE COVER SHALL BE 40 mm.
7. SHEAR LINK WITH HOOK AND BEND SHALL BE PLACED NOT MORE THAN 600 mm.
8. THE HOOK OF SHEAR LINK SHALL BE PLACED AT THE INTERNAL FACE OF HOUSEHOLD SHELTER WALL (SEE FIGURE 11A) AND BOTTOM FACE OF SLAB (SEE FIGURE 26).
9. THE HOOK AND BEND OF SHEAR LINK MUST BE ANCHORED OVER THE OUTER MOST REINFORCEMENT BARS OF HOUSEHOLD SHELTER WALL AND SLAB.
10. 6R6 SHEAR LINK SPACED AT 100 mm SHALL BE PROVIDED AT BOTTOM AND TOP PART OF THE RIB BETWEEN TWO HOLLOW CORES OF PRECAST HOUSEHOLD SHELTER (SEE FIGURE 17).
11. THE LIFTING DEVICES FOR HANDLING PRECAST HOUSEHOLD SHELTERS SHALL BE DESIGNED WITH ADEQUATE SAFETY FACTORS BY PROFESSIONAL ENGINEERS.

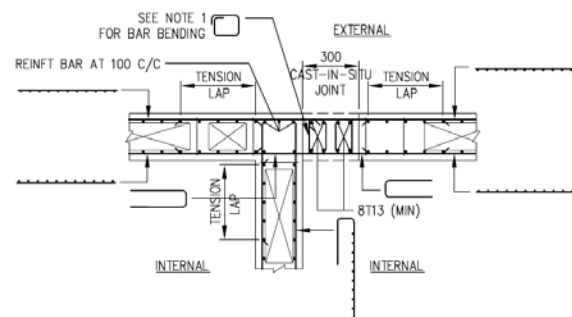




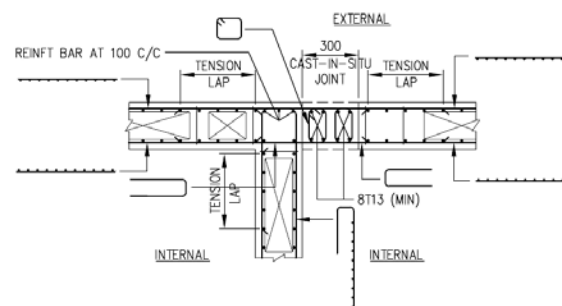
**FIGURE 13: REINFORCEMENT BAR DETAILS OF WALL AND RIB
FOR C-SHAPED PRECAST HS (TYPE 5)**



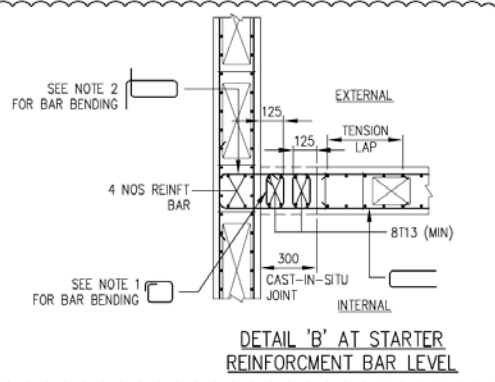
**FIGURE 14: REINFORCEMENT BAR DETAILS OF WALL AND RIB
FOR C-SHAPED PRECAST HS (TYPE 6)**



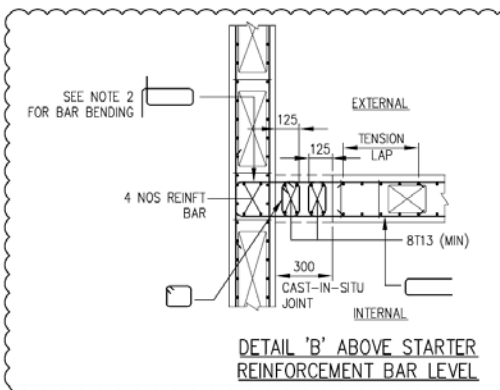
DETAIL 'A' AT STARTER
REINFORCEMENT BAR LEVEL



DETAIL 'A' ABOVE STARTER
REINFORCEMENT BAR LEVEL

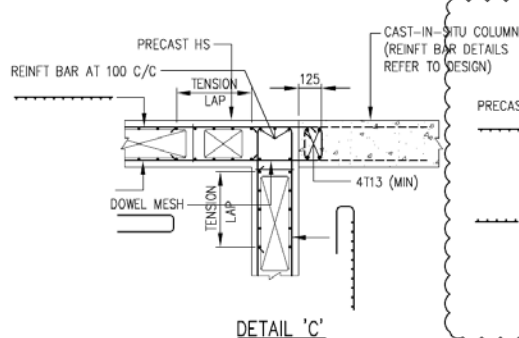


DETAIL 'B' AT STARTER
REINFORCEMENT BAR LEVEL

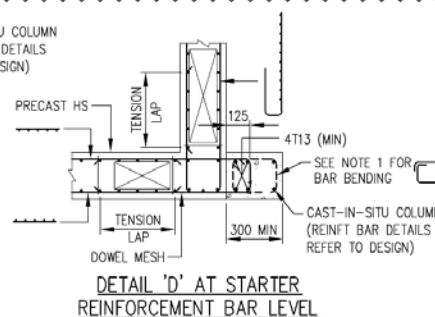


DETAIL 'B' ABOVE STARTER
REINFORCEMENT BAR LEVEL

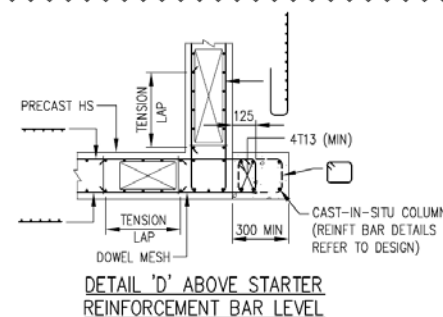
FIGURE 15: CONNECTION DETAILS BETWEEN TWO PRECAST HS



DETAIL 'C'



DETAIL 'D' AT STARTER
REINFORCEMENT BAR LEVEL

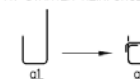


DETAIL 'D' ABOVE STARTER
REINFORCEMENT BAR LEVEL

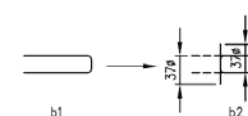
FIGURE 16: CONNECTION DETAILS BETWEEN PRECAST HS AND CAST-IN-SITU WALL/COLUMN

NOTES:

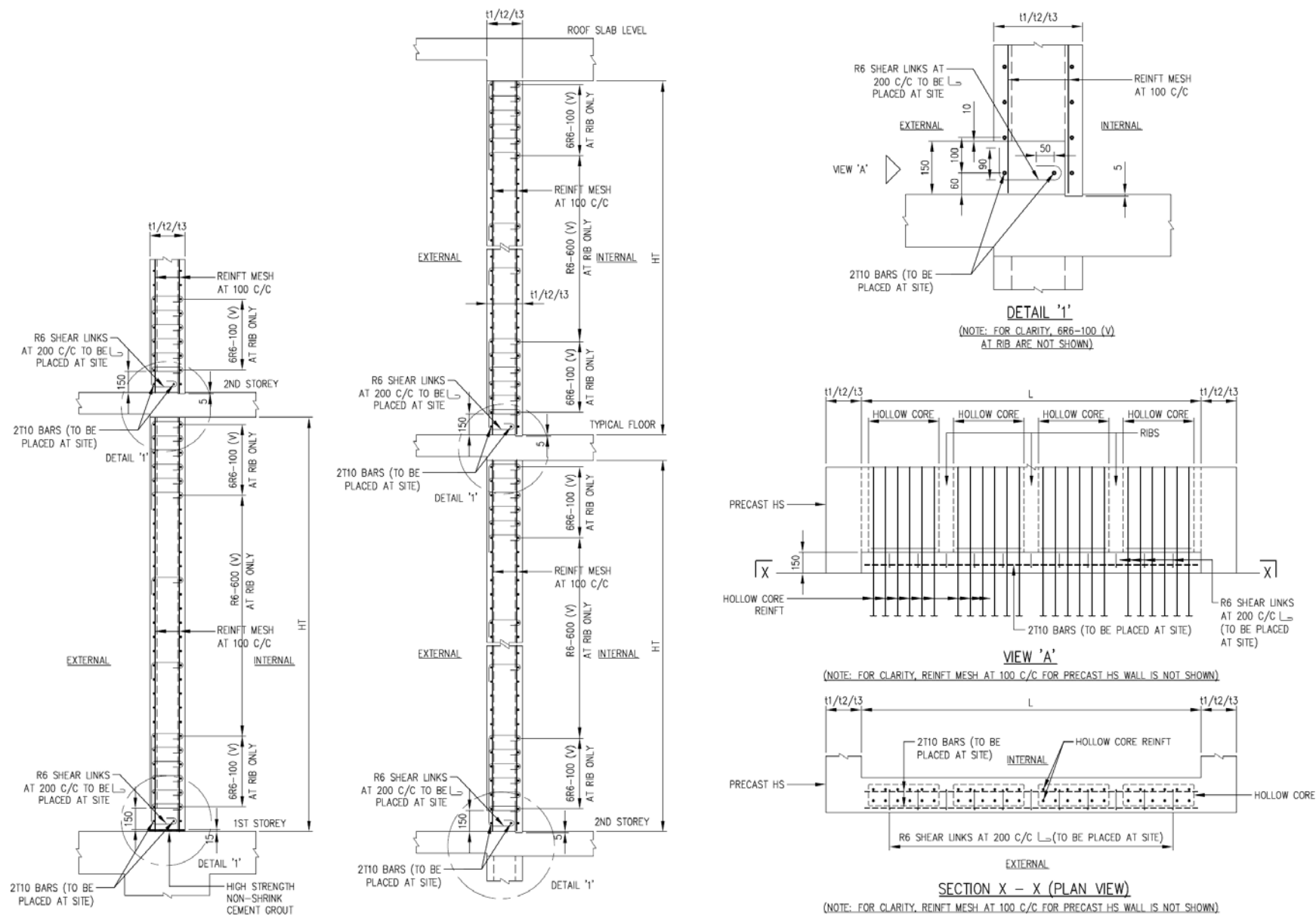
1. PRE-BENT J-SHAPE BARS (a1) SHALL BE BENT AT SITE TO FORM A CLOSE LINK (a2) AS SHOWN IN DETAIL 'A' AT STARTER REINFORCEMENT BAR LEVEL.



2. PRE-BENT U-SHAPE BARS (b1) SHALL BE BENT TO FORM PROJECTED LOOP BARS (b2) WITH ANCHORAGE LENGTH AS SHOWN IN DETAIL 'B'.



3. MINIMUM BAR SIZE OF THE LINK SHALL BE THE SAME AS THE WALL REINFORCEMENT OF THE HS.



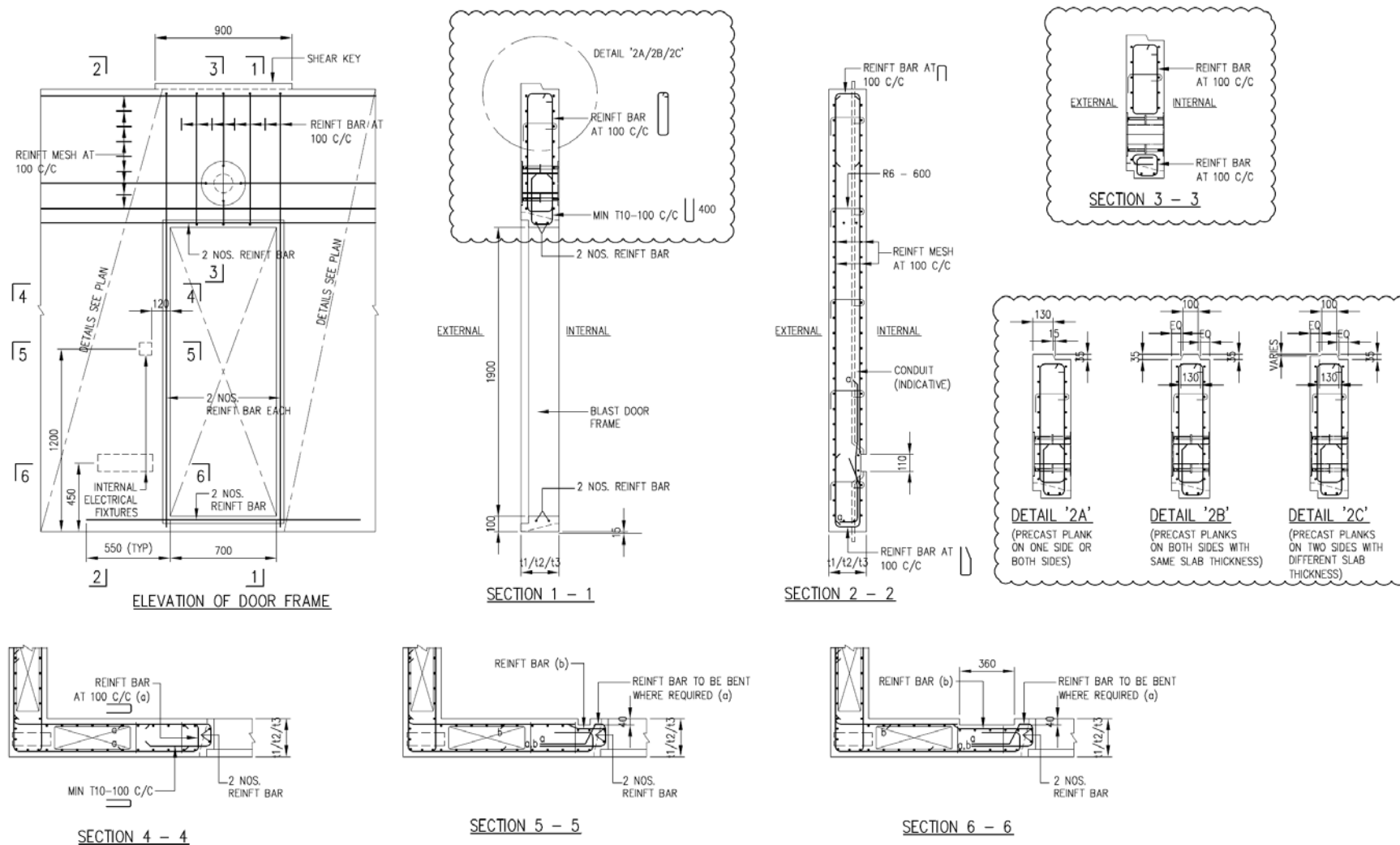


FIGURE 18: DETAILS OF REINFORCEMENT BARS NEAR DOOR FRAME AND AT ELECTRICAL FIXTURES ON INTERNAL FACE OF PRECAST HS

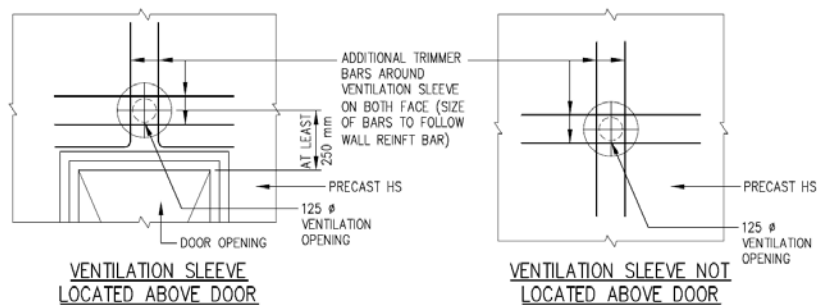


FIGURE 19: DETAILS OF TRIMMER BARS FOR VENTILATION SLEEVE

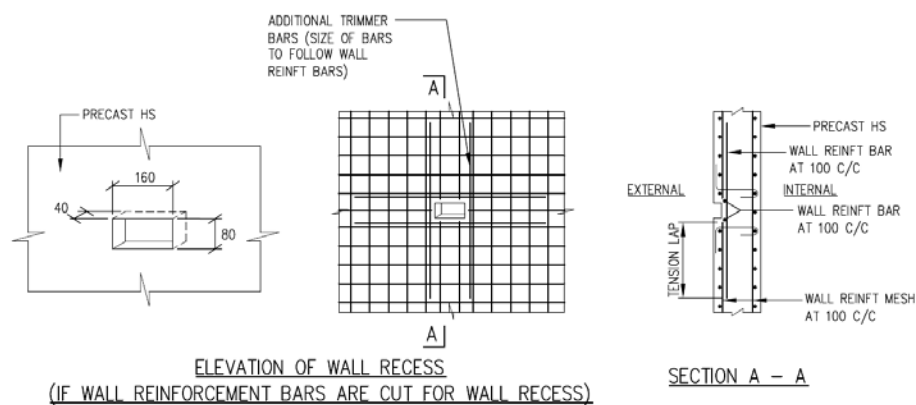
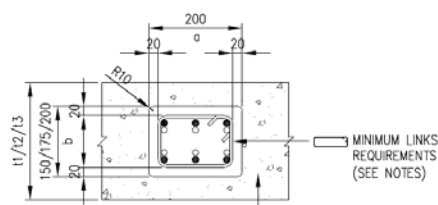
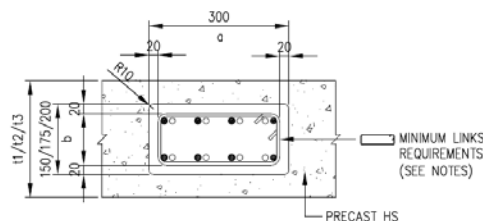


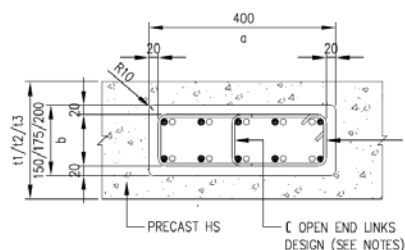
FIGURE 20: DETAILS OF TRIMMER BARS FOR WALL RECESS FOR HS DOOR HANDLE



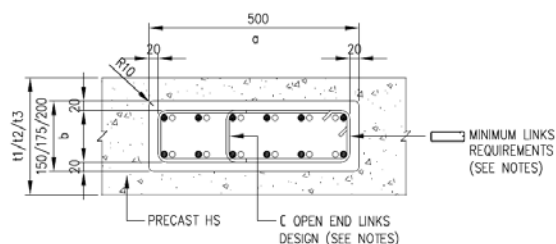
CAGE 1: 200 (a) X 150/175/200 (b)



CAGE 2: 300 (a) X 150/175/200 (b)



CAGE 3: 400 (a) X 150/200/175 (b)



CAGE 4: 500 (a) X 150/175/200 (b)

FIGURE 21: CAGE REINFORCEMENT BARS IN HOLLOW CORES**TABLE C: SIZE OF HOLLOW CORES**

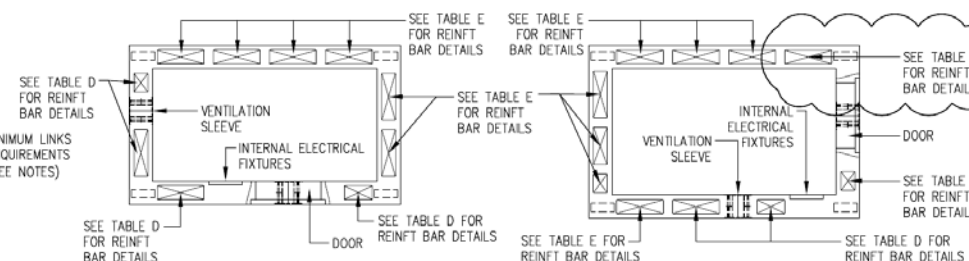
PRECAST HS THICKNESS (mm)	SIZE OF HOLLOW CORE	
	b (mm)	a (mm)
t1 (250)	150	200
		300
		400
		500
t2 (275)	175	200
		300
		400
		500
t3 (300)	200	200
		300
		400
		500

TABLE D: MINIMUM REINFORCEMENT BARS IN HOLLOW CORES 'WITH' ADJACENT VENTILATION SLEEVE, DOOR AND INTERNAL ELECTRICAL FIXTURES

PRECAST HS THICKNESS (mm)	SIZE OF HOLLOW CORE	HS CLEAR HT $\leq$ 3000mm	3000mm < HS CLEAR HT $\leq$ 3900mm
b (mm)	a (mm)		
t1 (250) t2 (275) t3 (300)	200	6T16	6T20
	300	8T16	8T20
	400	10T16	10T20
	500	12T16	12T20

TABLE E: MINIMUM REINFORCEMENT BARS IN HOLLOW CORES 'WITHOUT' ADJACENT VENTILATION SLEEVE, DOOR AND INTERNAL ELECTRICAL FIXTURES

PRECAST HS THICKNESS (mm)	SIZE OF HOLLOW CORE	HS CLEAR HT $\leq$ 3000mm	3000mm < HS CLEAR HT $\leq$ 3900mm
b (mm)	a (mm)		
t1 (250) t2 (275) t3 (300)	200	6T13	6T16
	300	8T13	8T16
	400	10T13	10T16
	500	12T13	12T16

**FIGURE 22: REINFORCEMENT BARS IN HOLLOW CORES OF PRECAST HS WITH AND WITHOUT ADJACENT VENTILATION SLEEVE, DOOR AND INTERNAL ELECTRICAL FIXTURES****NOTES:**

1. DETAILS BELOW SHOW CAGE REINFORCEMENT BARS IN HOLLOW CORES AT LAPPING LEVEL.

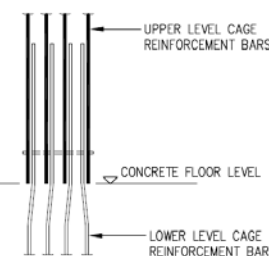


2. DENOTES UPPER LEVEL CAGE



DENOTES CRANKED BARS OF LOWER LEVEL CAGE

3. CAGE REINFORCEMENT BARS SHALL BE ERECTED WITH THE CRANKED PORTION OF THE MAIN BARS AT THE TOP LEVEL FOR LAPPING.



4. THERE IS ONLY ONE ARRANGEMENT OF CAGE REINFORCEMENT BARS PER CORE SIZE.

5. OPEN END LINKS SHALL BE PROVIDED FOR MAIN BARS WHICH ARE LOCATED 150 mm AWAY FROM RESTRAINT BARS (SEE CAGE 3 AND CAGE 4 DETAILS).

6. THE CONCRETE GRADE IN HOLLOW CORE MUST BE AT LEAST THE SAME AS THE CONCRETE GRADE OF PRECAST HS WALL.

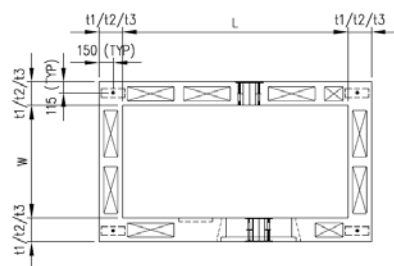
7. BIGGER REINFORCEMENT BAR SIZE SHALL BE USED FOR HOLLOW CORE ADJACENT TO VENTILATION SLEEVE, DOOR AND INTERNAL ELECTRICAL FIXTURES (SEE FIGURE 22 AND TABLE D).

8. MINIMUM LINKS FOR CAGE REINFORCEMENT BARS ARE: LINKS FOR T13 CORE CAGE TO BE R6-500 (MAX) LINKS FOR T16 CORE CAGE TO BE R6-250 (MAX) LINKS FOR T20 CORE CAGE TO BE R6-250 (MAX)

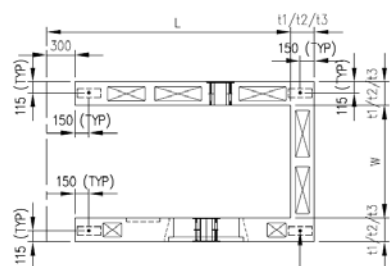
9. WHERE STRUCTURAL DESIGN REQUIRES BIGGER BAR SIZES OF T25, T28 AND T32 THE MINIMUM CAGE REINFORCEMENT BAR SHALL BE AS FOLLOWS: LINKS FOR T25 CORE CAGE TO BE R8-400 (MAX) LINKS FOR T28 CORE CAGE TO BE R8-400 (MAX) LINKS FOR T32 CORE CAGE TO BE R8-400 (MAX)

10. IF BAR SIZE REQUIRED ARE BIGGER THAN THOSE IN THE REQUIREMENTS FOR CASE 1 TO 4 OF HOLLOW CORE, THE NUMBER OF BARS SHALL REMAIN THE SAME AND CLEAR SPACING BETWEEN BARS SHALL NOT BE MORE THAN 100mm





REFERENCE PLAN FOR 1ST PRECAST HS
(SIZE AND ARRANGEMENT OF CORES SHOWN IS INDICATIVE ONLY)



SPLICE SLEEVE AT SOFFIT OF
1ST PRECAST HS (TYPICAL)
- SEE ELEVATION

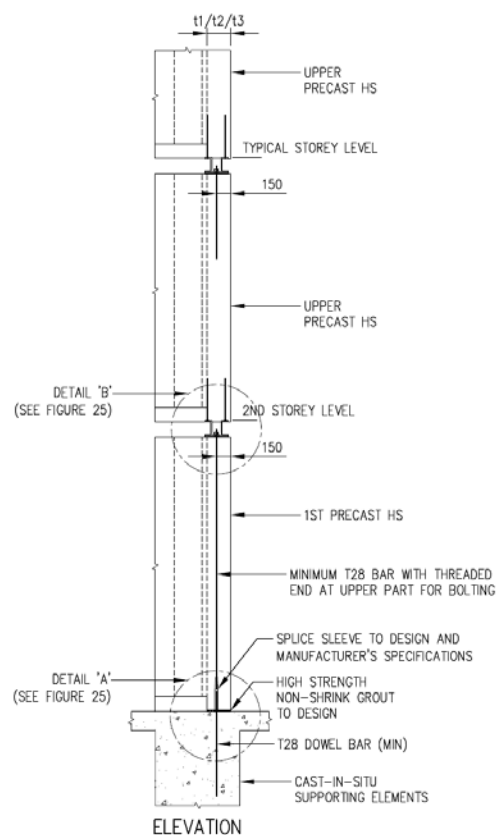


FIGURE 24: SPLICE SLEEVE CONNECTION DETAILS BETWEEN
PRECAST HS AND CAST-IN-SITU ELEMENT AND BOLT
CONNECTION DETAILS BETWEEN TWO PRECAST HS

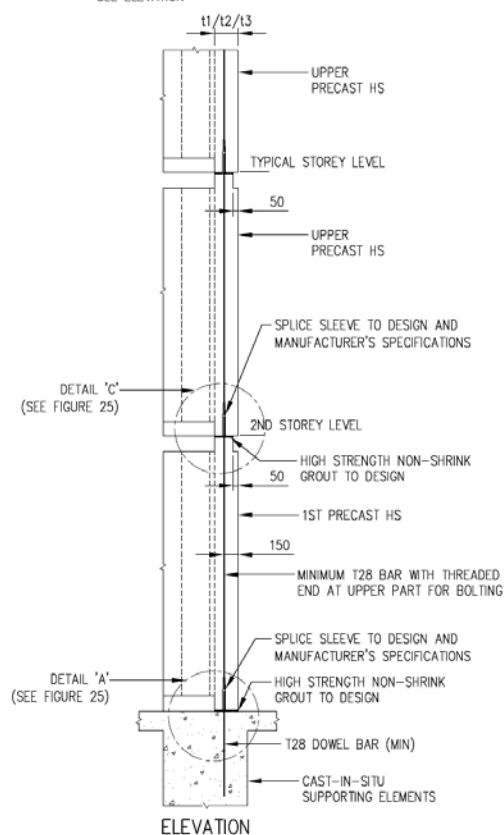


FIGURE 24A: SPLICE SLEEVE CONNECTION DETAILS
FOR PRECAST HS TOWER

NOTES:

1. THE 1ST OR LOWEST PRECAST HOUSEHOLD SHELTER MUST BE CONNECTED BY SPLICE SLEEVE (DETAIL A, FIGURE 25) AT 4 CORNERS OF SHELTER WALL. MINIMUM T28 LOWER DOWEL BAR FOR SPLICE SLEEVE SHALL BE CAST IN THE CAST-IN-SITU SUPPORTING ELEMENTS (WALL, COLUMN, BEAM, TRANSFERRED STRUCTURES OR FOUNDATION).
2. THE UPPER PRECAST HOUSEHOLD SHELTERS SHALL BE JOINED BY BOLT CONNECTION (SEE FIGURE 24, DETAIL A, DETAIL B, SECTION 1-1 AND 2-2) AT THEIR 4 CORNERS OF SHELTER WALL.
3. ALTERNATIVELY, SPLICE SLEEVE CONNECTION CAN BE USED FOR PRECAST HS TOWER (SEE FIGURE 24A, DETAIL A, DETAIL C AND SECTION 3-3).
4. HOT ROLLED STEEL SECTION OR PLATE SHALL BE OF GRADE 43 (MIN).
5. T28 BARS REQUIRED FOR THESE TWO TYPES OF CONNECTION SHALL BE PROPERLY SECURED IN POSITION AT 4 TOP CORNERS OF LOWER PRECAST HOUSEHOLD SHELTER WALL WITH TEMPLATE SUCH THAT THEY ARE ALIGNED WITH THE BOLT HOLES OR SPLICE SLEEVE PROVIDED AT THE BASE OR LOWER PART OF THE UPPER PRECAST HOUSEHOLD SHELTER RESPECTIVELY.

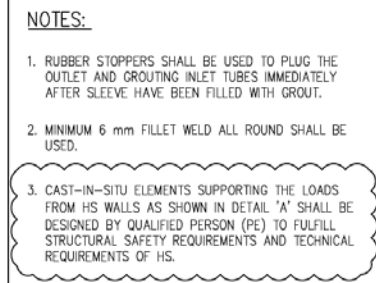
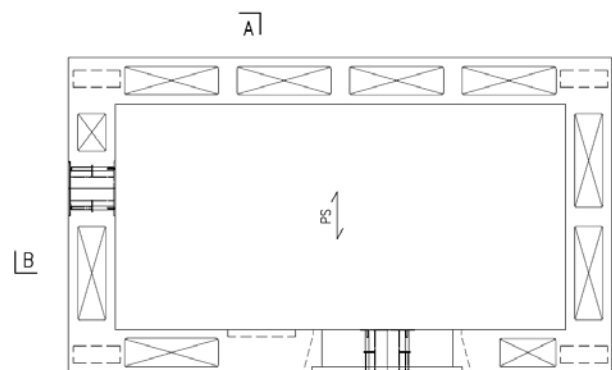
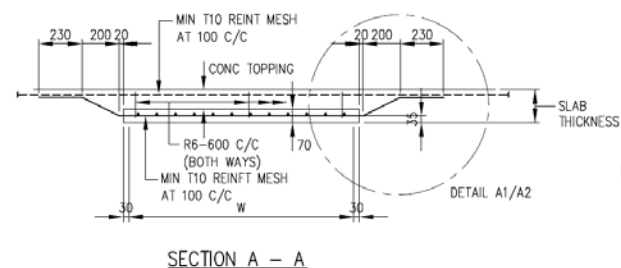


FIGURE 25: CONNECTION DETAILS BETWEEN LOWER AND UPPER PRECAST HS



A]
PLAN OF PRECAST PLANK
(SIZE AND ARRANGEMENT OF CORES SHOWN IS INDICATIVE ONLY)

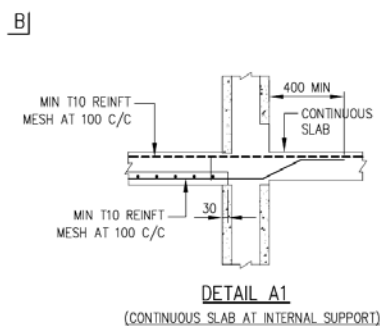


SECTION B - B

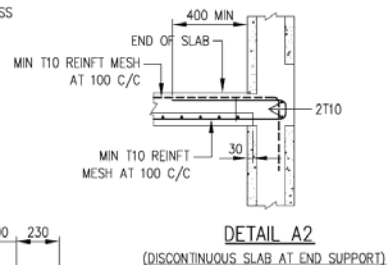
FIGURE 26: DETAILS OF PRECAST PLANK (MARKED AS PS) AND CONCRETE TOPPING

TABLE E: THICKNESS OF SLAB AND CONCRETE TOPPING

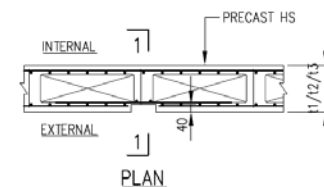
FLOOR TYPE	MIN SLAB THICKNESS	PS THICKNESS	CONCRETE TOPPING
HS ROOF SLAB	300 mm	70 mm	MIN 230 mm
HS INTERMEDIATE SLAB	175 mm	70 mm	MIN 105 mm



DETAIL A1
(CONTINUOUS SLAB AT INTERNAL SUPPORT)



DETAIL A2
(DISCONTINUOUS SLAB AT END SUPPORT)



PLAN

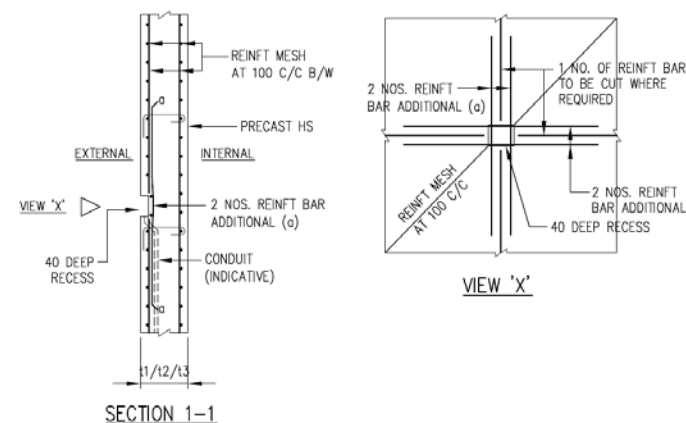
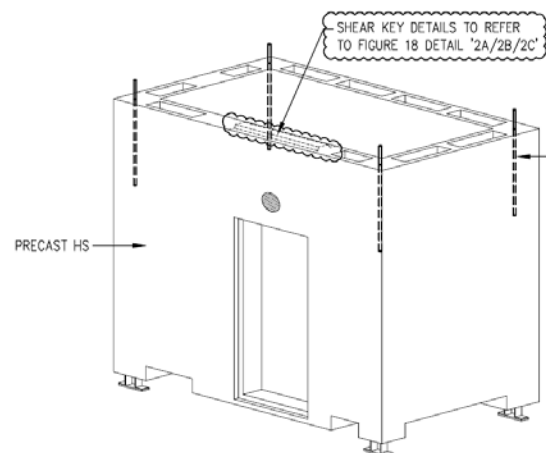
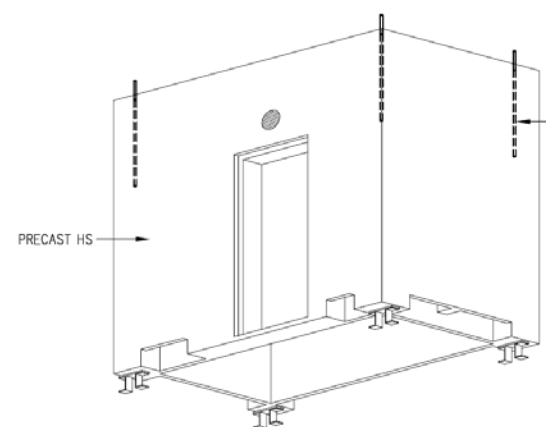


FIGURE 27: ELECTRICAL FIXTURES ON EXTERNAL FACE OF PRECAST HS



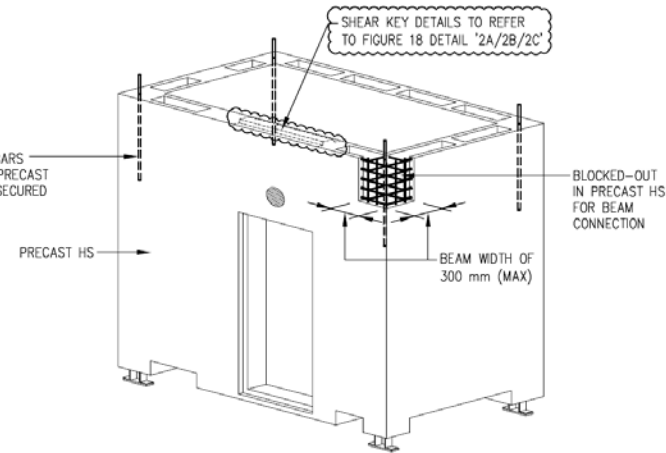
ISOMETRIC VIEW FROM TOP



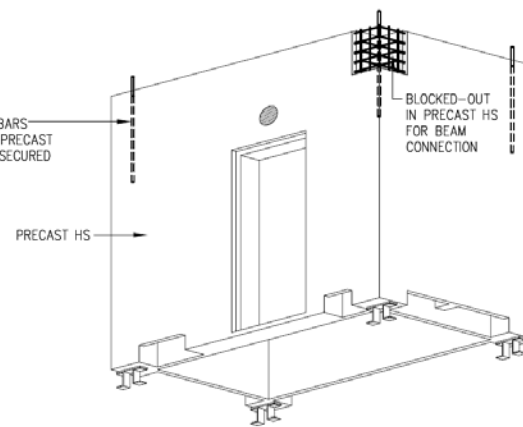
ISOMETRIC VIEW FROM BOTTOM

FIGURE 28: ISOMETRIC VIEW OF PRECAST HS WITH BOLTS AND STEEL PLATE CONNECTION (WITHOUT BLOCKED-OUT FOR BEAM)

(FOR ILLUSTRATION, SIZE AND ARRANGEMENT OF HOLLOW CORES SHOWN ARE INDICATIVE ONLY)



ISOMETRIC VIEW FROM TOP



ISOMETRIC VIEW FROM BOTTOM

FIGURE 29: ISOMETRIC VIEW OF PRECAST HS WITH BOLTS AND STEEL PLATE CONNECTION (WITH BLOCKED-OUT FOR BEAM)

(FOR ILLUSTRATION, SIZE AND ARRANGEMENT OF HOLLOW CORES SHOWN ARE INDICATIVE ONLY)

NOTES:

1. WHERE TOP CORNER OF PRECAST HOUSEHOLD SHELTER IS BLOCKED-OUT FOR IN-SITU BEAM, THE EXPOSED CAST-IN T28 DOWEL BAR WITH THREADED END SHALL BE SECURED BY A TEMPLATE SO AS TO ALIGN IT WITH BOLT HOLES PROVIDED IN THE CONNECTION PLATE AT THE BASE OF THE UPPER PRECAST HOUSEHOLD SHELTER. THIS IS ESSENTIAL FOR EASE OF INSTALLING THE UPPER HOUSEHOLD SHELTER.

