

Our Ref: CD/FSSD/12/02/03/01

Date: 29 September 2017

Registrar, Board of Architects
Registrar, Professional Engineers Board
President, Singapore Institute of Architects
President, Institution of Engineers, Singapore
President, Association of Consulting Engineers, Singapore

Dear Sir/Madam

AMENDMENTS/INSERTIONS TO TECHNICAL REQUIREMENTS FOR STOREY SHELTERS 2015

In pursuant to Section 14 of the Civil Defence Shelter Act (CDSA)¹, this circular is to notify building industry of the amendments/insertions to Technical Requirements for Storey Shelters 2015. The changes are as follows:

(a) Permissible Variation to Technical Requirements for Storey Shelters 2015 – Technical Requirements for Design and Construction of Precast Hollow Core Staircase Storey Shelters 2017

2. In view of the increasing trend towards the use of Prefabricated Prefinished Volumetric Construction (PPVC) method in residential development projects, SCDF and BCA have jointly developed the “Technical Requirements for Design and Construction of Precast Hollow Core Staircase Storey Shelter (SSS) 2017” (refer to Annex A). This is aimed at guiding the industry in the use and design of precast SSS in PPVC projects so as to raise construction quality and productivity of staircase storey shelters as well as PPVC projects as a whole.

¹ Specifications for construction of shelters

14. The Commissioner may –

- (a) issue or approve and, from time to time, review and amend the specifications, technical codes and standards relating to the design, construction and maintenance of shelters to be provided under this Act and the equipment to be installed therein.



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(b) Updating of Structural Requirements (Chapter 3 of SSTR 2015) to comply with Eurocode

3. In addition, Chapter 3 of the “Technical Requirements for Storey Shelters 2015” is revised to align with the adoption of the Eurocode by the industry. Among others, these revisions include specification of minimum concrete grade of C32/40, minimum yield stress of steel reinforcement bars of 500 N/mm², minimum and maximum concrete cover of 25mm and 40mm respectively, minimum full tension lap and anchorage length, minimum reinforcement bar requirement for SSS wall and slab, etc. These are highlighted in red text (refer to Annex B).

4. The above-mentioned revisions shall take immediate effect from the date of this circular.

5. 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/e-info>. For any inquiry or clarification, please contact the undersigned at 6848 1478.

Yours faithfully,

(transmitted via e-mail)

MAJ Andy Tan
Fire Safety & Shelter Department
for Commissioner
Singapore Civil Defence Force



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SCDF

The Life Saving Force

SINGAPORE CIVIL DEFENCE FORCE

cc

CEO, BCA
CEO, URA
CEO, HDB
President, IFE
President, SISV
SCDF Fire Safety Standing Committee
Fire Code Review Committee
Shelter Codes Review Committee



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HQ SINGAPORE CIVIL DEFENCE FORCE, 91 UBI AVENUE 4, SINGAPORE 408827
TEL: 6848 1478 FAX: 68481 493 EMAIL: Andy_Tan@scdf.gov.sg

**TECHNICAL REQUIREMENTS
FOR
DESIGN AND CONSTRUCTION
OF
PRECAST HOLLOW CORE
STAIRCASE STOREY SHELTERS (SSS)
2017**

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Appendix 1 to Annex A

Figure 1 to 20

Details of Precast Hollow Core Staircase Storey Shelters

Technical Requirements for Design and Construction of Precast Hollow Core Staircase Storey Shelters (SSS)

A General

1. Precast hollow core staircase storey shelters shall comply with the latest “Technical Requirements for Storey Shelters” unless otherwise specified in this part of technical requirements for precast hollow core staircase storey shelters.

B Material

2. a) Concrete

The minimum grade of concrete shall be C32/40 for precast hollow core SSS including Concrete for hollow core and joints

- b) Steel Reinforcements

The minimum yield stress of steel reinforcements and shear links in structural elements forming the precast hollow cores SSS shall be 500 N/mm².

C Dimensions of Precast Hollow Core Staircase Storey Shelters

3. Precast hollow core staircase storey shelter (hereafter known as precast SSS) shall be designed to meet the shelter area and volume requirements. The internal length and width of the precast SSS walls shall be modular with an increment of 100mm or 50mm respectively. Precast SSS comprises 3 parts as shown in Figure 1 and 2. Precast SSS, including the dimensions and spacing of modular hollow cores (See Table A & B of Annex A), ventilation sleeves, blast door, blast hatch and electrical fixtures are shown in Figure 1 to 3:

- a) Figure 1: Plan of 3 Volumetric Components of Precast SSS

- b) Figure 2: Internal Elevation View ‘A’ of 3 Volumetric Components of Precast SSS

- c) Figure 3: Blast Door and Ventilation Sleeve

4. To facilitate de-moulding of the precast SSS, the hollow cores shall be tapered all round along its height as shown in Figure 4.

- a) Figure 4: Hollow Core Shape

5. Where possible, hollow core of maximum 500mm long shall be adopted to achieve lighter precast SSS components for ease of handling and achievement of maximum vertical continuity.

D Reinforcement Requirements

6. The reinforcements of precast SSS shall be welded steel fabric mesh and hot rolled steel bars. Reinforcements specified for precast slab components, walls and hollow cores of the precast SSS refer to minimum bar diameters and maximum spacing in both directions.
7. In the precast SSS walls, reinforcements shall be welded steel fabric mesh of minimum H13 at 100mm c/c spacing or minimum H16 at 100mm c/c spacing depending on the clear height of staircase storey shelter as given in the “Technical Requirements for Storey Shelters”.
8. The details of reinforcements for precast SSS, the rib of precast SSS, connection between precast SSS components, SSS door frame, blast hatch, electrical fixtures, trimmer bars around ventilation sleeve openings, at door recess and hollow cores are shown in Figure 5 to 15:
 - a) Figure 5A: Plan of Precast SSS (Component ‘A’)
 - b) Figure 5B: Plan of Precast SSS Wall with Reinforcement Details at Blast Hatch Opening (SSS Component ‘A’)
 - c) Figure 5C: Plan of Precast SSS Wall with Reinforcement Details above Blast Hatch Opening (SSS Component ‘A’)
 - d) Figure 5D: Section D-D (SSS Component ‘A’)
 - e) Figure 5E: Section E-E (SSS Component ‘A’)
 - f) Figure 5F: Section F-F (SSS Component ‘A’)
 - g) Figure 5G: Section G-G (SSS Component ‘A’)
 - h) Figure 5H: Section H-H (SSS Component ‘A’)
 - i) Figure 6A: Plan of Precast (SSS Component ‘B’)
 - j) Figure 6B: Plan of Precast SSS Wall with Reinforcement Details (SSS Component ‘B’)
 - k) Figure 6C: Internal Elevation View ‘B’ (SSS Component ‘B’)
 - l) Figure 6D: Section K1-K1 (SSS Component ‘B’)
 - m) Figure 6E: Section K2-K2 (SSS Component ‘B’)
 - n) Figure 6F: Section L-L (SSS Component ‘B’)
 - o) Figure 7A: Plan of Precast SSS (Component ‘C’)

- p) Figure 7B: Plan of Precast SSS Wall with Reinforcement Details (SSS Component 'C')
 - q) Figure 7C: Section S-S (SSS Component 'C')
 - r) Figure 7D: Section T-T (SSS Component 'C')
 - s) Figure 7E: Section U-U at Ventilation Sleeve (SSS Component 'C')
 - t) Figure 7F: Section X-X at Ventilation Sleeve (SSS Component 'C')
 - u) Figure 7G: Section V-V (SSS Component 'C')
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 - w) Figure 8: Reinforcement details of Rib
 - x) Figure 9: Details of Reinforcements near Door Frame and at Electrical Fixtures on Internal Face of Precast SSS
 - y) Figure 10: Details of Trimmer Bars for Ventilation Sleeve
 - z) Figure 11: Details of Trimmer Bars for Wall Recess for Precast SSS Door Handle
 - aa) Figure 12: Electrical Fixtures on External Face of Precast SSS
 - bb) Figure 13: Reinforcements in Hollow Cores
 - cc) Figure 14: Reinforcements in Hollow Cores of Precast SSS
 - dd) Figure 15: Reinforcements Lapping in Hollow Cores
9. For the rib between two hollow cores of precast SSS, its top and bottom portion shall be provided with closer shear links of at least 6 numbers of H8 at maximum 100mm c/c spacing as shown in Figure 8. For area between these top and bottom portions, minimum shear links of at least H8 at maximum 600mm c/c spacing shall be provided as shown in Figure 8. The hook of the shear links must be anchored around the outermost reinforcements of the internal face of precast SSS wall.
10. The reinforcements for the precast SSS door frame, ventilation sleeves, wall recess for electrical fixtures on internal face of precast SSS wall and wall recess for the external SSS door handle are shown in Figure 10 to 12.
11. The modular length of the hollow cores of precast SSS shall vary between minimum 200mm and maximum 500mm with increment of 100mm whereas the modular width of the hollow cores of precast SSS shall be 165mm and 190mm for SSS wall thickness of 300mm and 325mm respectively as shown in Table C and Figure 13. In these hollow cores, minimum reinforcements and links shall be provided and installed as shown in Table D, Figure 13 and 14. Higher reinforcements and links shall be provided if they are required to meet the structural safety and stability requirements.

12. All reinforcement bars must be designed and detailed with full tension anchorage or lap length. The reinforcements for hollow cores of precast SSS wall shall be cranked at their upper part to facilitate placing of the reinforcements at lapping level as shown in Figure 15.
13. Full lap and anchorage length of reinforcements in SSS walls and slabs shall be provided. The lap length shall take into account good or poor bond condition, steel bar diameter, shape of steel bar, concrete cover, steel strength and location where reinforcement bar laps and confinement of transverse bars. Minimum tension lap and anchorage length of reinforcement bars for minimum concrete grade C32/40 with good bond condition shall be as shown in TABLE 1. Longer tension lap and anchorage length shall be provided if they are required to meet poor bond condition and/or the structural load and safety requirements.

TABLE 1: MINIMUM TENSION LAP AND ANCHORAGE LENGTH

Type	Reinforcement Bar Diameter Ø (mm)	
	$10 \leq \text{Ø} \leq 16$	$16 < \text{Ø} \leq 32$
Tension Lap Length	47Ø	52Ø
Tension Anchorage Length	37Ø	37Ø

E Connection between Precast Hollow Core Staircase Storey Shelters

14. The connection between Precast SSS hollow cores are shown in Figure 16 to 18:
 - a) Figure 16: Splice Sleeve Connection Details between Precast SSS and Cast In-Situ Element and Bolt Connection Details between Two Precast SSS
 - b) Figure 17: Splice Sleeve Connection Details for Precast SSS Tower
 - c) Figure 18: Connection Details between Lower and Upper Precast SSS
15. Where precast SSS is supported on cast in-situ elements (beam or wall), H28 dowel bars shall be cast in the in-situ elements for bolt and steel plate connection or splice sleeve connection between the precast SSS and the cast in-situ elements. These dowel bars must be properly secured in position with temporary template such that they are in line with bolt hole or splice sleeve of the upper precast SSS hollow core as shown in Figure 16 to 18. In case of the splice sleeve, it shall be pressure-grouted with minimum Grade 70 N/mm² grout to design and manufacturer's specification.
16. The lower and upper precast SSS can be connected by bolt and steel plate connection or splice sleeve connection as shown in Figure 18. To facilitate installation, H28 bars required for these two types of connection shall be properly secured in position at 4 top corners or other locations (if any) of lower precast SSS wall with a temporary template such that they are aligned with the bolt holes or splice sleeve provided at the base or lower part of the upper precast SSS respectively.

F Precast Slab

17. 90mm thick precast slab is cast as integrated part of the precast SSS component.
18. The minimum reinforcements to be provided for precast slab and structural concrete topping for the slab shall be as shown in Figure 19. The details show the thickness of precast slab and in-situ concrete topping.

Figure 19: Detailed Reinforcements of Precast Slab and Cast In-Situ Concrete Topping

Figure 20: Connection Details between Precast SSS and Cast In-Situ Wall

19. The shear links shall be cast in the precast slab. The hook of the shear links must be anchored around outermost layer of reinforcement bars of the precast slab. The bend of the shear link shall be anchored round the outermost layer of reinforcement bars in the concrete topping.

G External Electrical Fixtures

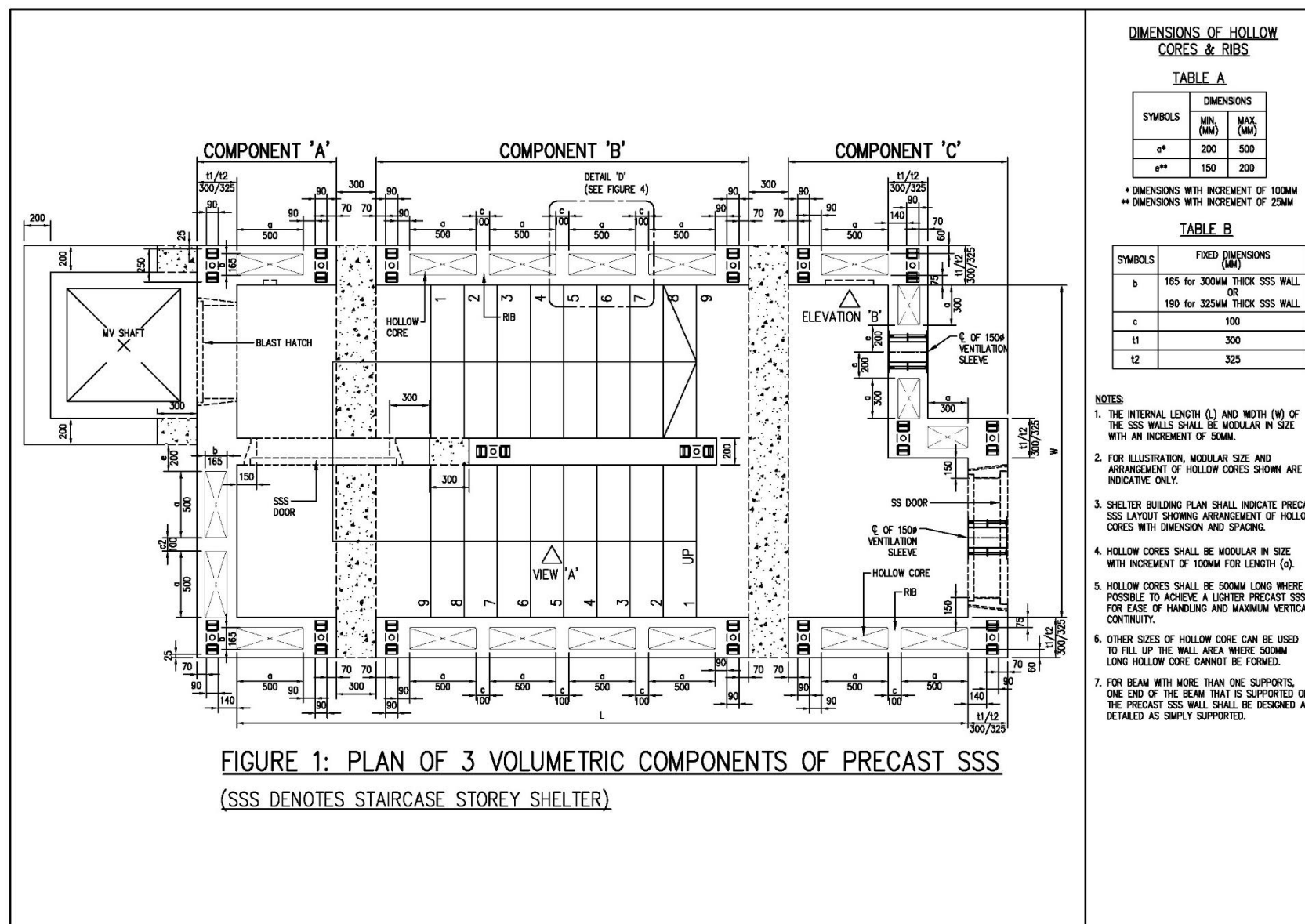
20. Where there are electrical fixtures on external face of SSS precast wall, a recess shall be formed on the rib of the precast SSS wall as shown in Figure 12.

H Ventilation Sleeves

21. One of the two ventilation sleeves shall be located above the precast SSS door at the entrance.
22. Ventilation sleeve shall not be located at the connection joint between two precast SSS walls.

I Door Recess on Precast SSS Wall

23. A recess shall be formed on the external face of the precast SSS wall to accommodate the SSS door handle when the SSS door is open in 180°. The recess shall not be larger than 160mm (length) x 80mm (height) x 40mm (depth). The reinforcement bars for the recess is shown in Figure 11.



DIMENSIONS OF HOLLOW CORES & RIBS

TABLE A

SYMBOLS	DIMENSIONS	
	MIN. (MM)	MAX. (MM)
a*	200	500
a**	150	200

* DIMENSIONS WITH INCREMENT OF 100MM
** DIMENSIONS WITH INCREMENT OF 25MM

TABLE B

SYMBOLS	FIXED DIMENSIONS (MM)
b	165 for 300MM THICK SSS WALL OR 190 for 325MM THICK SSS WALL
c	100
t1	300
t2	325

NOTES:

1. THE INTERNAL LENGTH (L) AND WIDTH (W) OF THE SSS WALLS SHALL BE MODULAR IN SIZE WITH AN INCREMENT OF 50MM.
2. FOR ILLUSTRATION, MODULAR SIZE AND ARRANGEMENT OF HOLLOW CORES SHOWN ARE INDICATIVE ONLY.
3. SHELTER BUILDING PLAN SHALL INDICATE PRECAST SSS LAYOUT SHOWING ARRANGEMENT OF HOLLOW CORES WITH DIMENSION AND SPACING.
4. HOLLOW CORES SHALL BE MODULAR IN SIZE WITH INCREMENT OF 100MM FOR LENGTH (a).
5. HOLLOW CORES SHALL BE 500MM LONG WHERE POSSIBLE TO ACHIEVE A LIGHTER PRECAST SSS FOR EASE OF HANDLING AND MAXIMUM VERTICAL CONTINUITY.
6. OTHER SIZES OF HOLLOW CORE CAN BE USED TO FILL UP THE WALL AREA WHERE 500MM LONG HOLLOW CORE CANNOT BE FORMED.
7. FOR BEAM WITH MORE THAN ONE SUPPORTS, ONE END OF THE BEAM THAT IS SUPPORTED ON THE PRECAST SSS WALL SHALL BE DESIGNED AND DETAILED AS SIMPLY SUPPORTED.

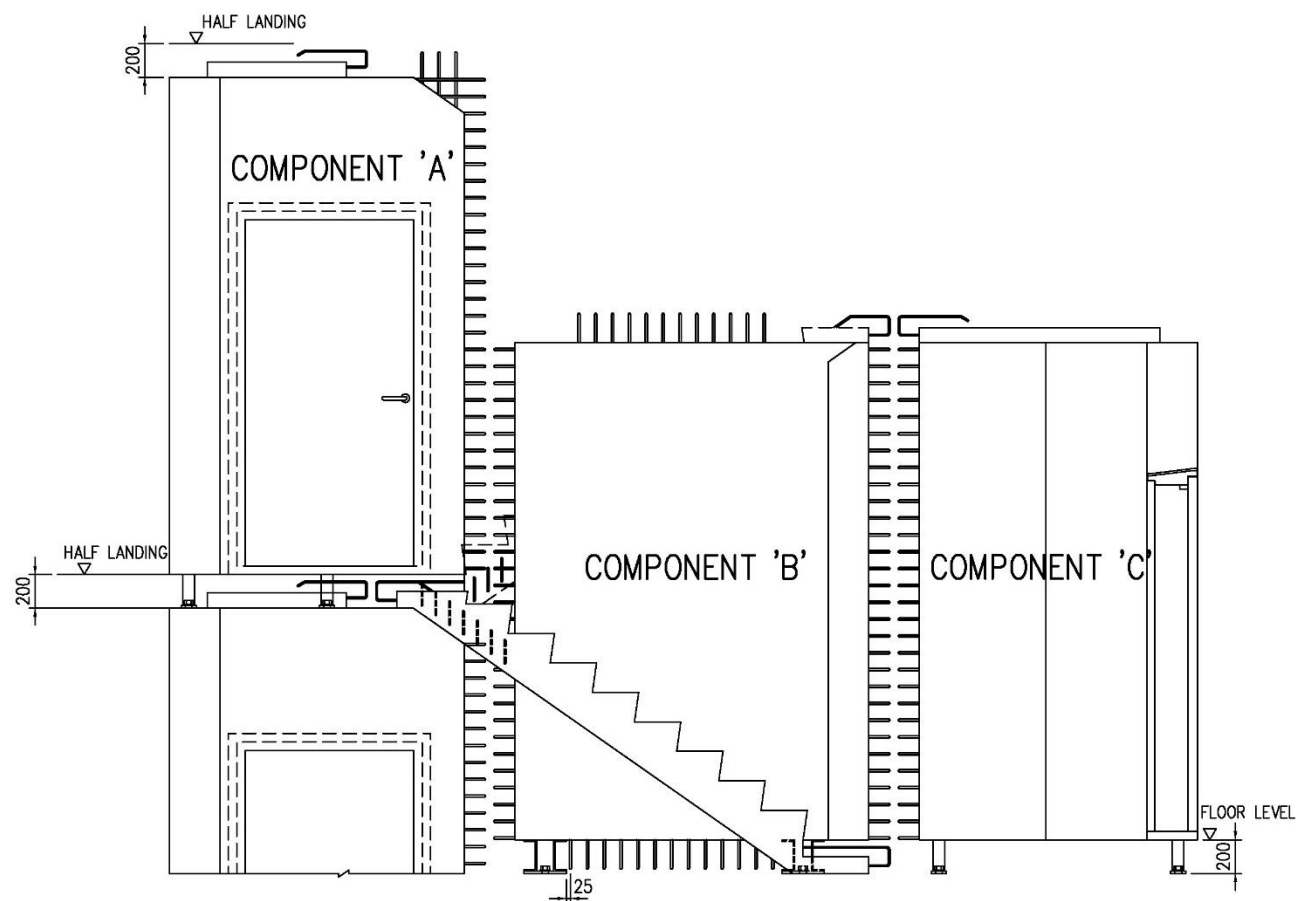


FIGURE 2: INTERNAL ELEVATION VIEW 'A' OF 3 VOLUMETRIC COMPONENTS OF PRECAST SSS

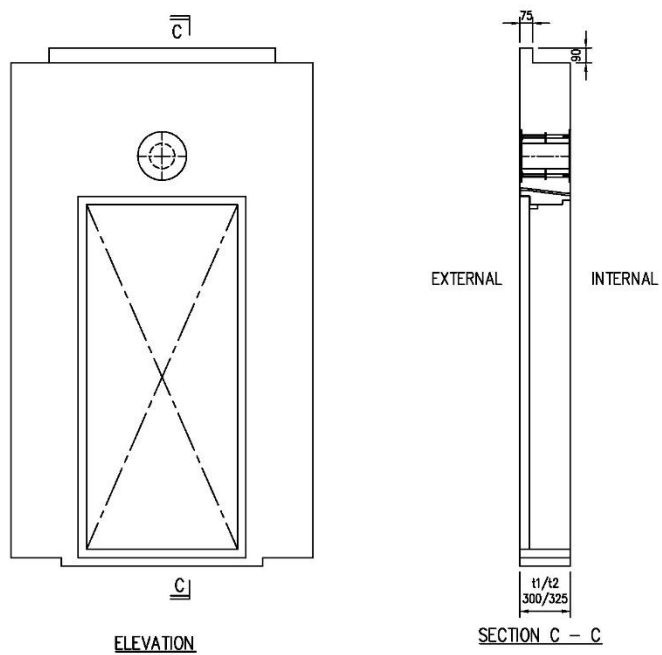


FIGURE 3: BLAST DOOR AND VENTILATION SLEEVE

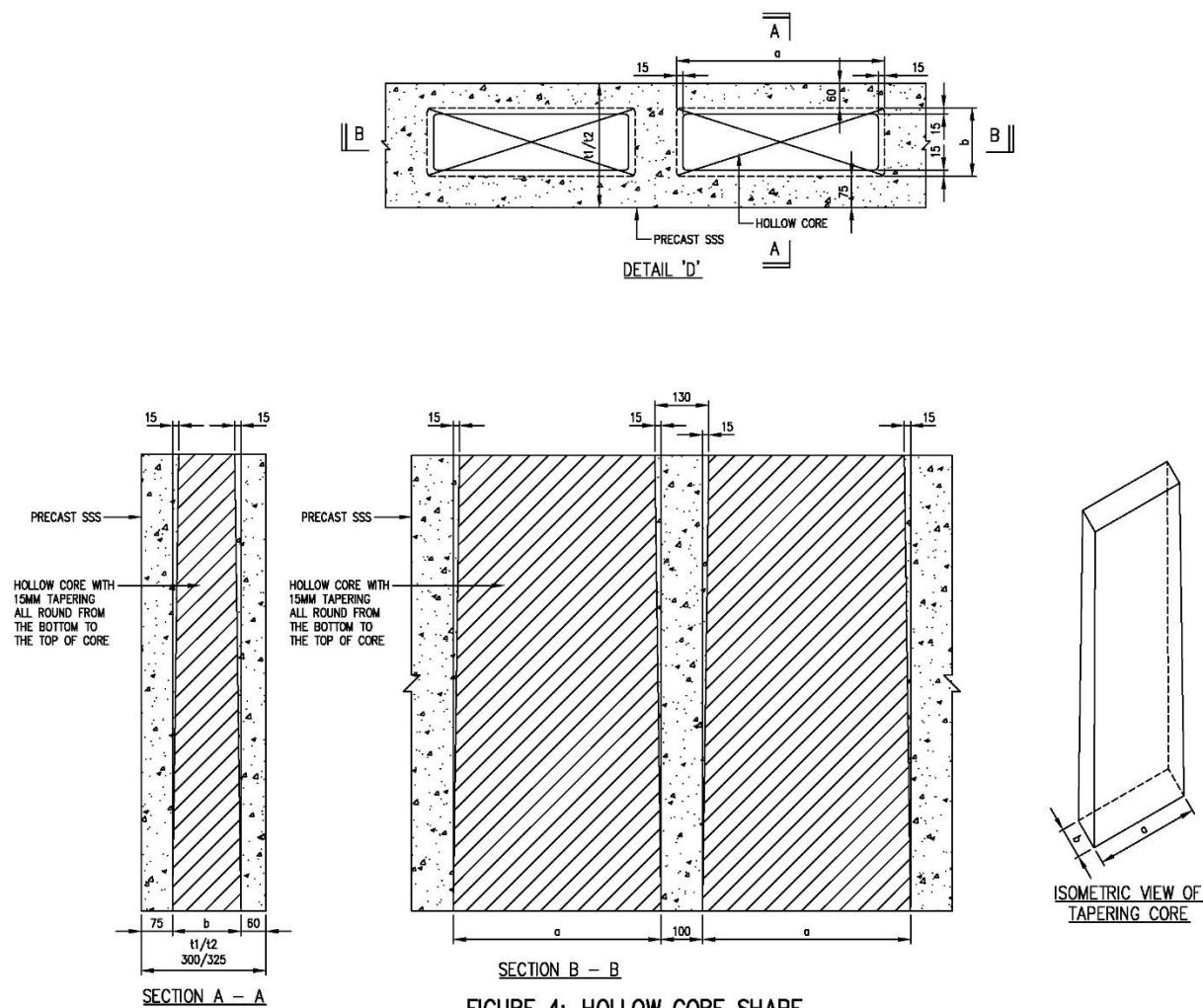
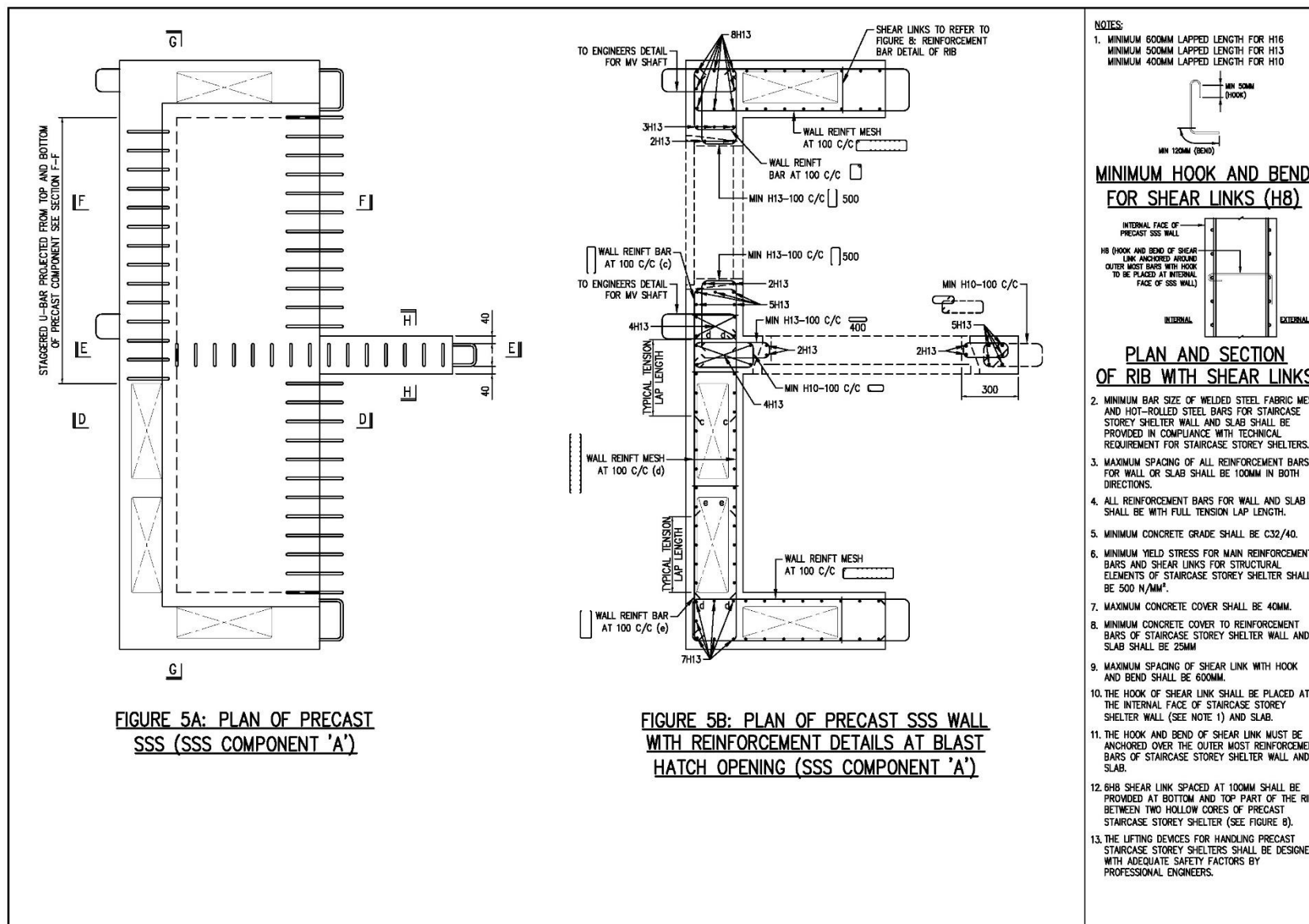
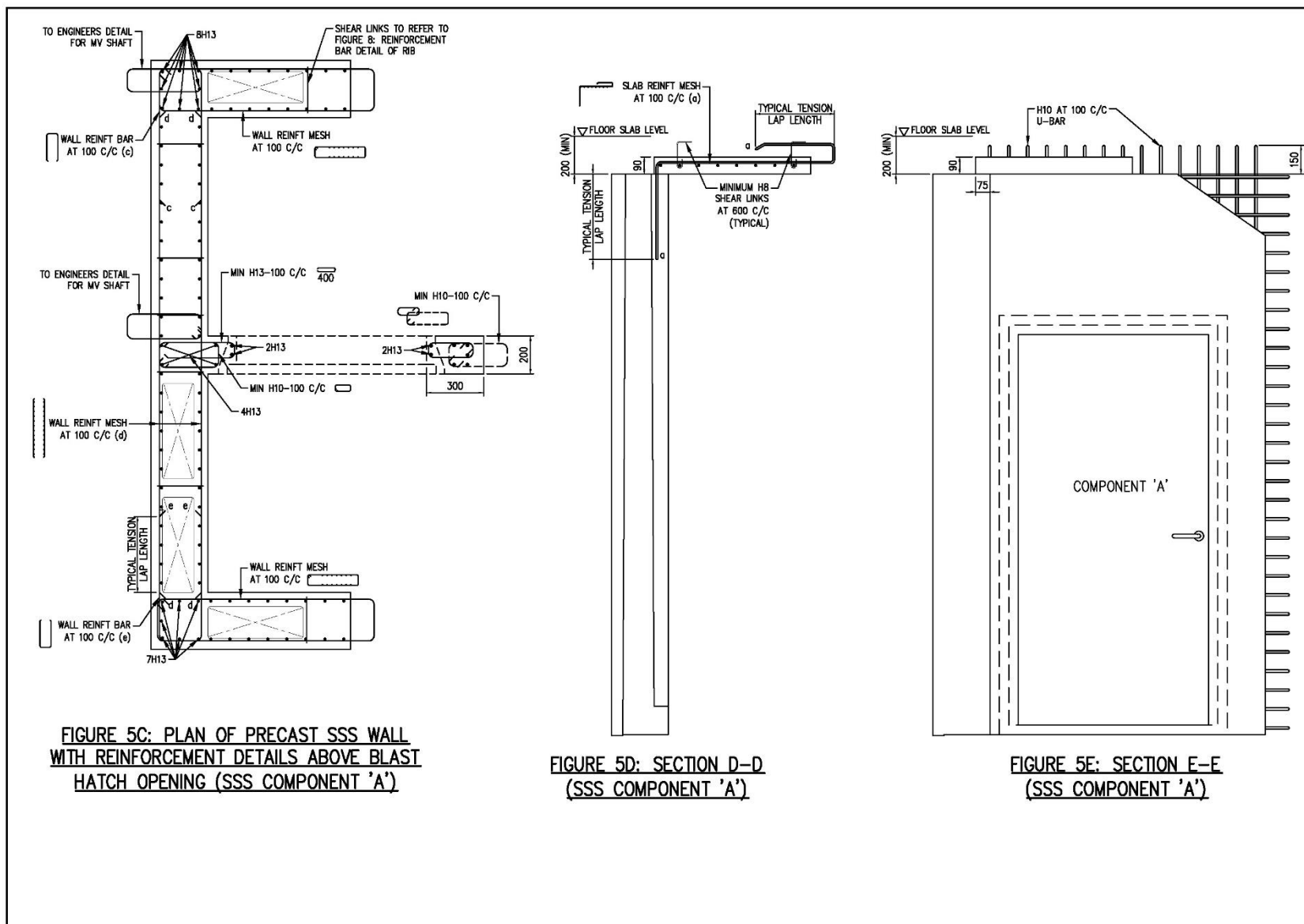
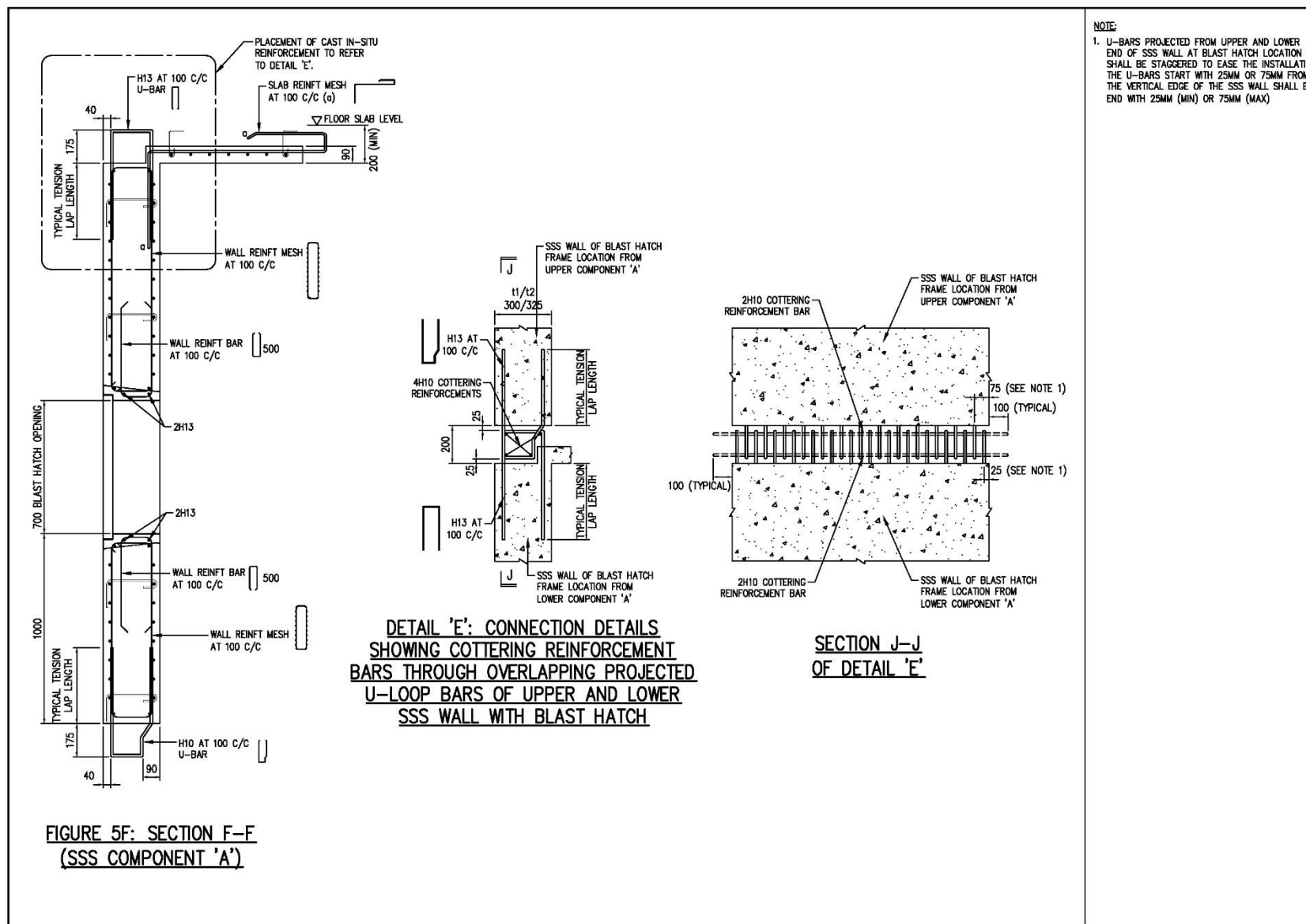
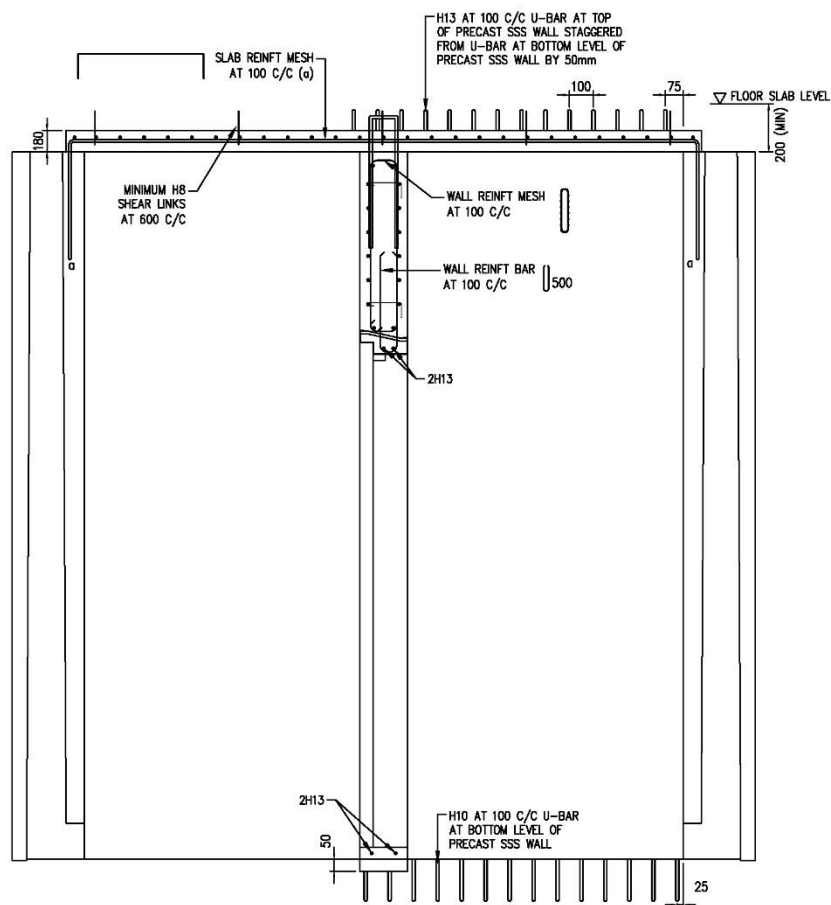


FIGURE 4: HOLLOW CORE SHAPE

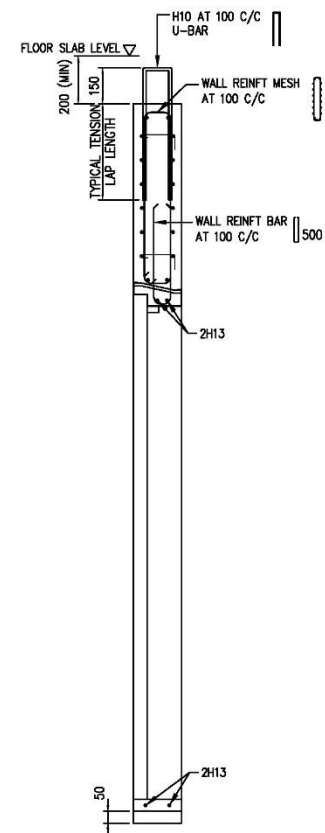








**FIGURE 5G: SECTION G-G
(SSS COMPONENT 'A')**



**FIGURE 5H:
SECTION H-H
(SSS COMPONENT 'A')**

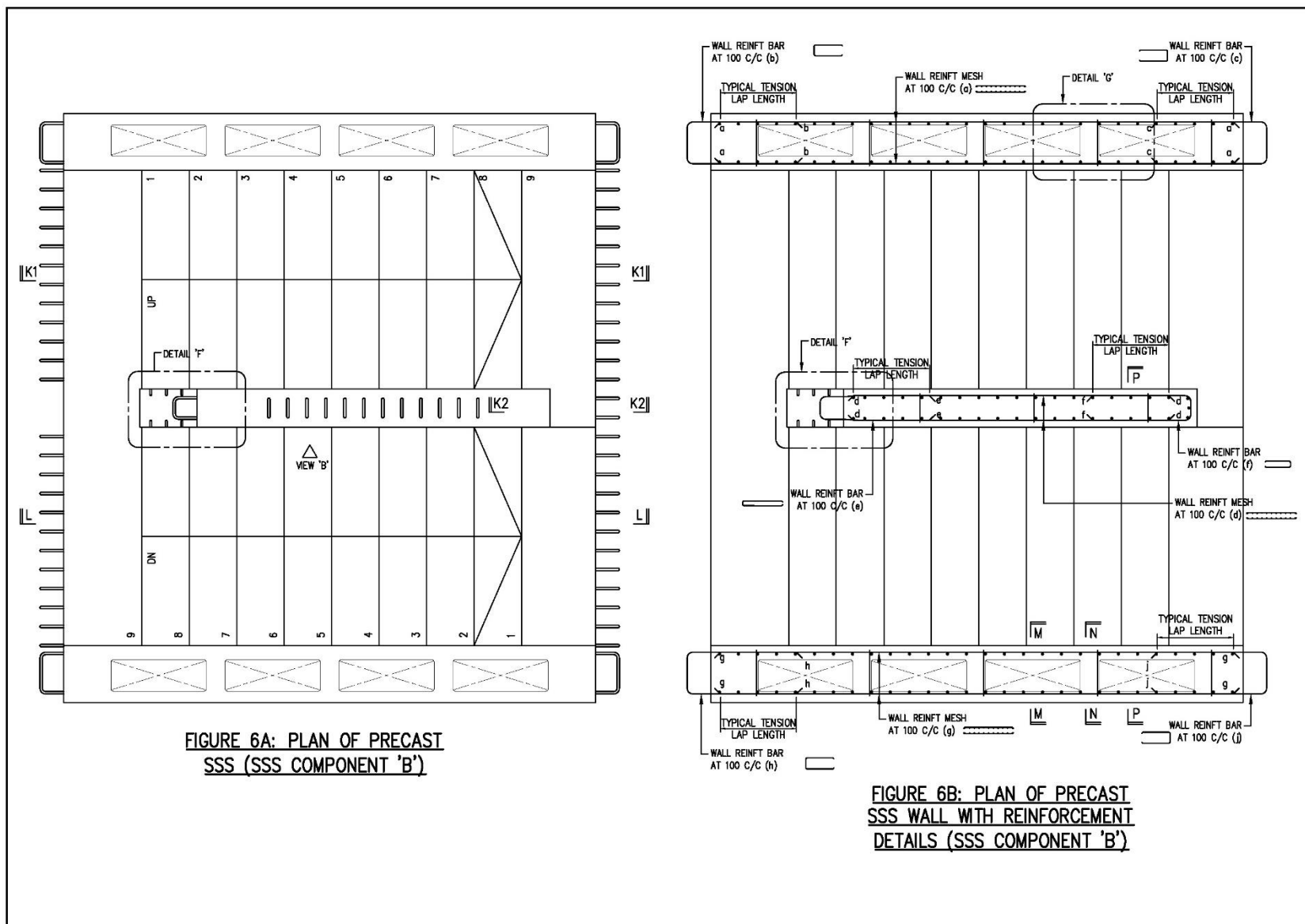
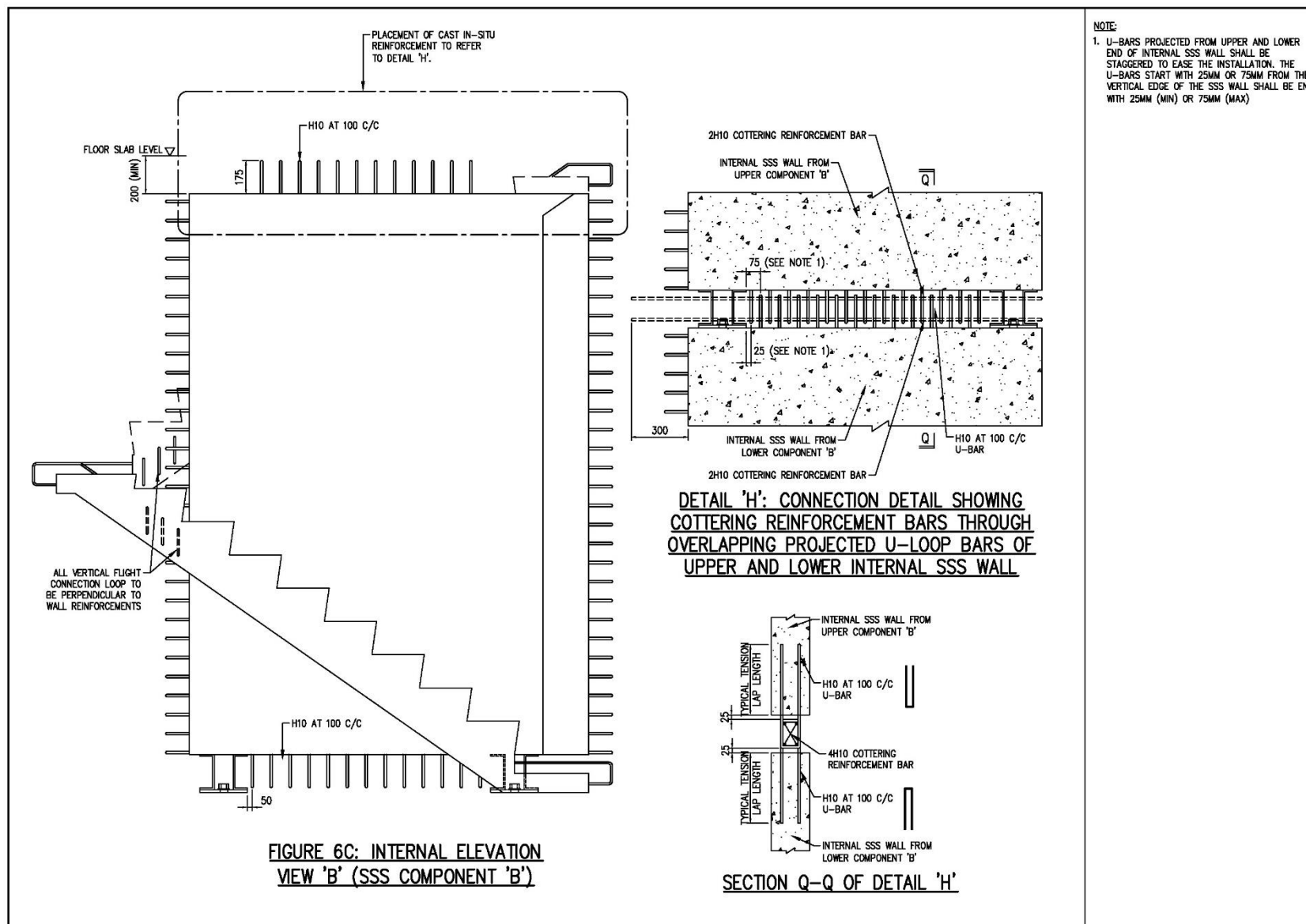
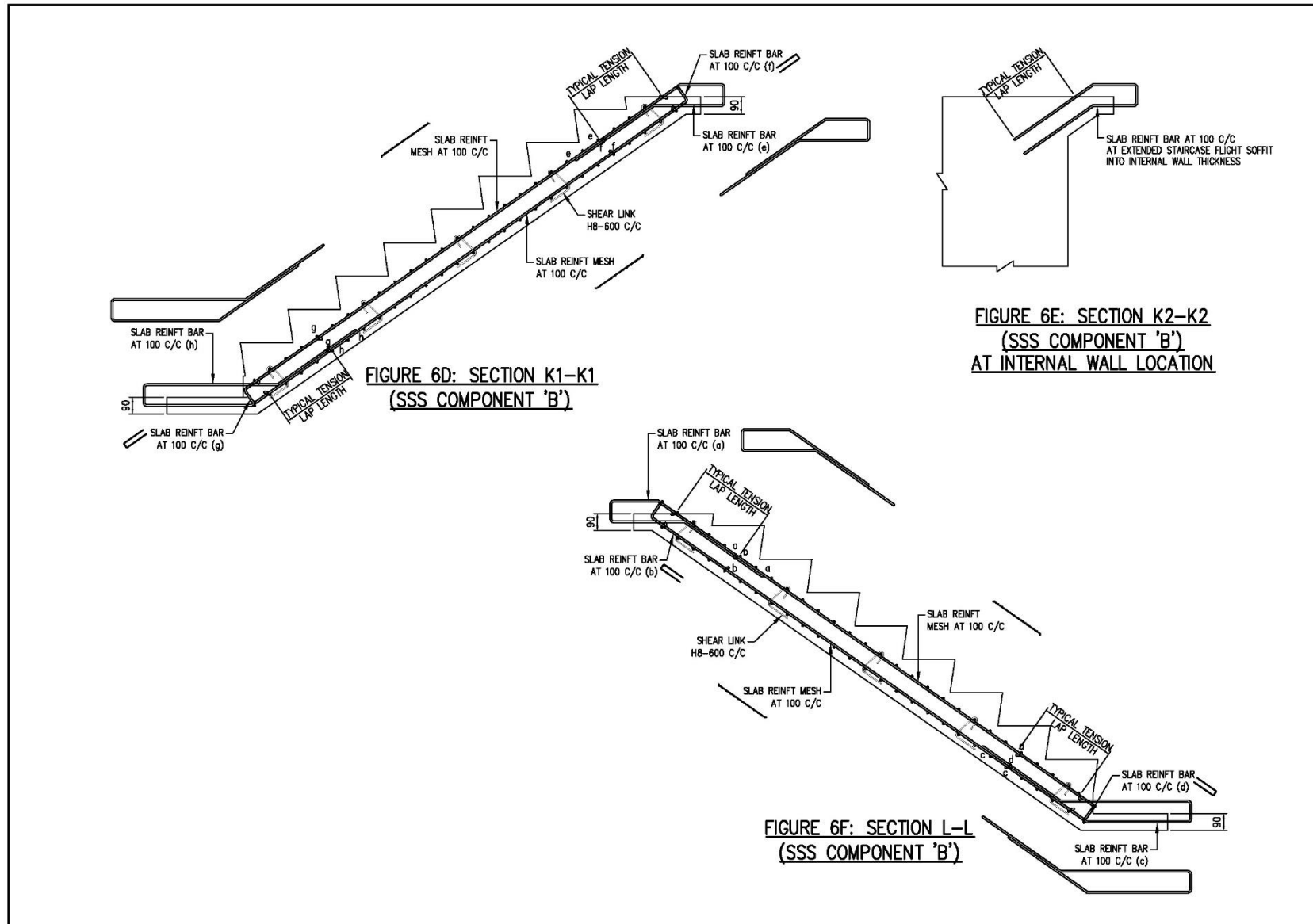
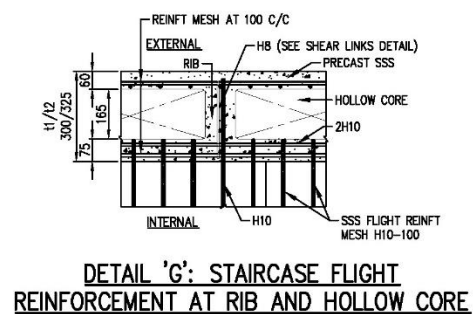
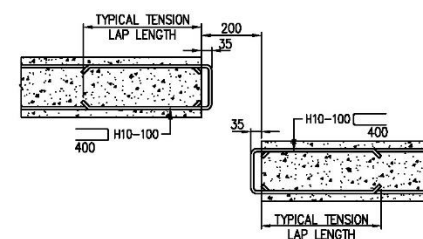
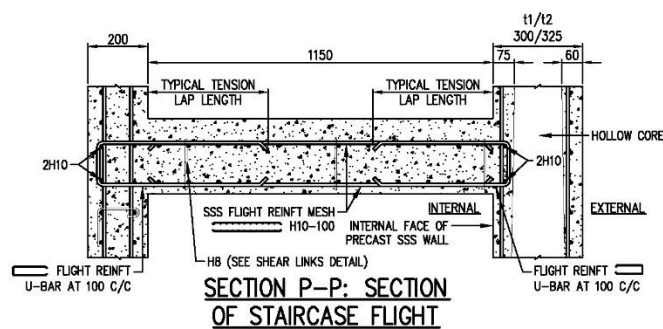
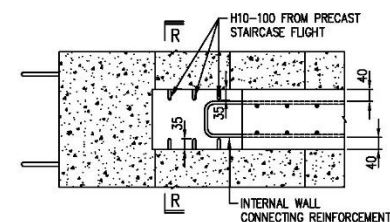
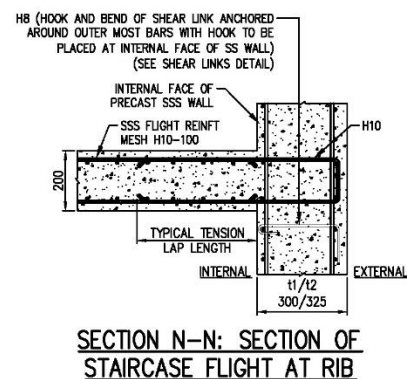
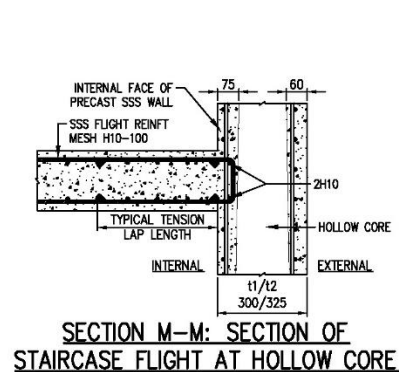


FIGURE 6A: PLAN OF PRECAST SSS (SSS COMPONENT 'B')

FIGURE 6B: PLAN OF PRECAST SSS WALL WITH REINFORCEMENT DETAILS (SSS COMPONENT 'B')







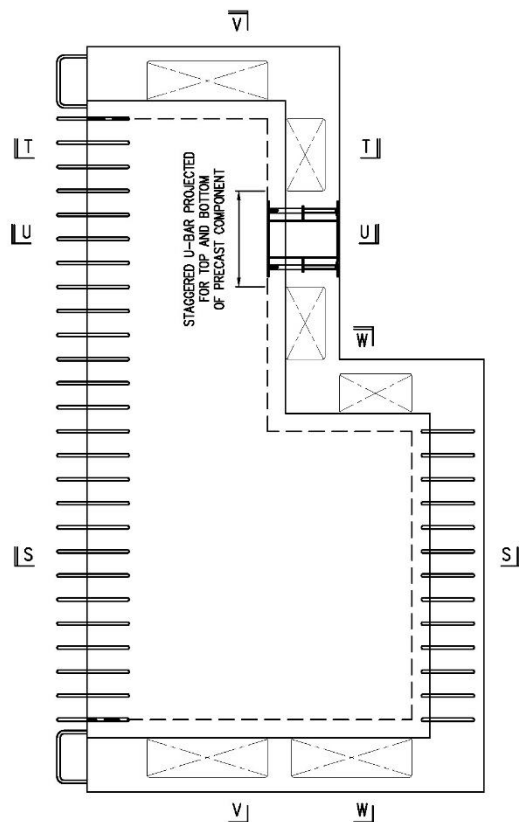


FIGURE 7A: PLAN OF PRECAST SSS (SSS COMPONENT 'C')

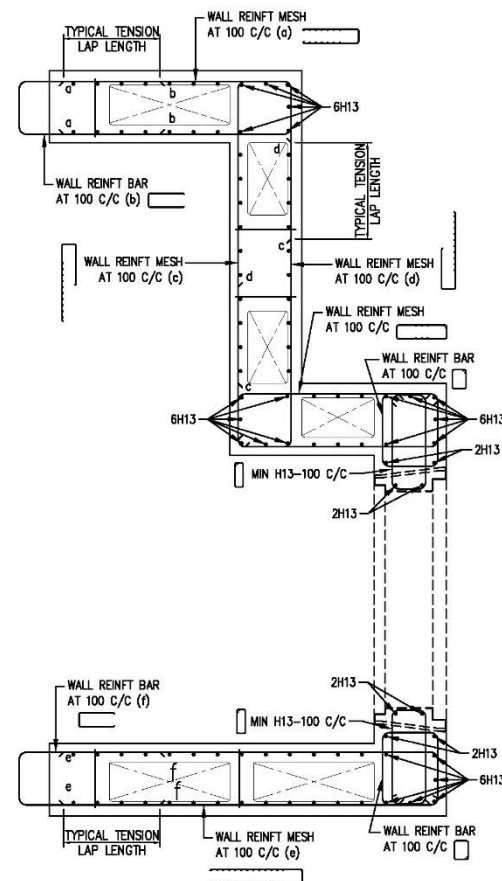
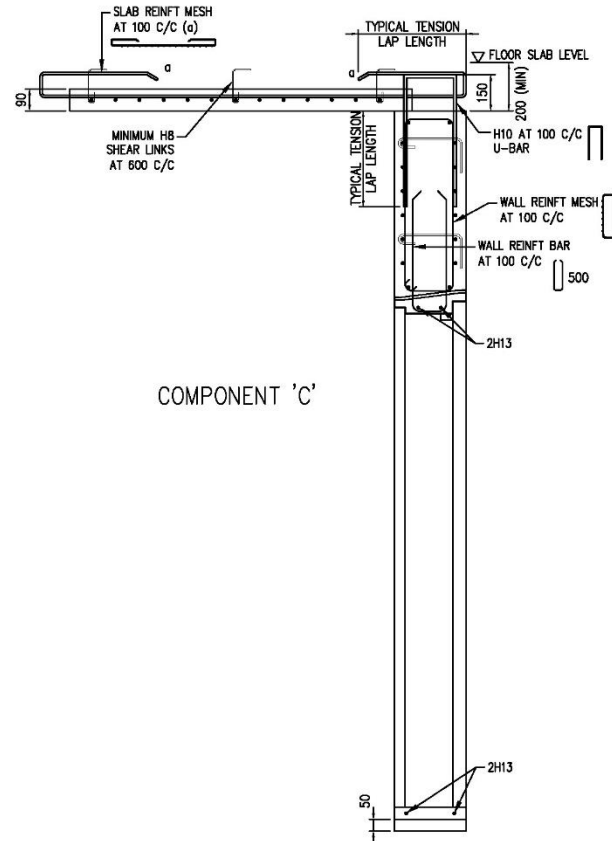
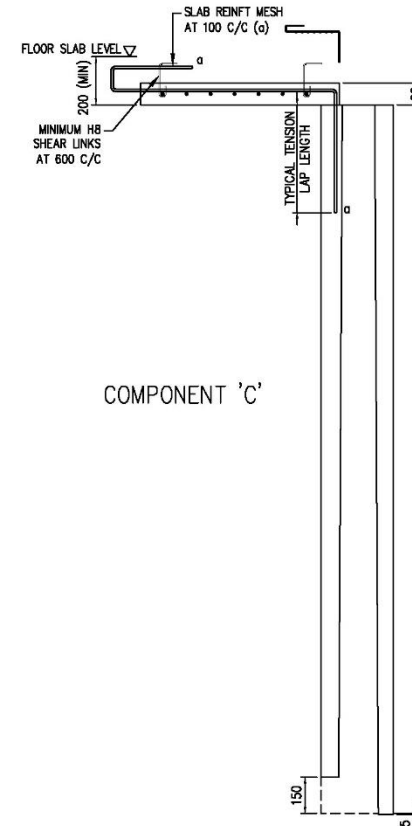


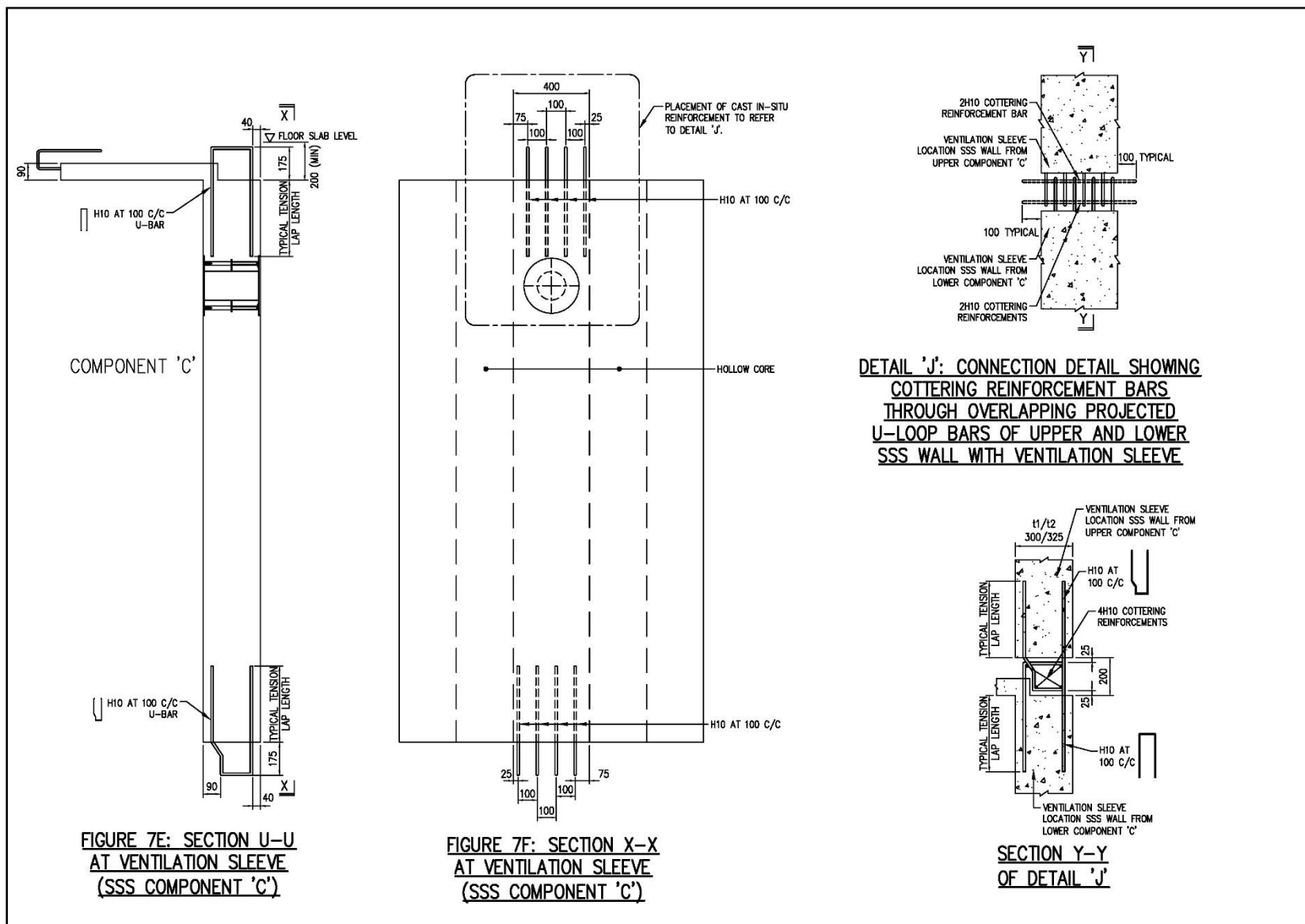
FIGURE 7B: PLAN OF PRECAST SSS WALL WITH REINFORCEMENT DETAILS (SSS COMPONENT 'C')

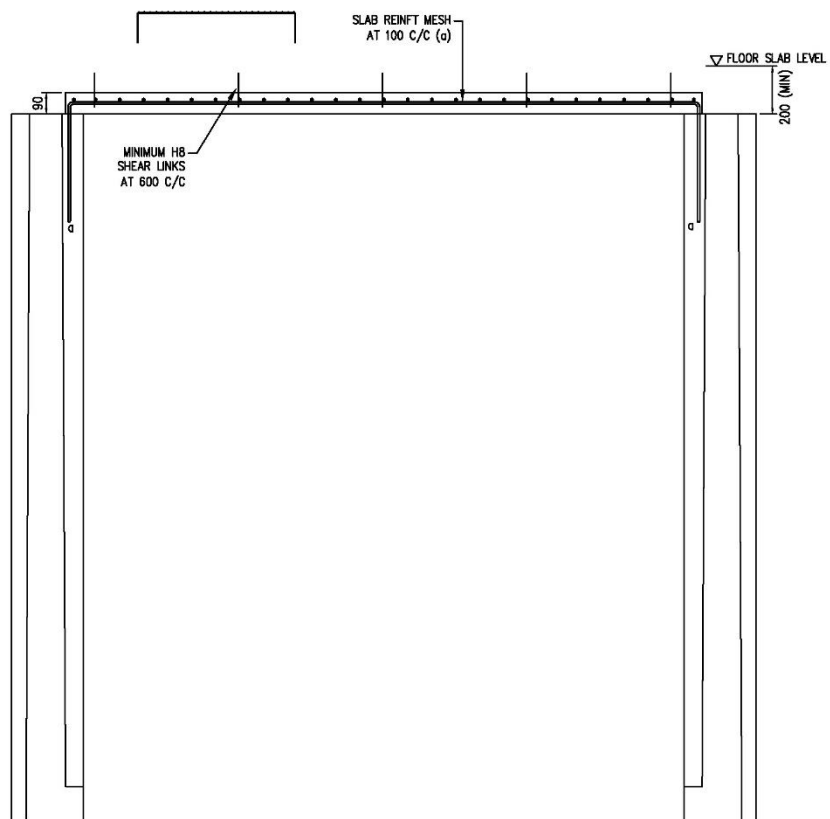


**FIGURE 7C: SECTION S-S
(SSS COMPONENT 'C')**

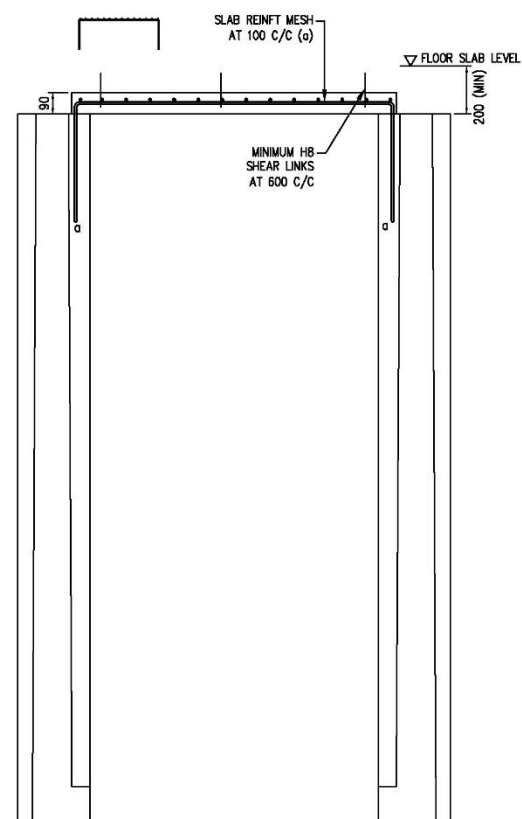


**FIGURE 7D: SECTION T-T
(SSS COMPONENT 'C')**

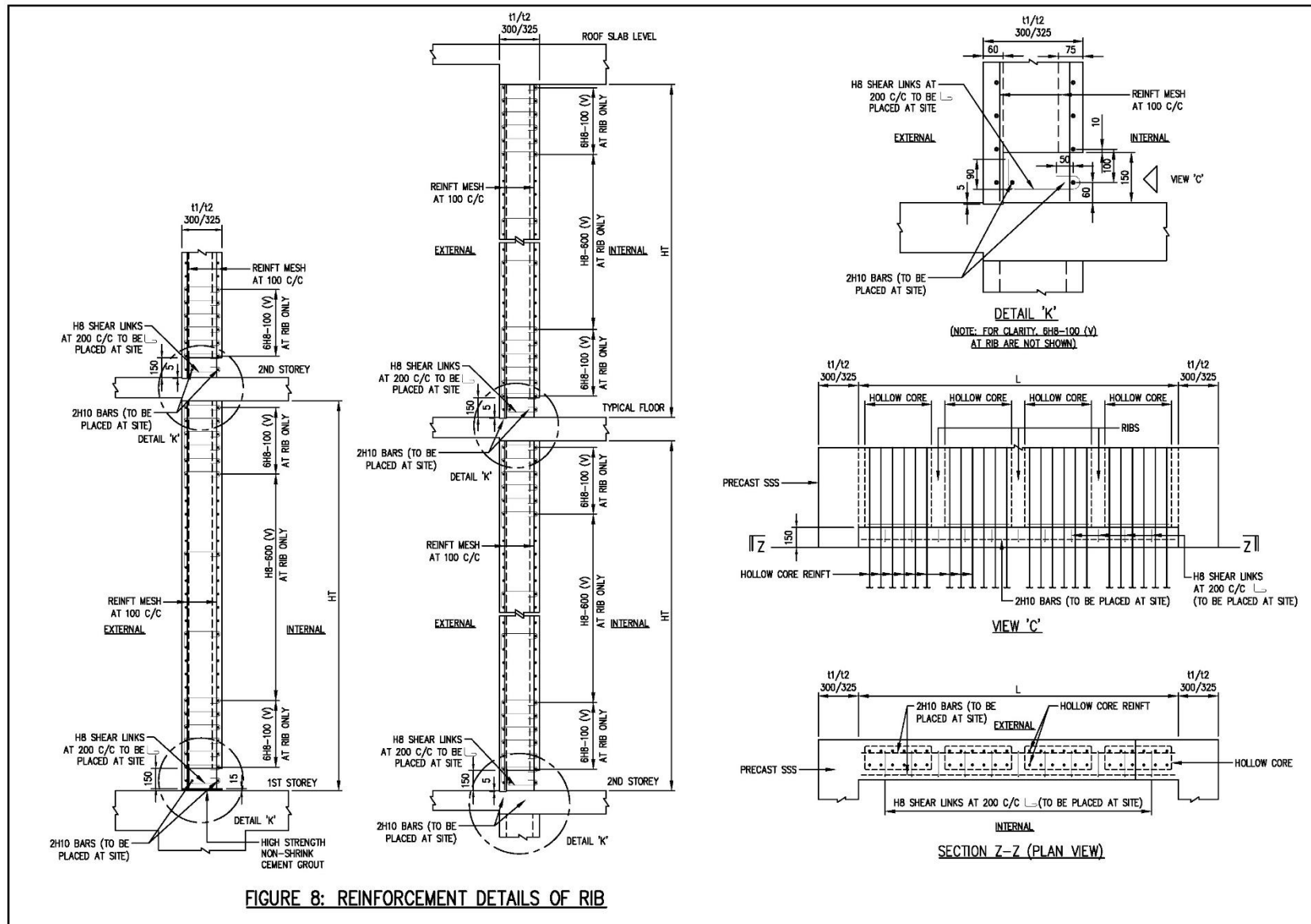


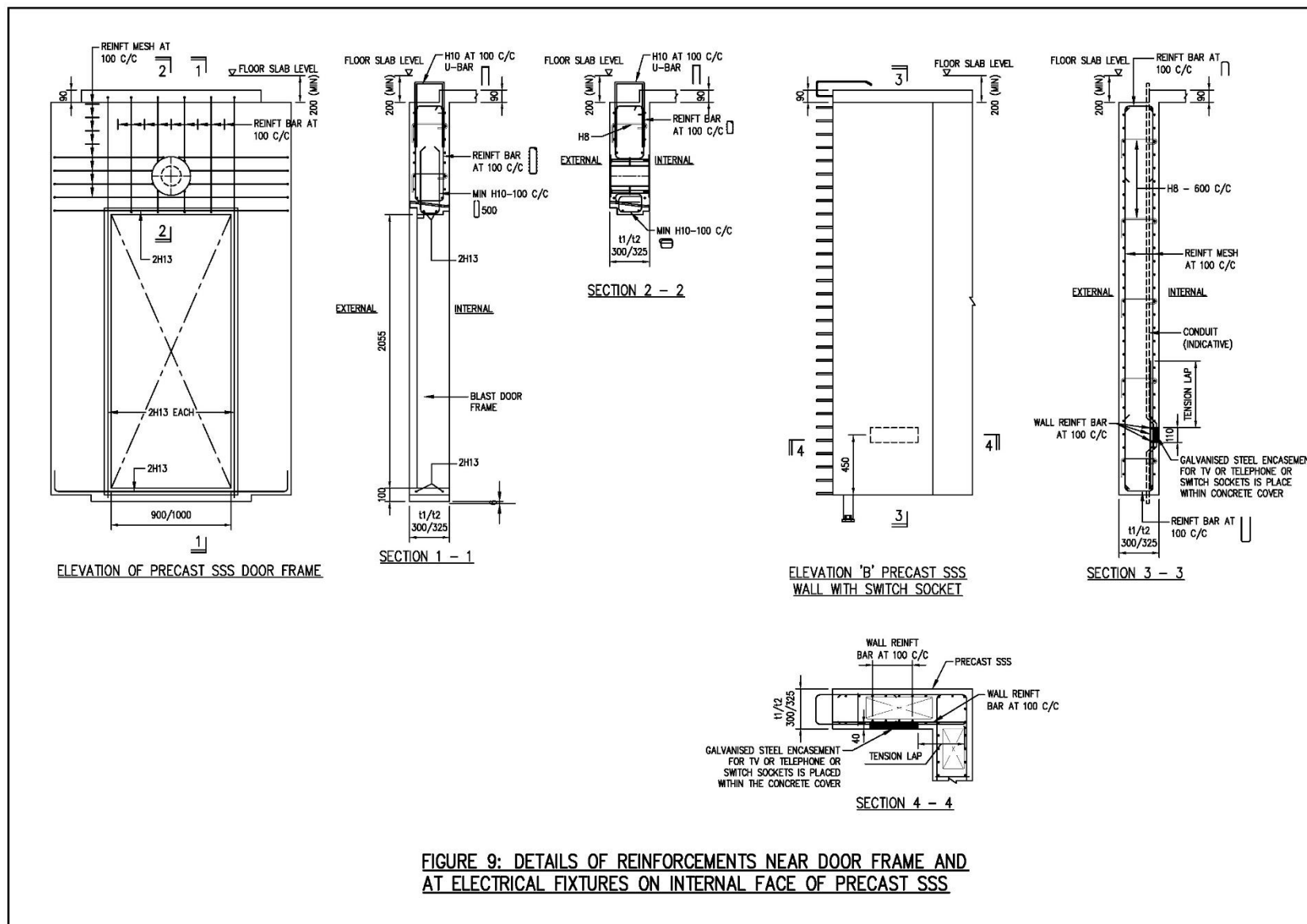


**FIGURE 7G: SECTION V-V
(SSS COMPONENT 'C')**



**FIGURE 7H: SECTION W-W
(SSS COMPONENT 'C')**





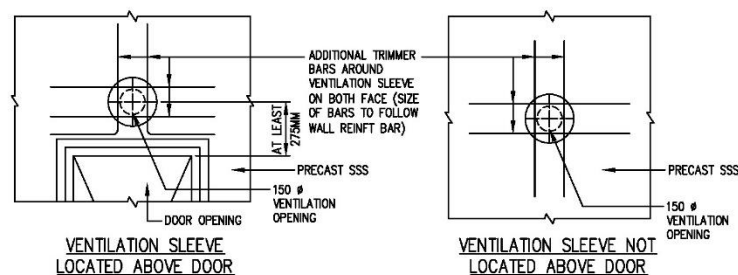
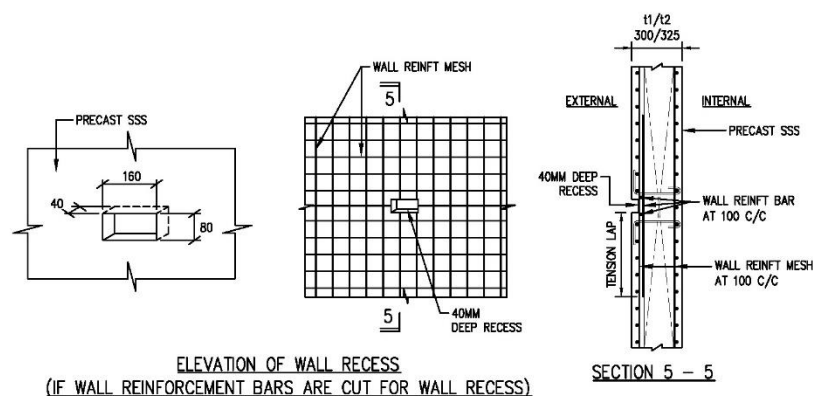


FIGURE 10: DETAILS OF TRIMMER BARS FOR VENTILATION SLEEVE



ELEVATION OF WALL RECESS
(IF WALL REINFORCEMENT BARS ARE CUT FOR WALL RECESS)

FIGURE 11: DETAILS OF TRIMMER BARS FOR WALL RECESS FOR PRECAST SSS DOOR HANDLE

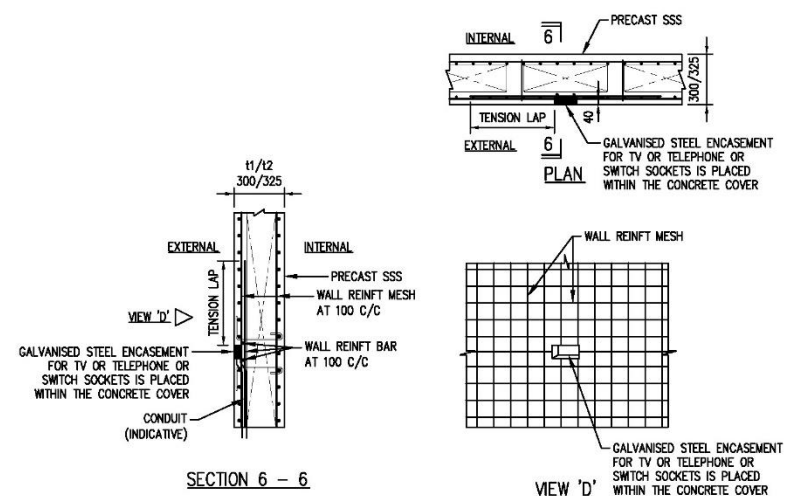
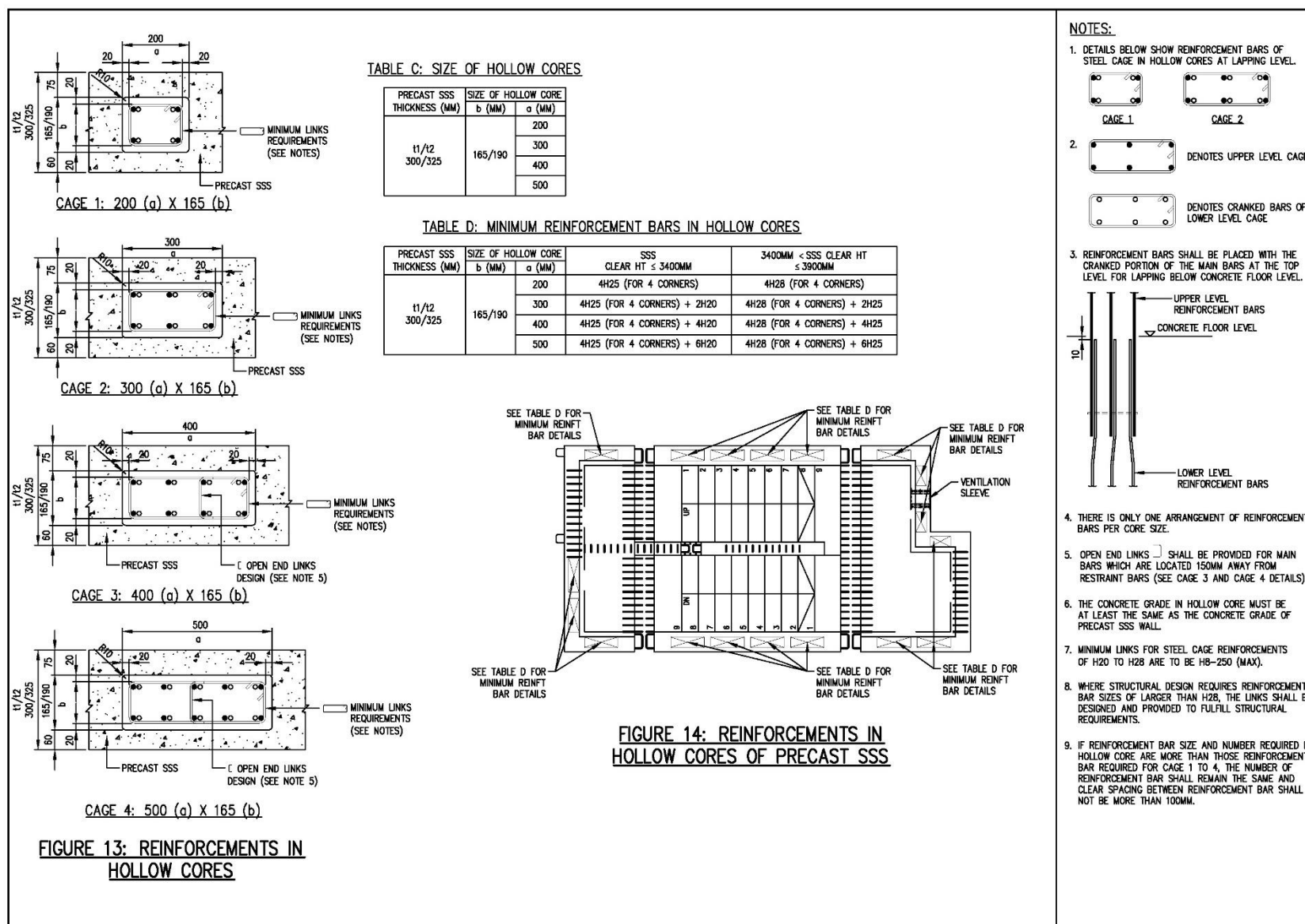
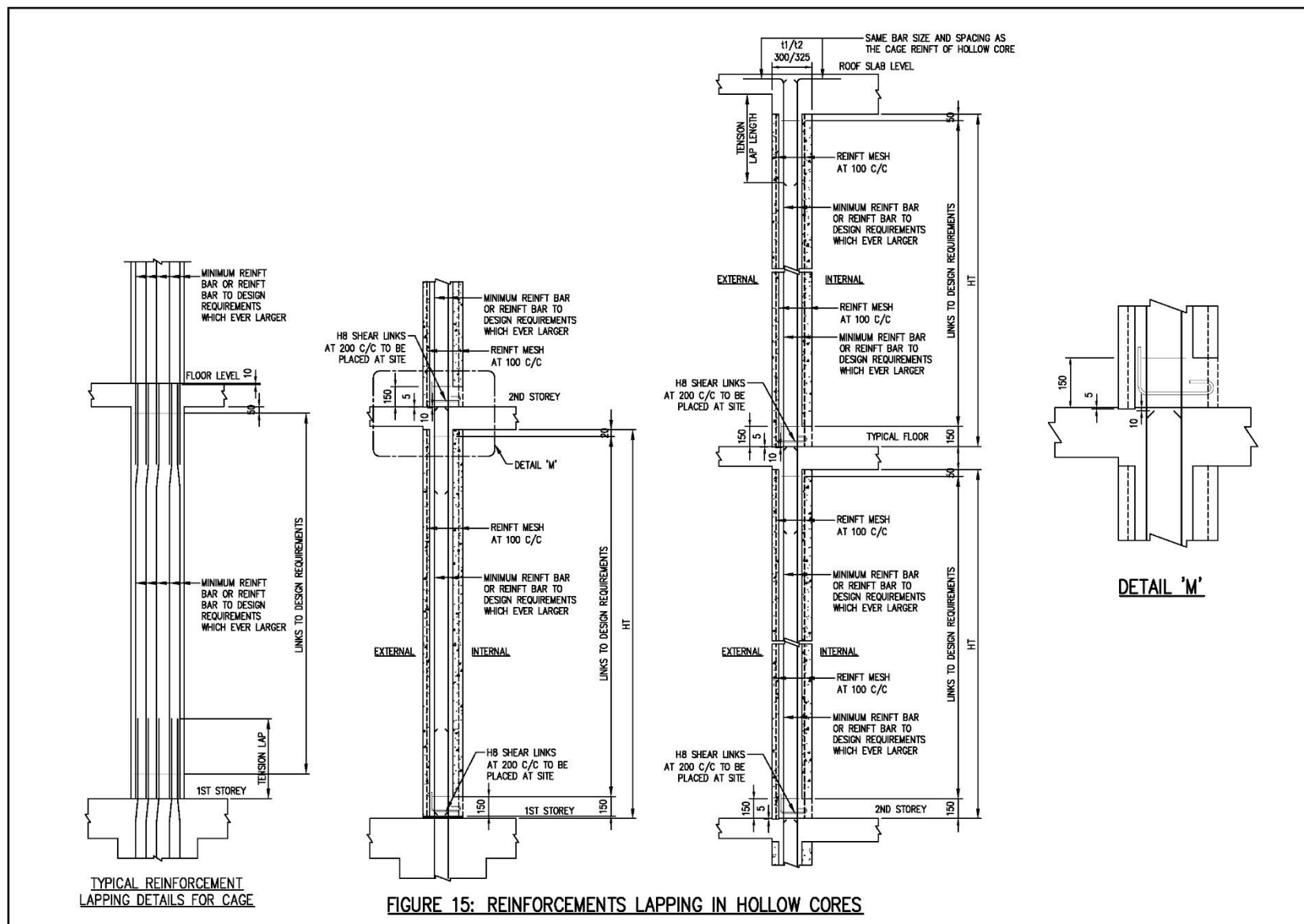
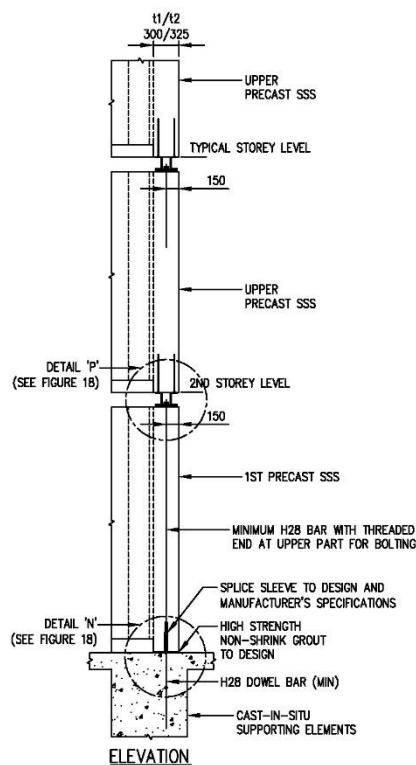


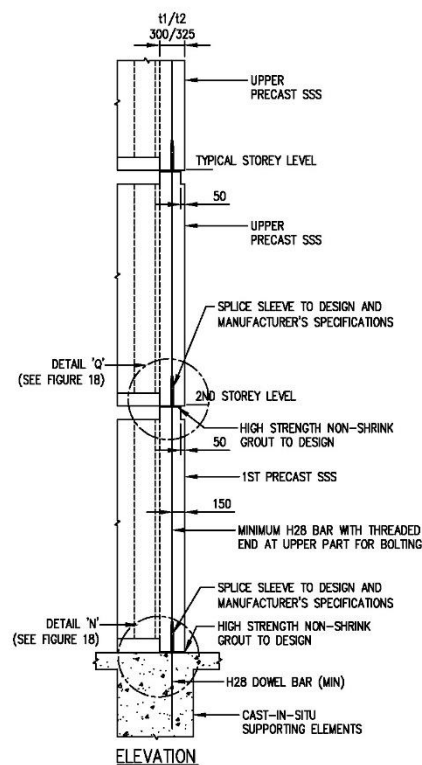
FIGURE 12: ELECTRICAL FIXTURES ON EXTERNAL FACE OF PRECAST SSS



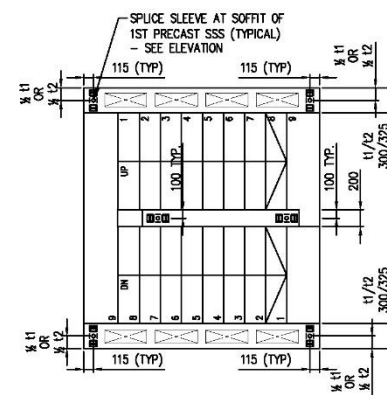




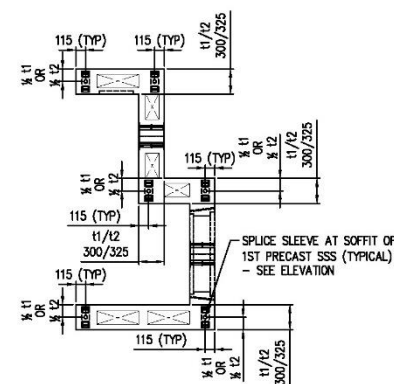
**FIGURE 16: SPLICE SLEEVE
CONNECTION DETAILS BETWEEN
PRECAST SSS AND CAST IN-SITU
ELEMENT AND BOLT CONNECTION
DETAILS BETWEEN TWO PRECAST SSS**



**FIGURE 17: SPLICE SLEEVE
CONNECTION DETAILS
FOR PRECAST SSS TOWER**



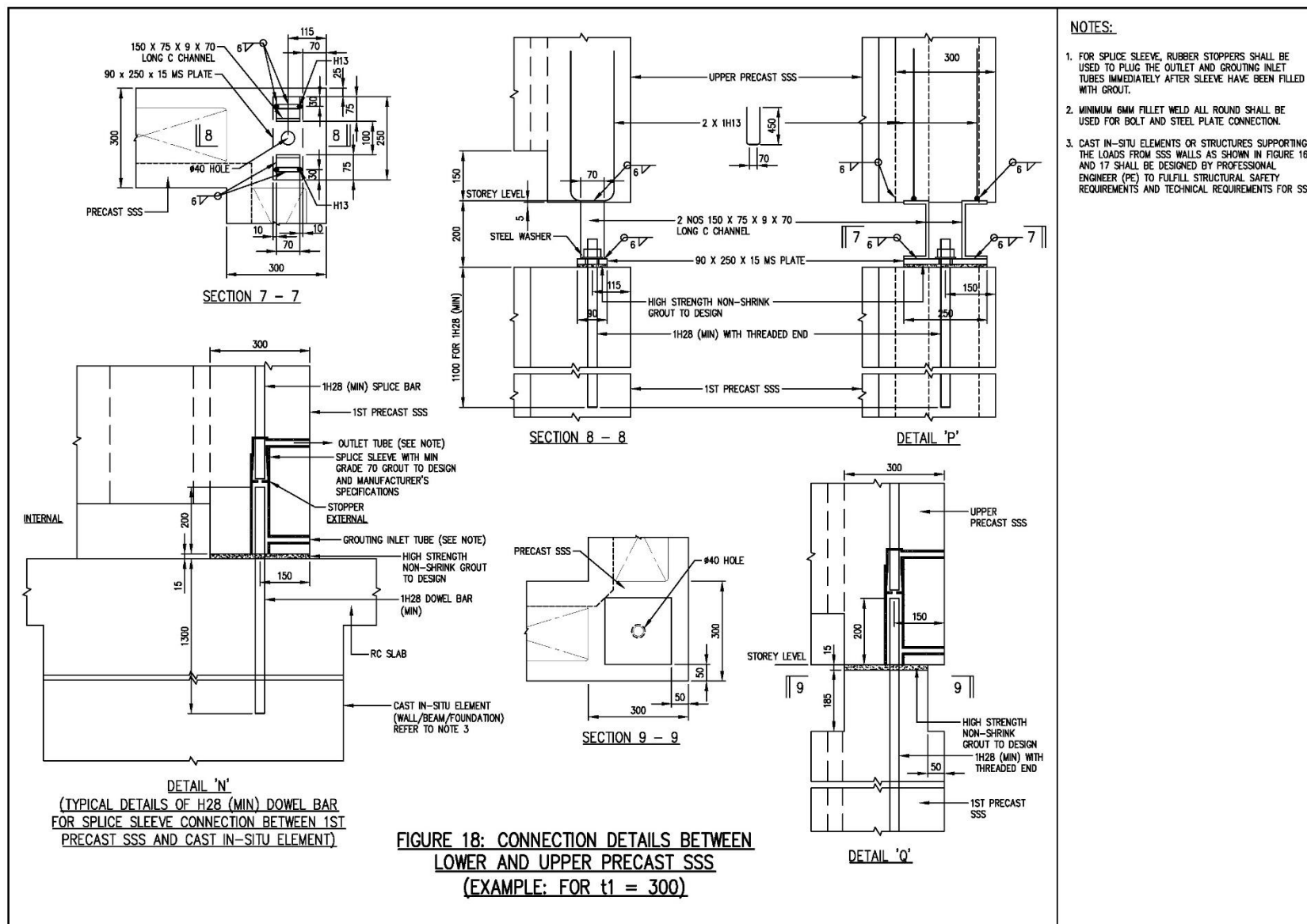
REFERENCE PLAN FOR 1ST STOREY
COMPONENT 'B' PRECAST SSS
(SIZE AND ARRANGEMENT OF CORES SHOWN IS INDICATIVE ONLY)

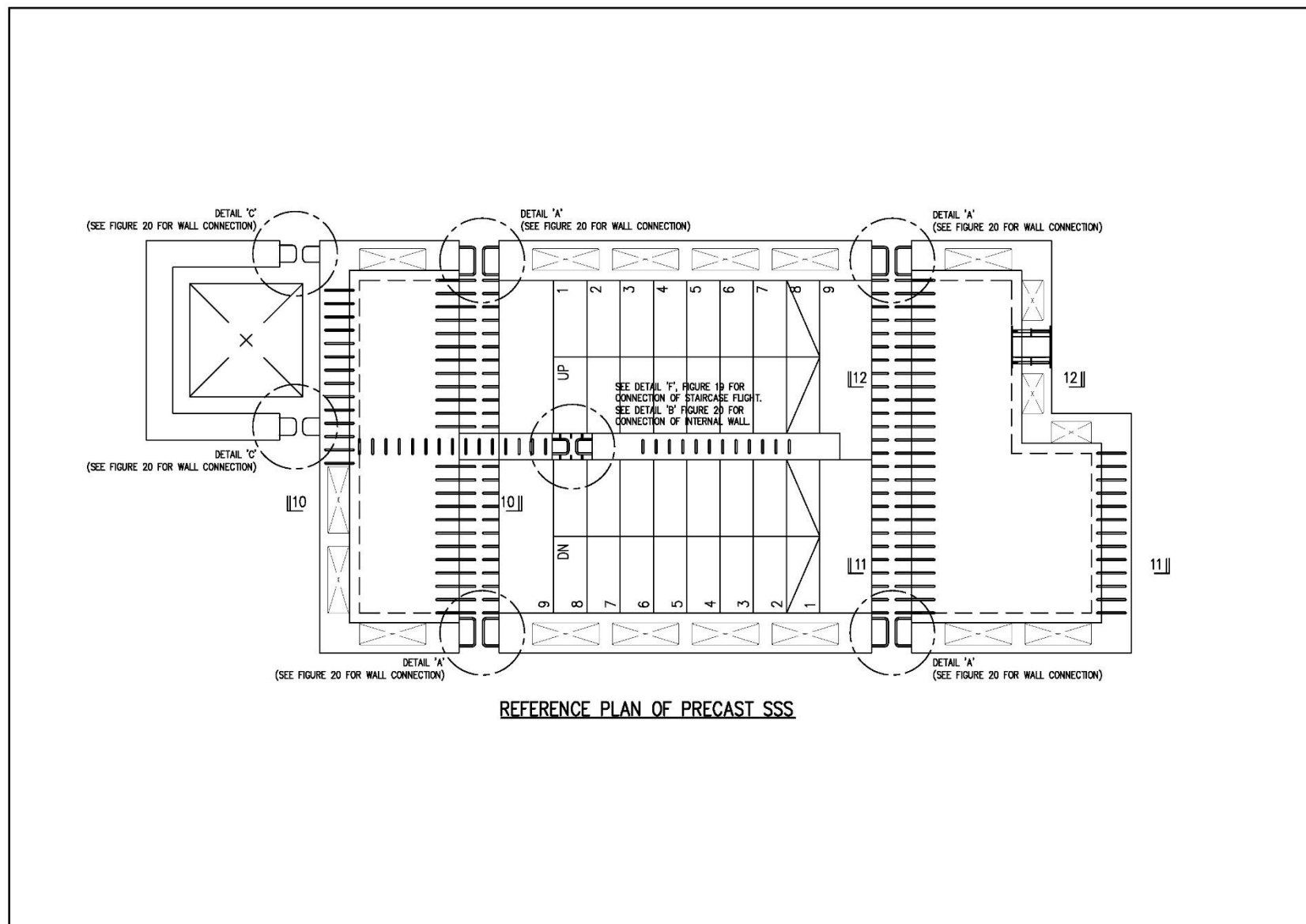


REFERENCE PLAN FOR 1ST STOREY
COMPONENT 'C' PRECAST SSS
(SIZE AND ARRANGEMENT OF CORES SHOWN IS INDICATIVE ONLY)

NOTES:

1. THE 1ST OR LOWEST PRECAST STOREY SHELTER MUST BE CONNECTED BY SPlice SLEEVE (DETAIL "N", FIGURE 17 FOR DETAIL "P" AND OTHER LOCATIONS OF SHELTER WALL, MINIMUM H28 DOWEL BAR FOR SPlice SLEEVE SHALL BE CAST IN THE CAST IN-SITU SUPPORTING ELEMENTS (WALL, COLUMN, BEAM OR FOUNDATION).
2. THE UPPER PRECAST STOREY SHELTERS SHALL BE JOINED BY BOLT AND STEEL PLATE CONNECTION (SEE FIGURE 17 FOR DETAIL "Q" AND FIGURE 18 FOR SECTION 9-9, SECTION 10-10 AND DETAIL "Q") AT THEIR 4 CORNERS OR OTHER LOCATION OF SHELTER WALL.
3. ALTERNATIVE TO THE ABOVE NOTE 2, SPlice SLEEVE CONNECTION CAN BE USED FOR PRECAST S/S TOWER (SEE FIGURE 17 FOR DETAIL "Q" AND FIGURE 18 FOR SECTION 11-11 AND DETAIL "Q").
4. HOT ROLLED STEEL SECTION OR PLATE SHALL BE GRADE S275.
5. H28 BARS REQUIRED FOR THESE TWO TYPES OF CONNECTION SHALL BE PROPERLY SECURED IN POSITION AT 4 TOP CORNERS OR OTHER LOCATIONS OF LOWER PRECAST S/S WALL WITH TEMPLATE SUELS THAT THEY ARE ALIGNED WITH THE BOLT HOLES OR SPlice SLEEVE PROVIDED AT THE BASE OF THE UPPER PRECAST STAIRCASE STOREY SHELTER.
6. THE BOLT AND STEEL PLATE CONNECTION SHALL BE CHECKED AND DESIGNED BY PROFESSIONAL ENGINEER IF THE PRECAST S/S COMPONENT IS LARGER OR HEAVIER THAN THAT SHOWN IN FIGURE 1.





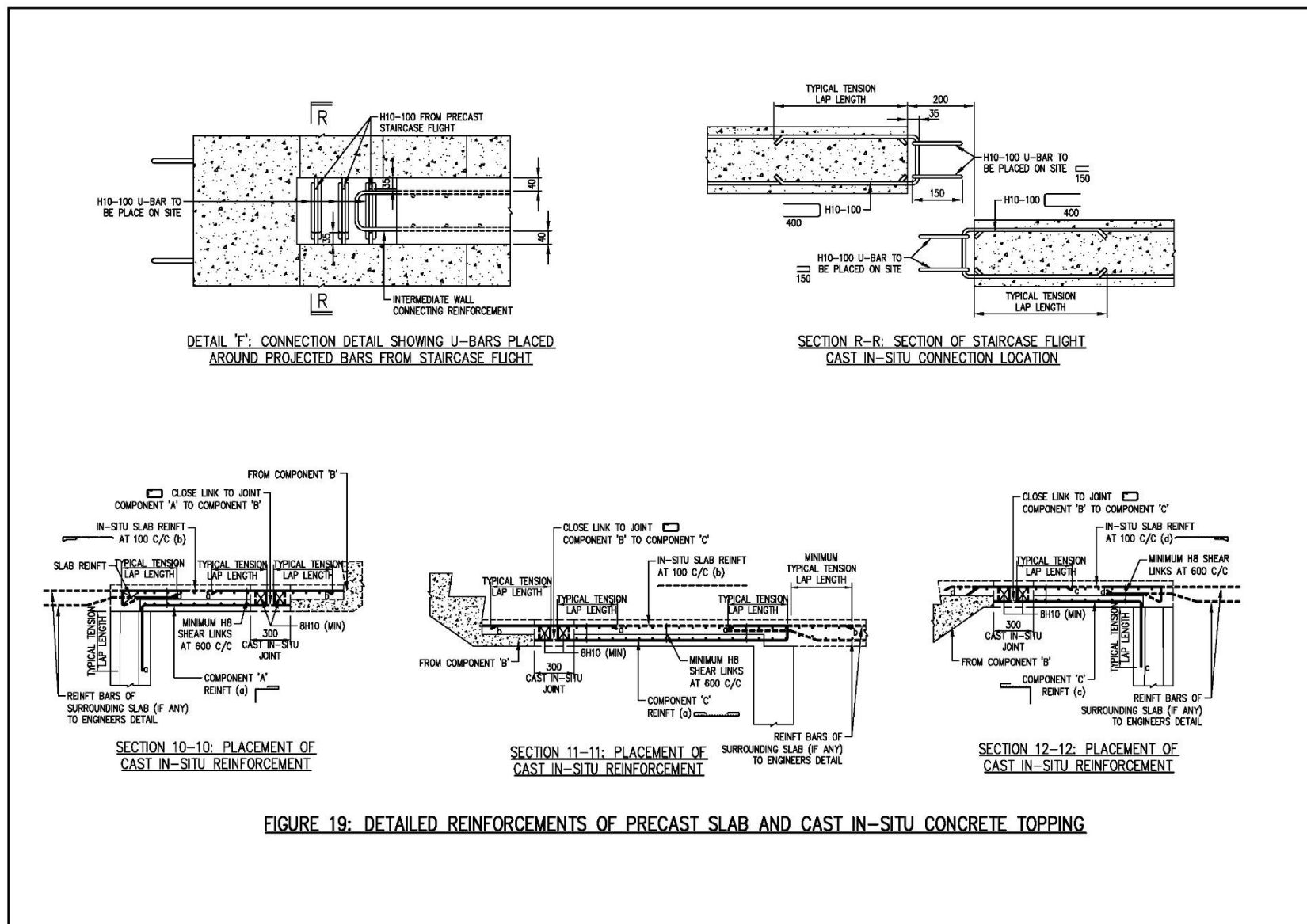


FIGURE 19: DETAILED REINFORCEMENTS OF PRECAST SLAB AND CAST IN-SITU CONCRETE TOPPING

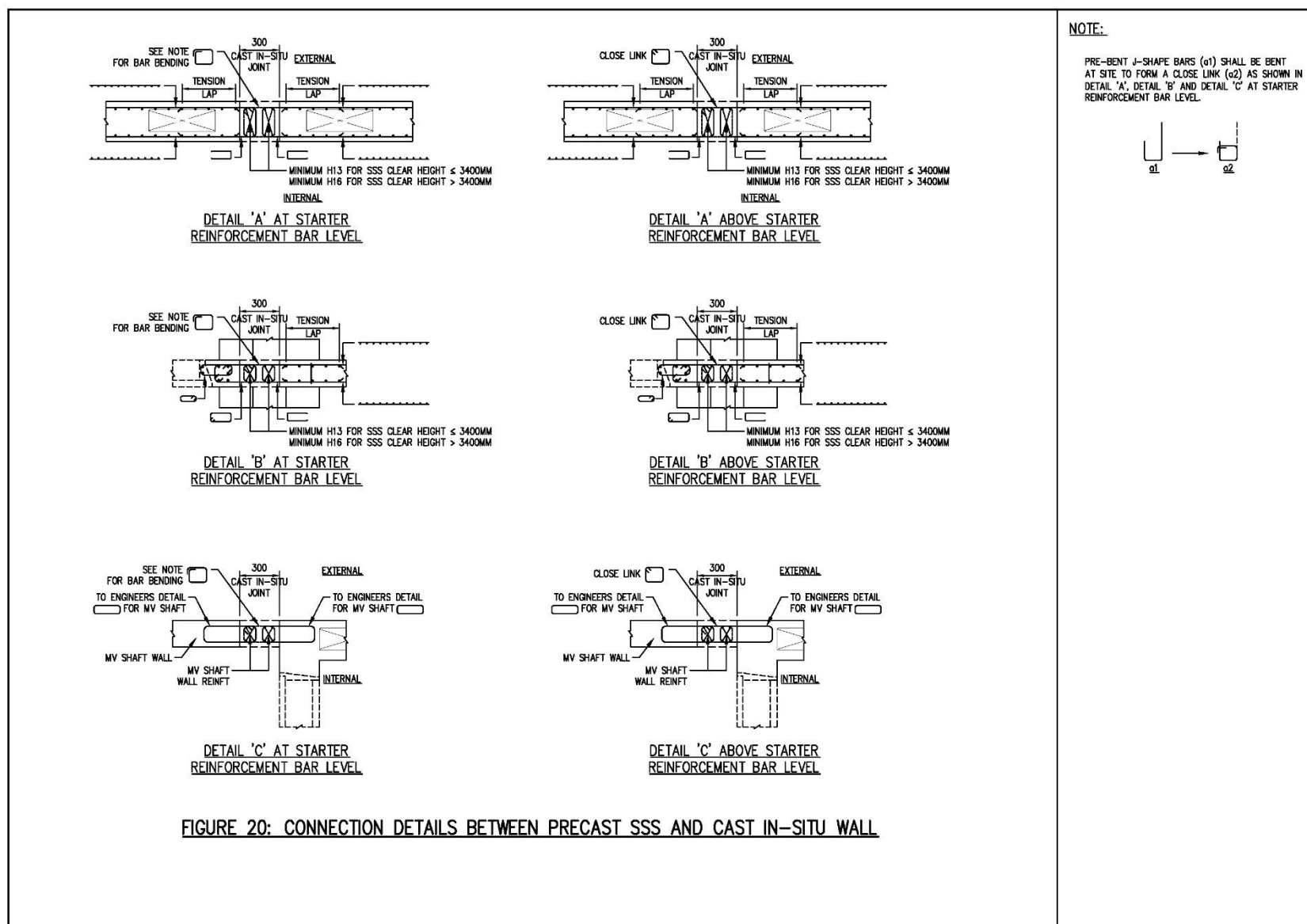


FIGURE 20: CONNECTION DETAILS BETWEEN PRECAST SSS AND CAST IN-SITU WALL

CHAPTER 3: STRUCTURAL REQUIREMENTS

3.1 GENERAL

The structural design of the SS tower shall take into account both the vertical and lateral loads, where applicable.

The SS tower shall be designed for maximum degrees of redundancy in the structural system against weapon effects.

3.2 MATERIALS

3.2.1 Concrete

The minimum grade of concrete for all SS elements shall be C32/40. The use of pre-stressed concrete for SS wall/slab and NS wall/slab in the SS, S/C SS or scissor S/C SS tower is not permitted.

3.2.2 Steel Reinforcement

The steel reinforcement in SS/NS wall and slab shall be welded steel fabric mesh for steel bar diameter of up to 16mm and hot rolled steel bars. The minimum yield stress of main reinforcement bars and shear links in the structural elements forming the SS, S/C SS or scissor S/C SS or NS shall be minimum 500 N/mm².

3.3 ANALYSIS

3.3.1 General

The vertical continuity of SS and NS walls, where applicable, to the foundation shall comply with clause 2.4.2.

In the case of S/C SS or scissor S/C SS tower, the SS and NS wall shall be continuous to foundation.

3.3.2 Beam Supported on SS wall

The end of the external beam that is supported on SS wall(s) shall be designed and detailed as simply support.

3.3.3 Shielded NS Walls and/or NS columns

(NS columns not applicable to S/C SS or scissor S/C SS Tower)

No additional design checks on SS tower is required if its supporting elements, wall(s), column(s) or any of its combination, are shielded. These structural elements are deemed shielded if reinforced concrete slab or other equivalent structural forms provided above them is extended beyond their edges by as minimum length of $0.5H$, where H is the aggregate wall height of NS (See FIGURE 3.3.3).

3.3.4 Unshielded NS Walls and /or NS Columns

(NS columns not applicable to S/C SS or scissor S/C SS Tower)

The following requirements are to be complied with if the design adopts:

(a) & (b) Unshielded NS Walls (4 NS walls or 2 opposite NS walls)

The minimum thickness of each NS wall shall be 300mm. The SS, S/C SS or scissor S/C SS tower shall be designed against the most severe effects as the result of the removal of a portion of the NS wall equivalent to an opening of 1500mm diameter on the NS wall at its most critical location (Refer to FIGURE 3.3.4(a) and FIGURE 3.3.4(b)).

(c) Unshielded NS Columns

The minimum size (either its diameter or the shorter dimension) of each NS column shall be 500mm. The SS tower shall be designed against the most severe effects as the result of the removal of any one NS column (Refer to FIGURE 3.3.4(c)).

(d) Combination of Unshielded NS Walls and NS Columns

The minimum thickness of each NS wall and minimum size (either its diameter or the shorter dimension) of each NS column shall be 300mm and 500mm respectively. The SS, S/C SS or scissor S/C SS tower shall be designed against the most severe effects as the result of the following (Refer to FIGURE 3.3.4(d)).

(i) Removal of a portion of the NS wall equivalent to an opening of 1500mm diameter at its most critical location and

(ii) Removal of any one NS column

The above item (i) and (ii) shall be considered mutually exclusive.

(e) The following are the criteria to be used when performing design checks for Clause 3.3.4(a), 3.3.4(b), 3.3.4(c) or 3.3.4(d):

(i) The design shall be based on the action combination and values of partial safety factor for actions in accordance with Table 3.3.4.

- (ii) The design strength for a given material is derived from the characteristic strength divided by the partial safety factor for strength of material, which shall be 1.2 for concrete and 1.0 for reinforcements.

3.4 MEMBER DIMENSIONS AND REINFORCEMENT REQUIREMENTS

3.4.1 Member Dimensions

The minimum member size of SS and NS shall be as stipulated in Chapter 2 - Architectural Design.

3.4.2 Reinforcement Requirements

All diameters of reinforcement specified hereinafter shall refer to minimum fabric mesh or bar diameters. All spacing of reinforcement specified hereinafter shall refer to maximum spacing of reinforcement in both directions.

3.4.2.1 Wall Reinforcements of SS and NS

- (a) Minimum Reinforcement in SS or NS walls - refer to TABLE 3.4.2.1.
- (b) Reinforcements at both faces of the internal common wall shall be H10-100 c/c in both faces. The shear links shall be H8-600 c/c in both directions.

3.4.2.2 Slab Reinforcements of SS and NS Slabs

- (a) Intermediate SS/NS slabs and slabs/waists of staircase SS/NS:

Top and bottom layer of slab reinforcements shall be H10-100 c/c in both directions. The shear links shall be H8-600 c/c in both directions.
- (b) Ceiling slab of top-most SS:
 - (i) Reinforcements at both external face and internal face of the slab shall be H13-100 c/c (both directions);
 - (ii) The shear links shall be H8-600 c/c in both directions
- (c) Floor slab of bottom-most SS or NS and floor slab of NS located above an SS:
 - (i) Slab reinforcements at both external face and internal face shall be H13-100 c/c (both directions);
 - (ii) The shear links shall be H8-600 c/c in both directions
- (d) Ceiling slab outside the SS tower which is immediately above SS door:

The minimum ceiling slab shall be constructed of 150mm thick reinforced concrete. The reinforcement shall consist of two layers of reinforcement (top and bottom) at

H10-100 c/c in both directions. These top and bottom layers of reinforcement bars shall be continuous or anchored to the slab of SS with tension anchorage length.

- (e) Floor slab outside SS tower:

The reinforcements of every floor slab immediately outside SS tower walls shall be structurally connected to the SS tower.

- (f) SS slab which is integrated with pile-cap/footing:

For SS slab integrated with the pile-cap or footing of 500mm thick or more, shear links is not required. The maximum spacing of main reinforcement shall be 200 c/c.

- (g) Shielding wall in front of SS door:

Reinforcements at both faces of the wall shall be minimum H10-200 c/c. The shear link with L-bend at two ends shall be H8 at 600 c/c in both directions.

3.5 DETAILING OF SS TOWER

3.5.1 General

The SS tower is to be detailed to allow for the installation of services and fixtures in SS and to resist spalling of the internal face of SS walls, soffit of ceiling slabs and/or finishes on SS floor slab.

3.5.2 Lap and Anchorage Length

- (a) Full lap and anchorage length of reinforcements in SS and NS walls and slabs shall be provided. The lap length shall take into account good or poor bond condition, steel bar diameter, shape of steel bar, concrete cover, steel strength and location where reinforcement bar laps and confinement of transverse bars.
- (b) Minimum tension lap and anchorage length of reinforcement bars for minimum concrete grade C32/40 with good bond condition shall be as shown in TABLE 3.5.2. Longer tension lap and anchorage length shall be provided if they are required to meet poor bond condition and/or the structural load and safety requirements.
- (c) Welding of reinforcement to attain full anchorage length and tension lap length is not permitted.
- (d) Bundled bars are not permitted.

3.5.3 Concrete Cover

The minimum and maximum concrete cover to the main reinforcements shall be 25mm and 40mm respectively.

3.5.4 Cast-In-Situ Elements for SS and S/C SS

Cast-In-Situ for SS elements shall comply with the dimensions and detailed requirements as shown in the following figures:

- FIGURE 3.5.4(a) - Plan of SS wall
- FIGURE 3.5.4(b) - Typical details of SS slabs/walls
- FIGURE 3.5.4(c) - Typical details of SS slabs/walls
- FIGURE 3.5.4(d) - Details of SS wall reinforcement bars near SS door
- FIGURE 3.5.4(e) - Typical details of embedded conduit in SS wall
- FIGURE 3.5.4(f) - Typical details of trimmer bars for ventilation sleeve
- FIGURE 3.5.4(g) - Typical details of trimmer bars for wall recess
- FIGURE 3.5.4(h) - Details of shear kinks in SS slabs/walls
- FIGURE 3.5.4(i) - Details of SS slab reinforcement near rescue hatch
- FIGURE 3.5.4(j) - Reinforcement plan details for S/C SS
- FIGURE 3.5.4(k) - Sectional details of SS slabs/walls for S/C SS
- FIGURE 3.5.4(l) - Sectional details of SS slabs/walls for S/C SS

3.5.5 Precast Elements for SS and S/C SS

Pre-cast SS elements shall comply with the dimensions and detailed requirements as shown in the following figures:

- FIGURE 3.5.5(a) - Plan of SS walls with precast SS door frame panel (Type 1)
- FIGURE 3.5.5(b) - Details and sections of precast SS door frame panel with ventilation sleeve above it (Type 1)
- FIGURE 3.5.5(c) - Sections of precast SS door frame panel with ventilation sleeve above it (Type 1)
- FIGURE 3.5.5(d) - Details and sections of precast SS door frame panel with ventilation sleeve along its side (Type 1)
- FIGURE 3.5.5(e) - Details and sections of precast SS door frame panel with ventilation sleeve along its side (Type 1)
- FIGURE 3.5.5(f) - Plan of SS walls with precast SS door frame panel ((Type 2)
- FIGURE 3.5.5(g) - Details and sections of precast SS door frame panel with ventilation sleeve above it (Type 2)
- FIGURE 3.5.5(h) - Sections of precast SS door frame panel with ventilation sleeve above it (Type 2)
- FIGURE 3.5.5(i) - Details and sections of precast SS door frame panel with ventilation sleeve along its side (Type 2)
- FIGURE 3.5.5(j) - Sections of precast SS door frame panel with ventilation sleeve along its side (Type 2)
- FIGURE 3.5.5(k) - Plan of SS walls with precast SS door frame panel (Type 3)
- FIGURE 3.5.5(l) - Details of precast SS door frame panel (Type 3)
- FIGURE 3.5.5(m) - Sections of precast SS door frame panel (Type 3)

- FIGURE 3.5.5(n) - Sections of precast SS door frame panel (Type 3)

3.5.6 Joints

- (a) Construction joints in an SS tower shall be properly executed to ensure that the strength and the integrity of the SS are not impaired. The type and location of joints shall be specified in the design after taking into account the following:
 - (i) A concrete kicker, if provided, shall not be more than 100mm high.
 - (ii) All SS walls located within each storey shall be cast in one operation.
- (b) Expansion joints or contraction joints in the SS tower are not permitted.

3.6 PENETRATION OF SERVICES

3.6.1 Electrical Services

All service conduits shall not penetrate through the walls and slabs of the SS. Service conduit for electrical and communication fixtures which are located on external SS wall can be embedded in the SS wall. Other than this, all services conduit which do not serve the SS shall not embed within the SS wall and slab.

Two cast-in embedded sockets mounted directly back to back on the internal and external faces of the SS wall are not permitted. Where sockets are to be mounted on both the internal and external faces of an SS wall, they shall be mounted at least 300mm apart from each other, measured between their clear edges. Refer to FIGURE 3.6.1(a)

Risers for electrical services may be mounted on the external face of SS tower walls.

Where fixture in the SS are exposed on internal walls and slab, non-metallic inserts are to be used for their mounting. For embedded service cables and fixtures serving the SS, the details shall be as shown in FIGURE 3.5.4(e). The encasement of switch socket outlets, TV and radio outlets, communication line for telephony outlet and switches of Clause 2.6 shall be galvanised steel. Refer to FIGURE 3.6.1(b).

A maximum of five numbers of 25mm diameter service conduits for electrical cables serving the SS are allowed to be embedded in the SS structural elements. Both ends of the concealed conduits shall be fully sealed with approved sealing material of up to a depth of not less than 100mm into the conduits to ensure air-tightness of the SS.

Where an SS or NS share a common wall with lift shaft or service risers, mounting of services on the common wall is allowed on the external face of SS or NS wall. For the purpose of installing M&E equipment in the lift core or service risers, hot-dipped galvanised cast-in bar with threaded end shall be used in this common wall. Where anchor bolts are used, they shall be installed according to manufacturer's technical specification. The spacing the anchor bolts, measured between their centrelines, shall not be less than 300mm.

3.6.2 Water and Gas Services

Water and gas services are allowed to pass through the SS walls provided that they are laid within a stainless steel conduit encased by 150mm reinforced concrete all round. Refer to FIGURE 3.6.2. Joints in pipes or the stainless steel conduit shall be located outside the SS. Risers for services can be mounted on the external face of SS tower walls.

TABLE 3.3.4: ACTION COMBINATION AND VALUES OF PARTIAL SAFETY FACTORS FOR ULTIMATE LIMIT STATE

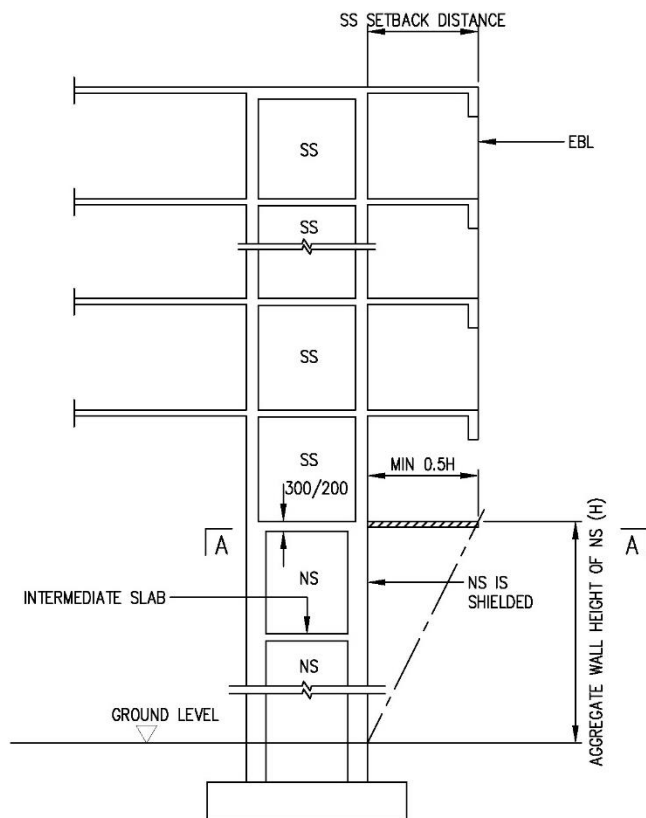
Action Combination	Permanent Action		Variable Action		Earth/Water Pressure Load, if applicable
	Favourable	Unfavourable	Imposed Load	Wind Load	
Permanent and Variable (Imposed Load, Wind Load), Earth/Water Pressure Load, if applicable)	1.0	1.0	1.0	1.0	1.0

TABLE 3.4.2.1: MINIMUM REINFORCEMENTS OF SS OR NS WALLS

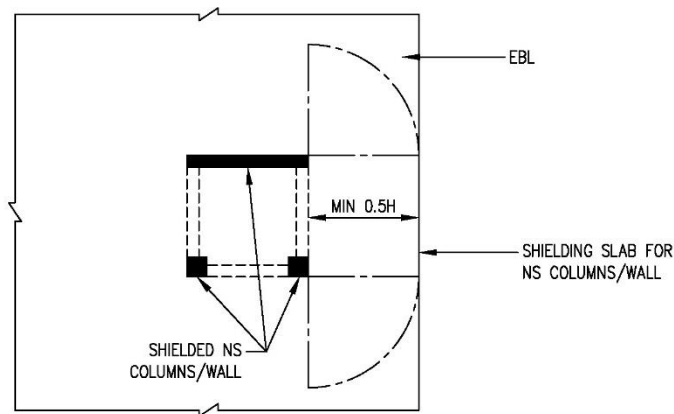
SS/NS Clear Height (mm)	Reinforcement at both internal and external face of wall (both directions)	Shear Links (both directions)
$2400 \leq H_t \leq 3400$	H13 - 100 c/c	H8 - 600 c/c
$3400 < H_t \leq 3900$	H16 - 100 c/c	H8 - 600 c/c

TABLE 3.5.2: MINIMUM TENSION LAP AND ANCHORAGE LENGTH

Type	Reinforcement Bar Diameter \varnothing (mm)	
	$10 \leq \varnothing \leq 16$	$16 < \varnothing \leq 32$
Lap Length	47 \varnothing	52 \varnothing
Anchorage Length	37 \varnothing	37 \varnothing

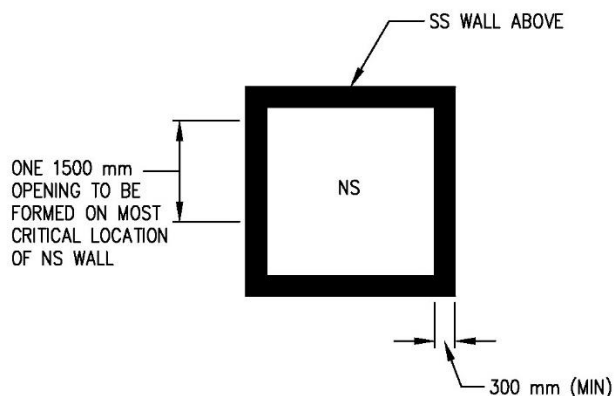


SECTION

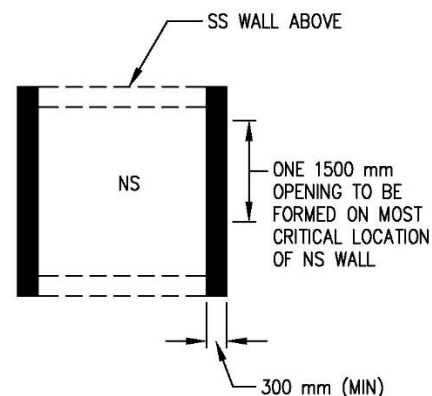


SECTION A-A (PLAN)

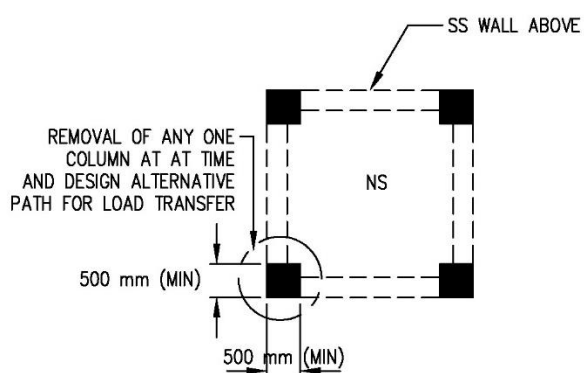
**FIGURE 3.3.3 SHIELDED NS WALLS AND/OR NS COLUMNS
(NS COLUMNS NOT APPLICABLE TO S/C SS OR SCISSOR S/C SS TOWER)**



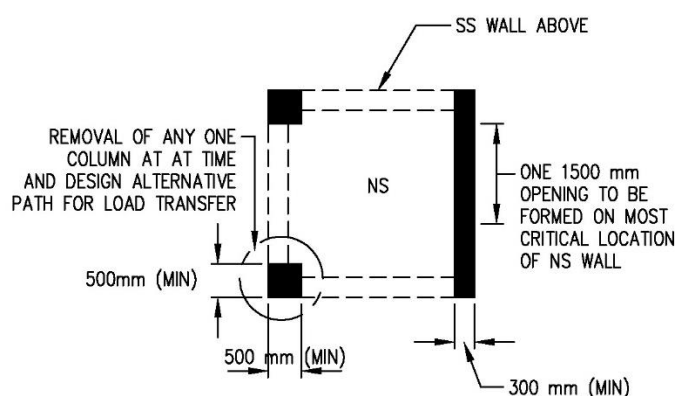
**FIGURE 3.3.4(a) UNSHIELDED
NS WALL(S)**



**FIGURE 3.3.4(b) UNSHIELDED NS
WALL(S)**



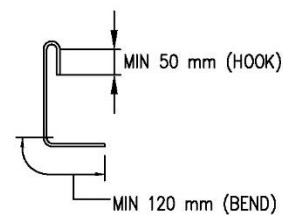
**FIGURE 3.3.4(c) UNSHIELDED
NS COLUMN(S)
(NS COLUMNS NOT APPLICABLE TO S/C SS OR
SCISSOR S/C SS TOWER)**



**FIGURE 3.3.4(d) COMBINATION OF
UNSHIELDED NS WALL(S) AND/OR NS
COLUMN(S)
(NS COLUMNS NOT APPLICABLE TO S/C SS OR
SCISSOR S/C SS TOWER)**



1. WALL REINFORCEMENT REFER TO TABLE 3.4.2.1

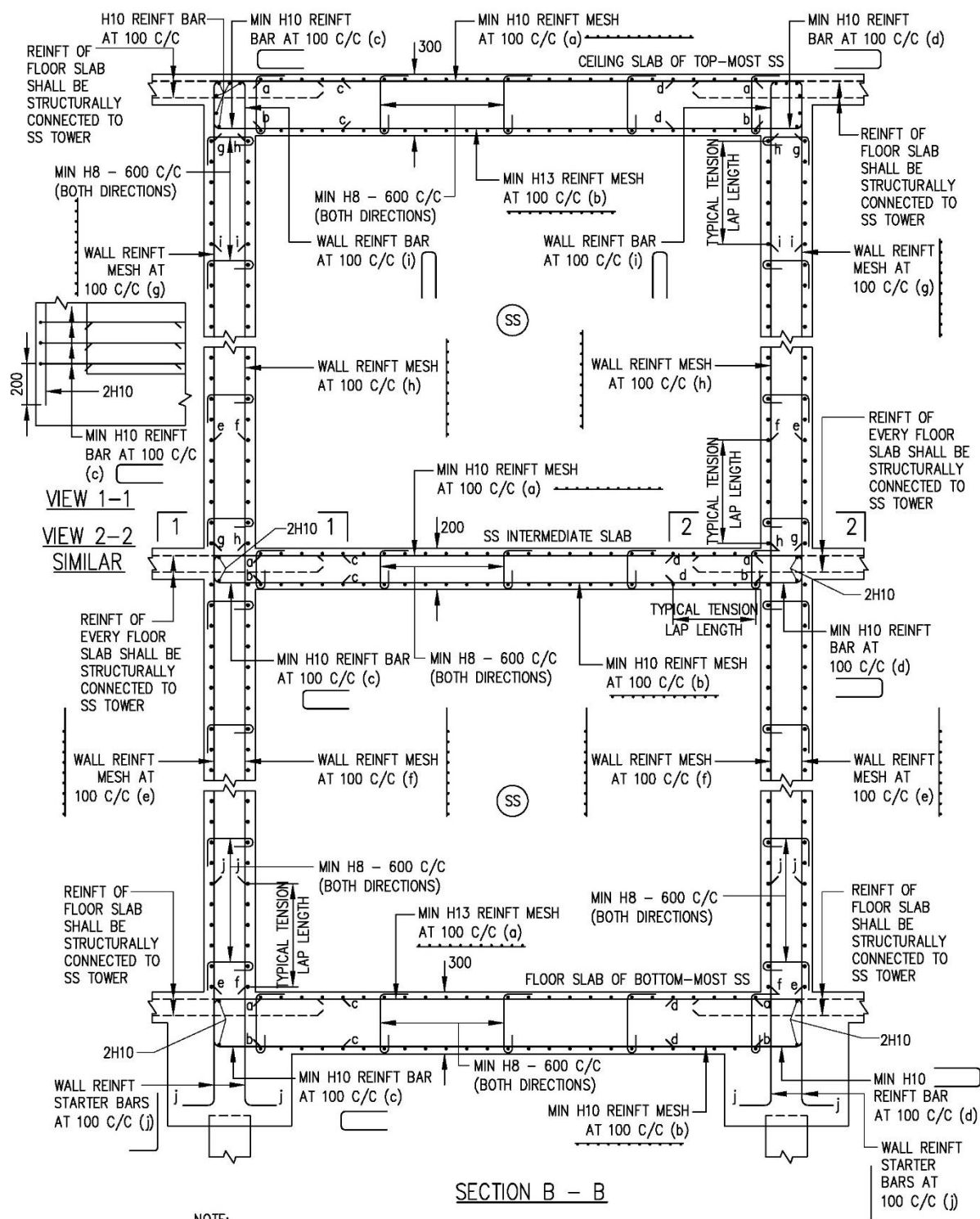


MINIMUM HOOK AND BEND ALLOWANCE FOR SHEAR LINKS (H8)

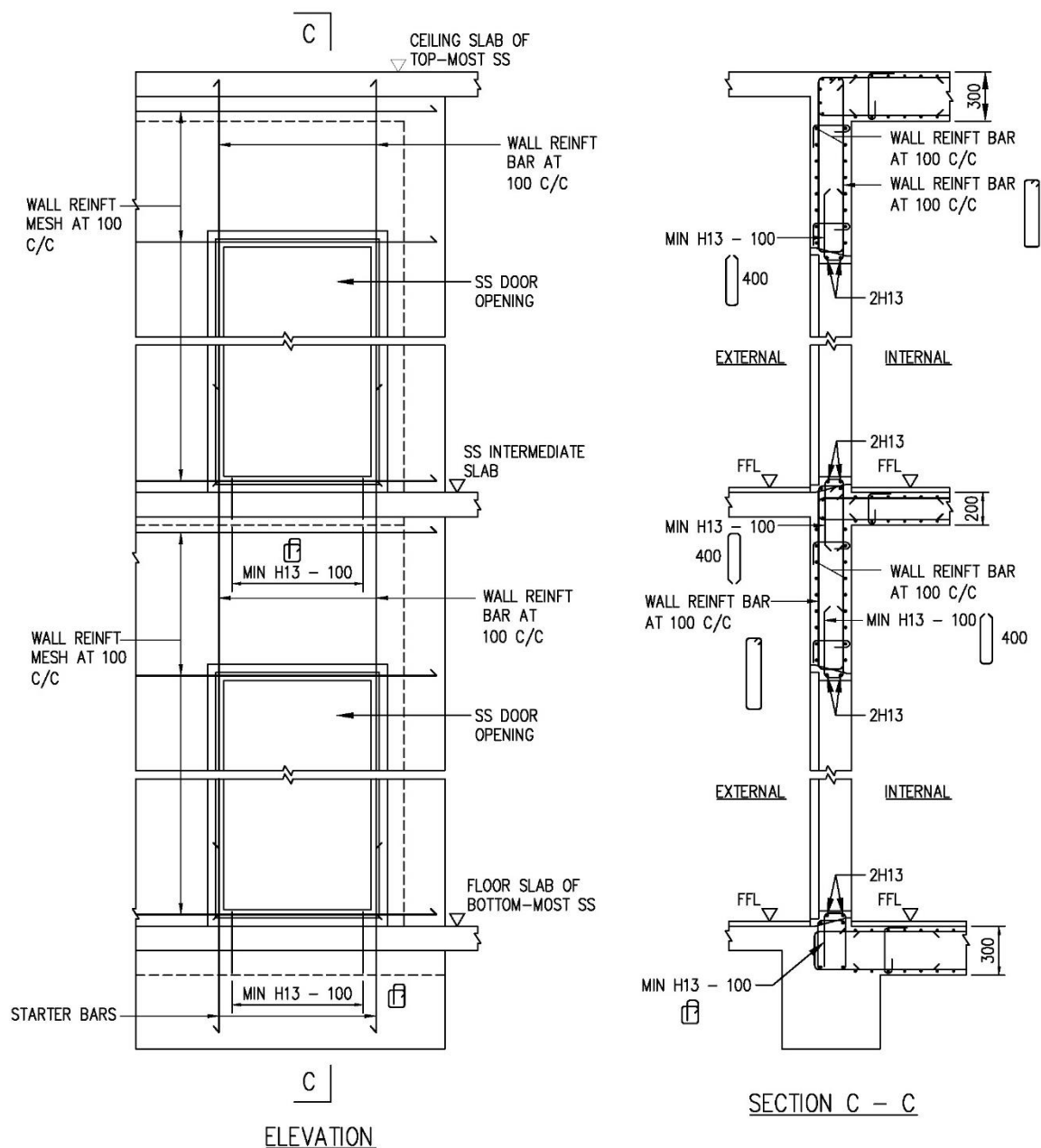
FIGURE 3.5.4(a) PLAN OF SS WALL



FIGURE 3.5.4(b) SECTIONAL DETAILS OF SS SLABS/ WALLS



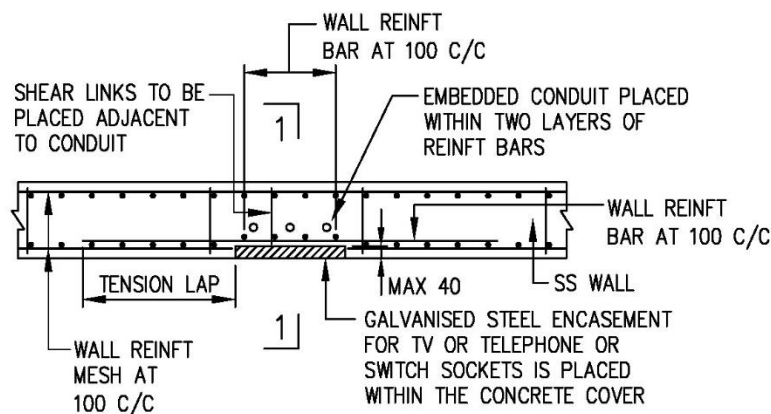
3.5.4(c) SECTIONAL DETAILS OF SS SLABS/ WALLS



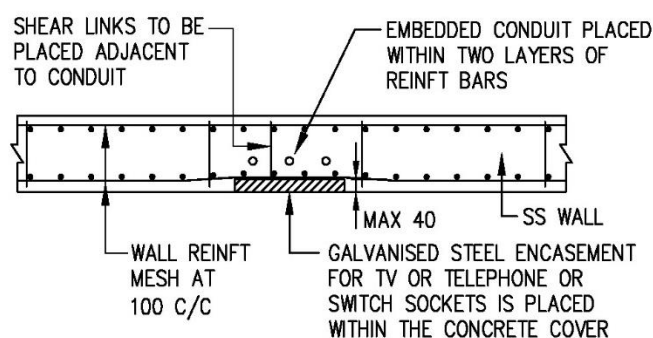
NOTE:

1. WALL REINFORCEMENT REFER TO TABLE 3.4.2.1

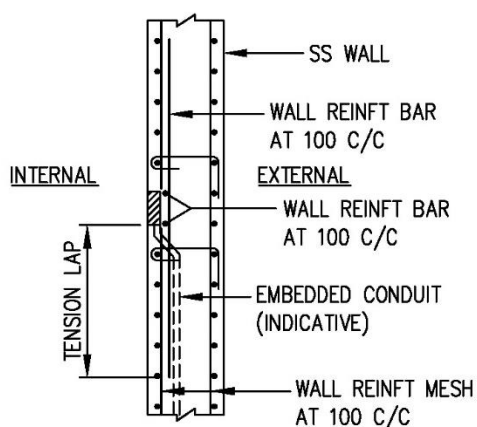
FIGURE 3.5.4(d) DETAILS OF SS WALL REINFORCEMENT BARS NEAR SS DOOR



PLAN
(IF REINFORCEMENT BARS ARE CUT)



PLAN
(REINFORCEMENT BARS ARE NOT CUT)



SECTION 1 – 1

NOTE:

1. WALL REINFORCEMENT REFER TO TABLE 3.4.2.1

FIGURE 3.5.4(e) TYPICAL DEATILS OF EMBEDDED CONDUIT IN SS WALL

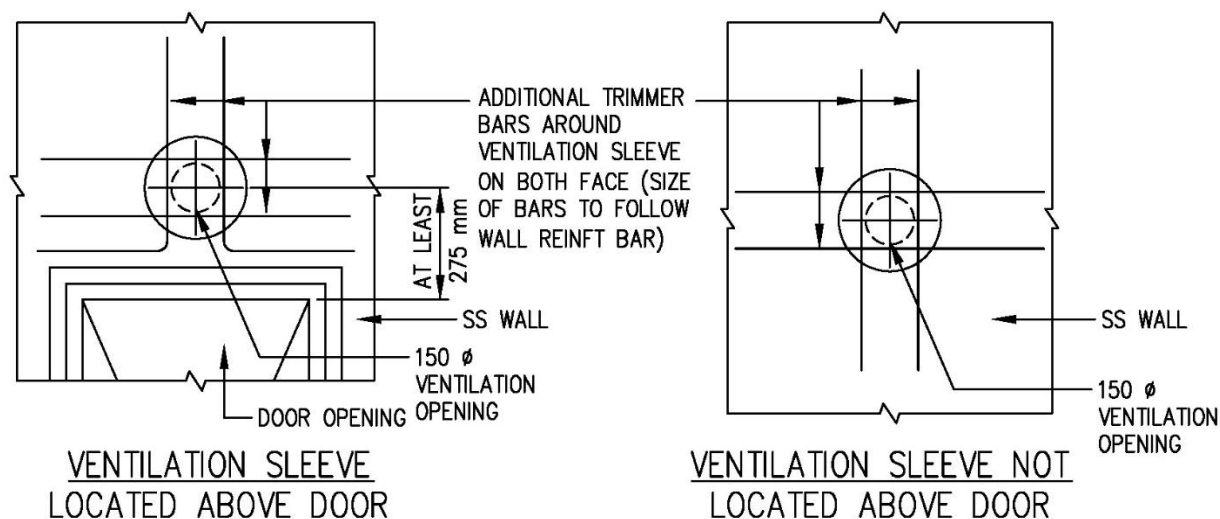
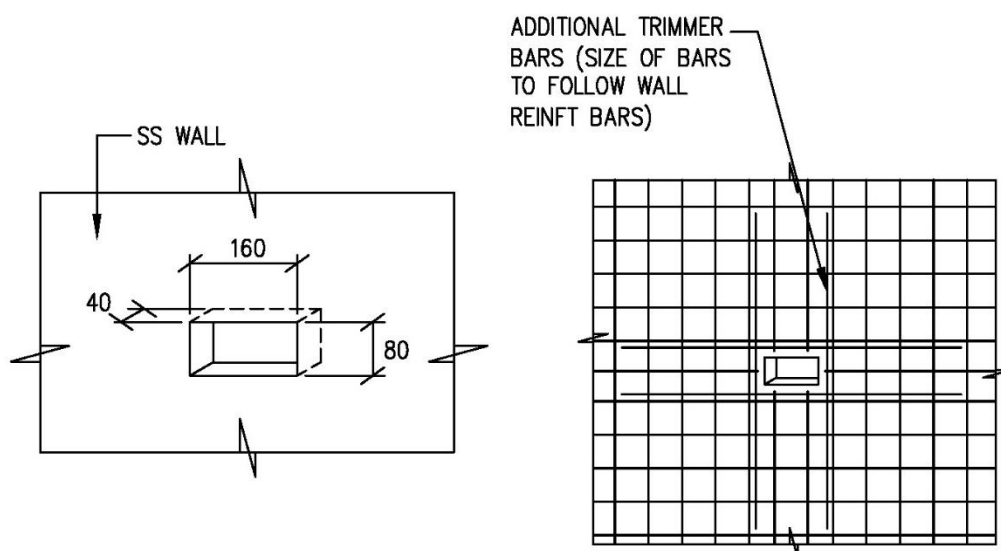


FIGURE 3.5.4(f) TYPICAL DETAILS OF TRIMMER BARS FOR VENTILATION SLEEVE



ELEVATION OF WALL RECESS
(IF WALL REINFORCEMENT BARS ARE CUT FOR WALL RECESS)

NOTE:

1. WALL REINFORCEMENT REFER TO TABLE 3.4.2.1

FIGURE 3.5.4(g) TYPICAL DETAILS OF TRIMMER BARS FOR WALL RECESS

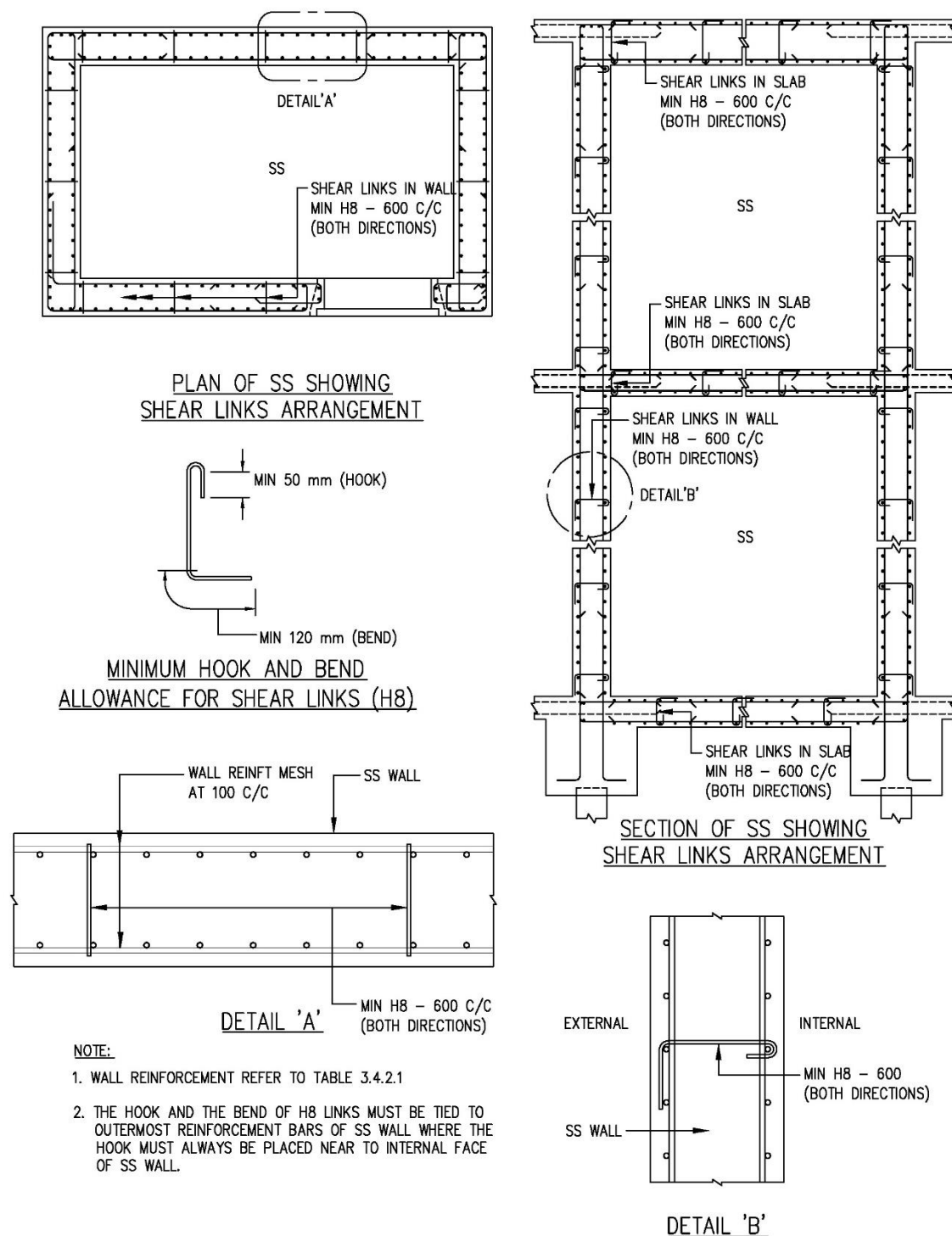
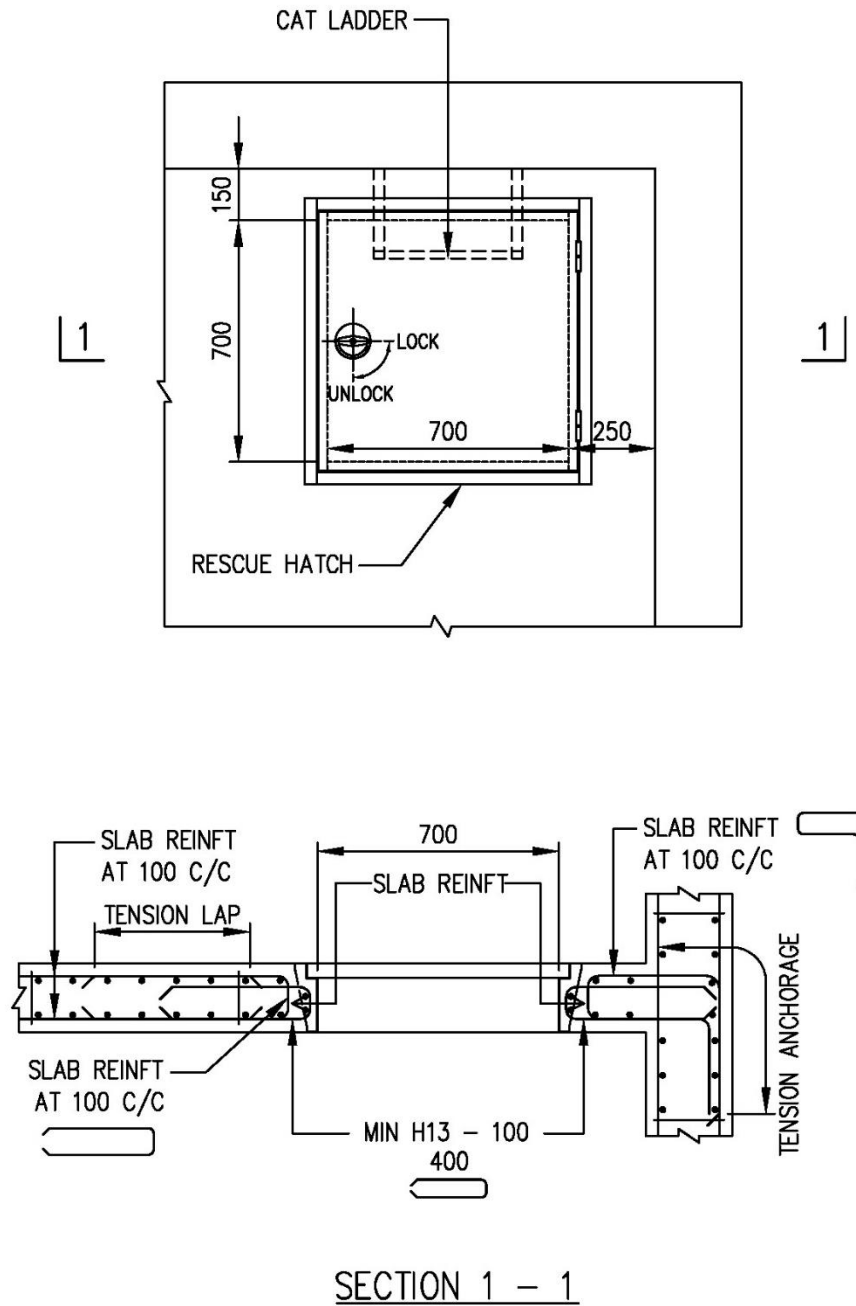


FIGURE 3.5.4(h) DETAILS OF SHEAR LINKS IN SS SLABS/ WALLS

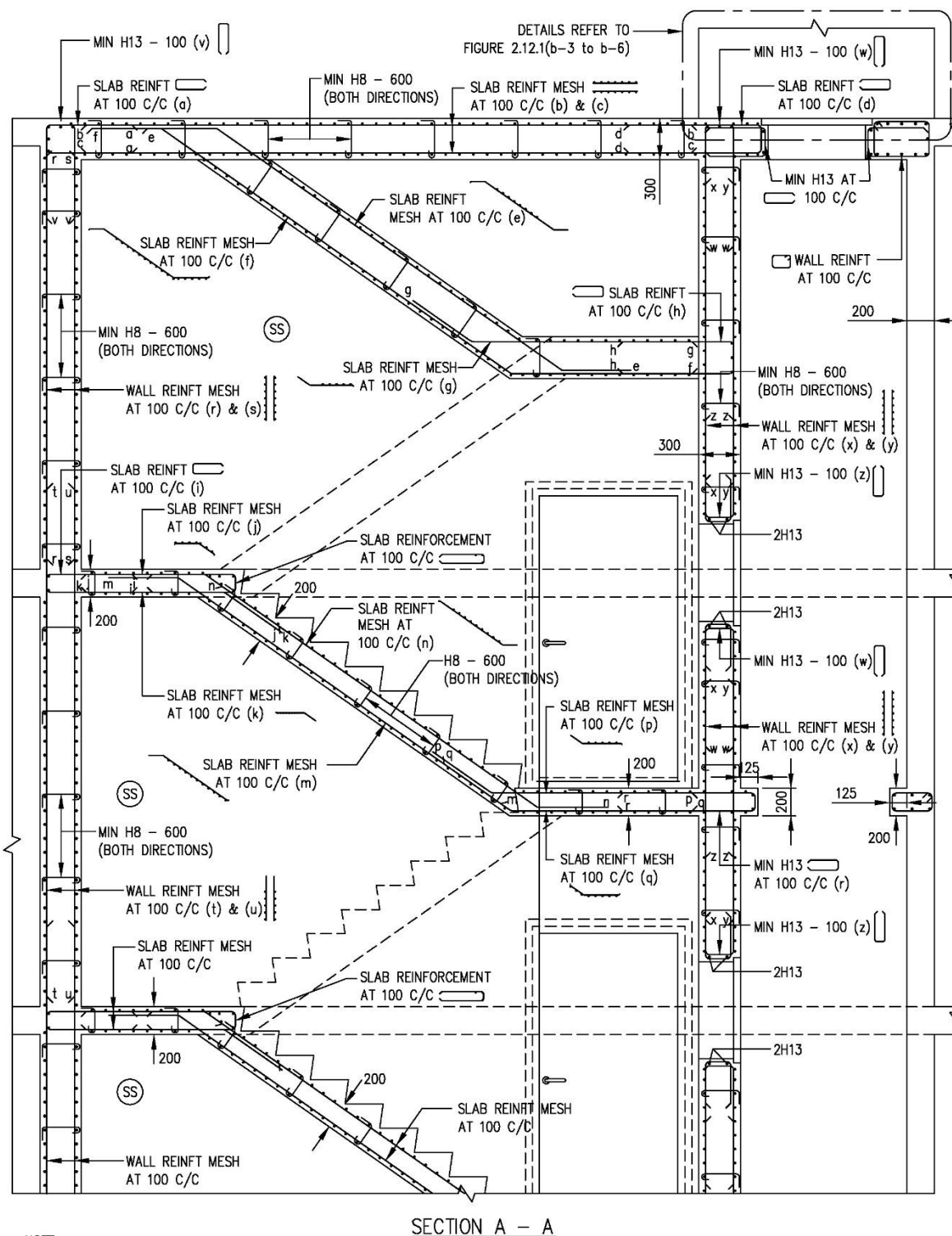


NOTE:

1. WALL REINFORCEMENT REFER TO TABLE 3.4.2.1

FIGURE 3.5.4(i) DETAILS OF SS SLAB REINFORCEMENT NEAR RESCUE HATCH

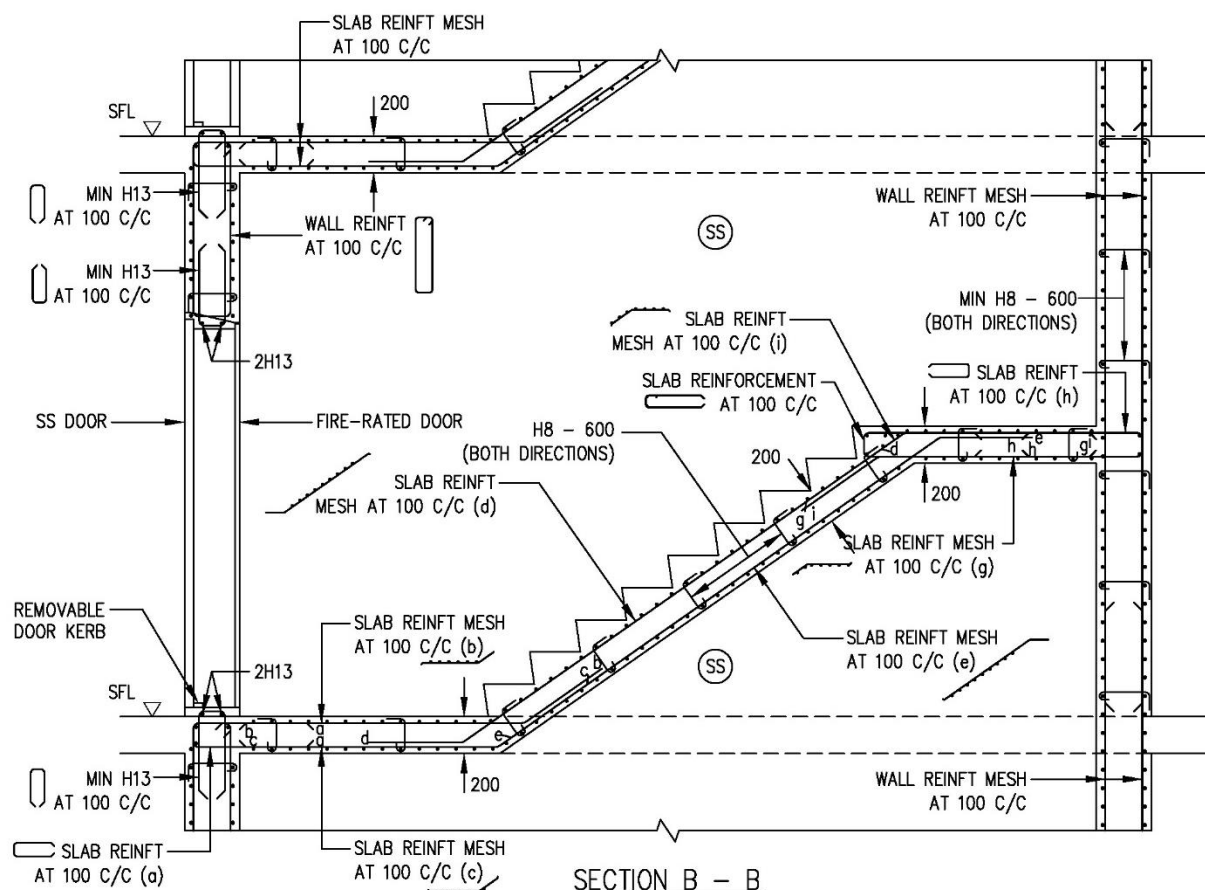




NOTE:

1. WALL REINFORCEMENT REFER TO TABLE 3.4.2.1

FIGURE 3.5.4(k) SECTIONAL DETAILS OF SS SLABS/ WALLS FOR S/C SS



NOTE:

1. WALL REINFORCEMENT REFER TO TABLE 3.4.2.1

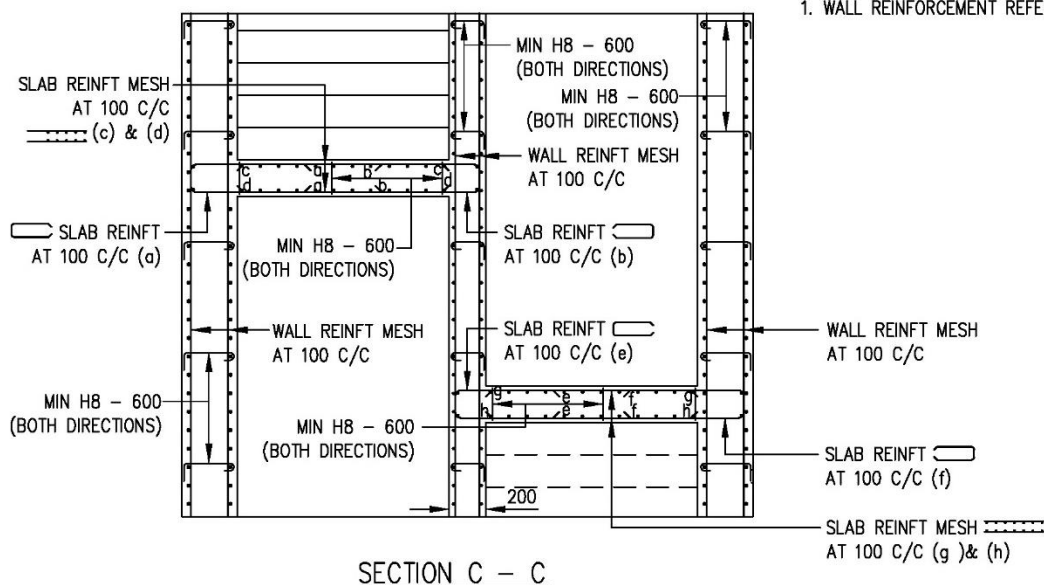
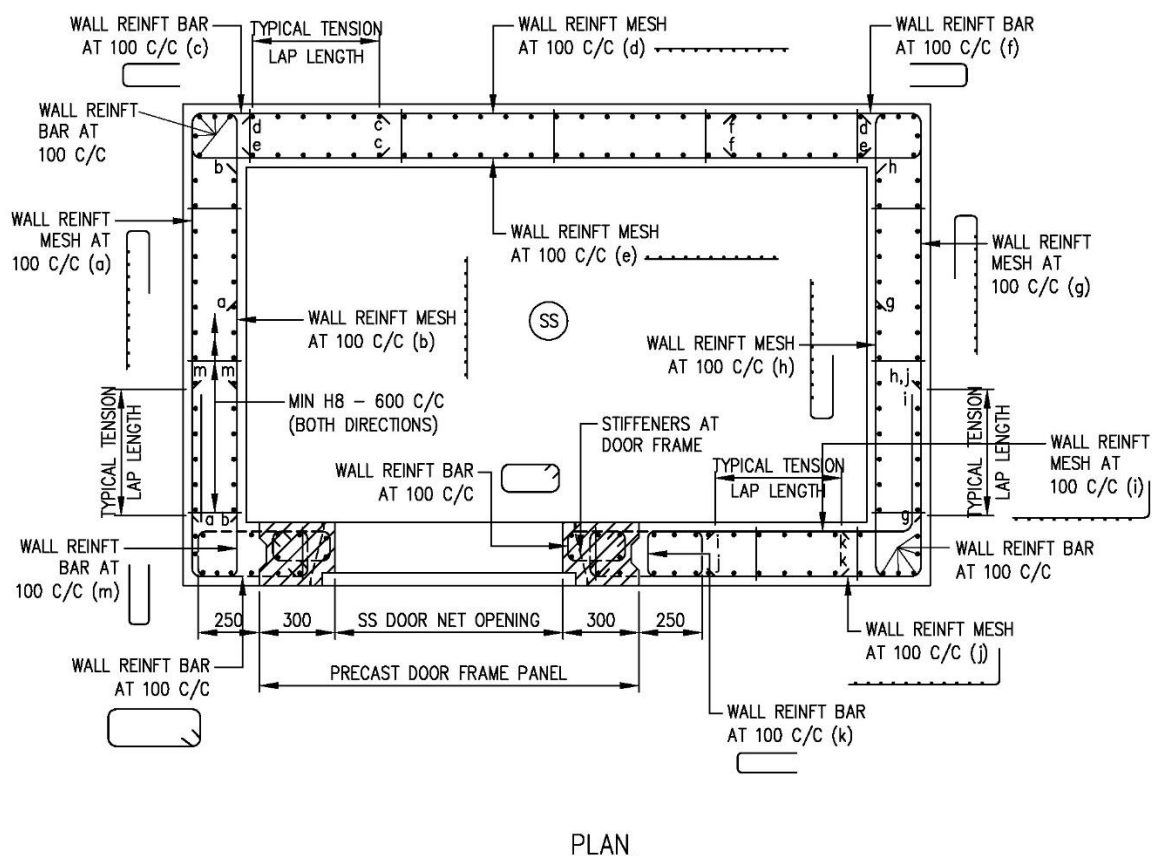


FIGURE 3.5.4(i) SECTIONAL DETAILS OF SS SLABS/ WALLS FOR S/C SS



NOTE:

1. WALL REINFORCEMENT REFER TO TABLE 3.4.2.1

FIGURE 3.5.5(a) PLAN OF SS WITH PRECAST SS DOOR FRAME PANEL (TYPE 1)

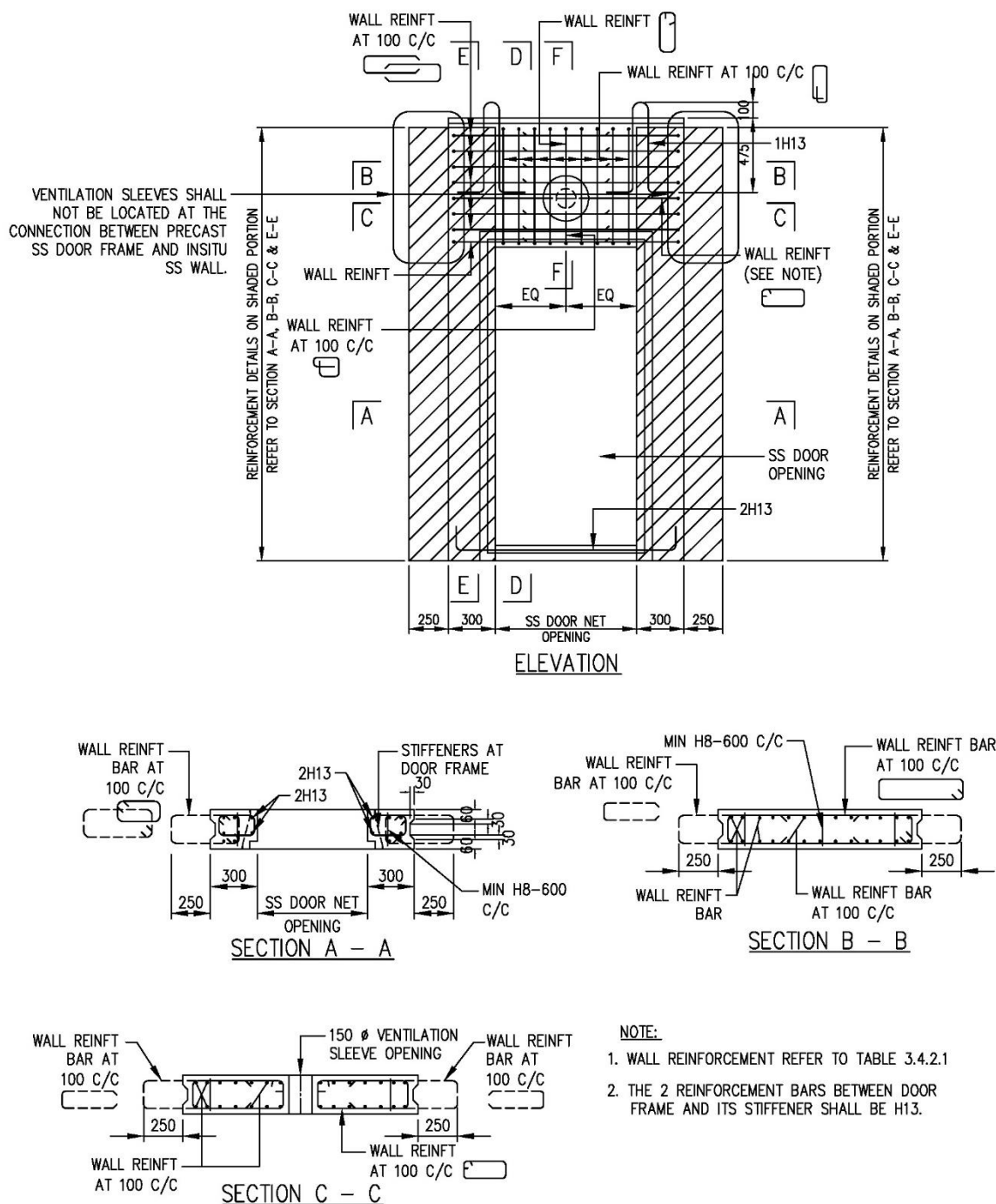


FIGURE 3.5.5(b) DETAILS AND SECTIONS OF PRECAST SS DOOR FRAME PANEL WITH VENTILATION SLEEVE ABOVE IT (TYPE 1)

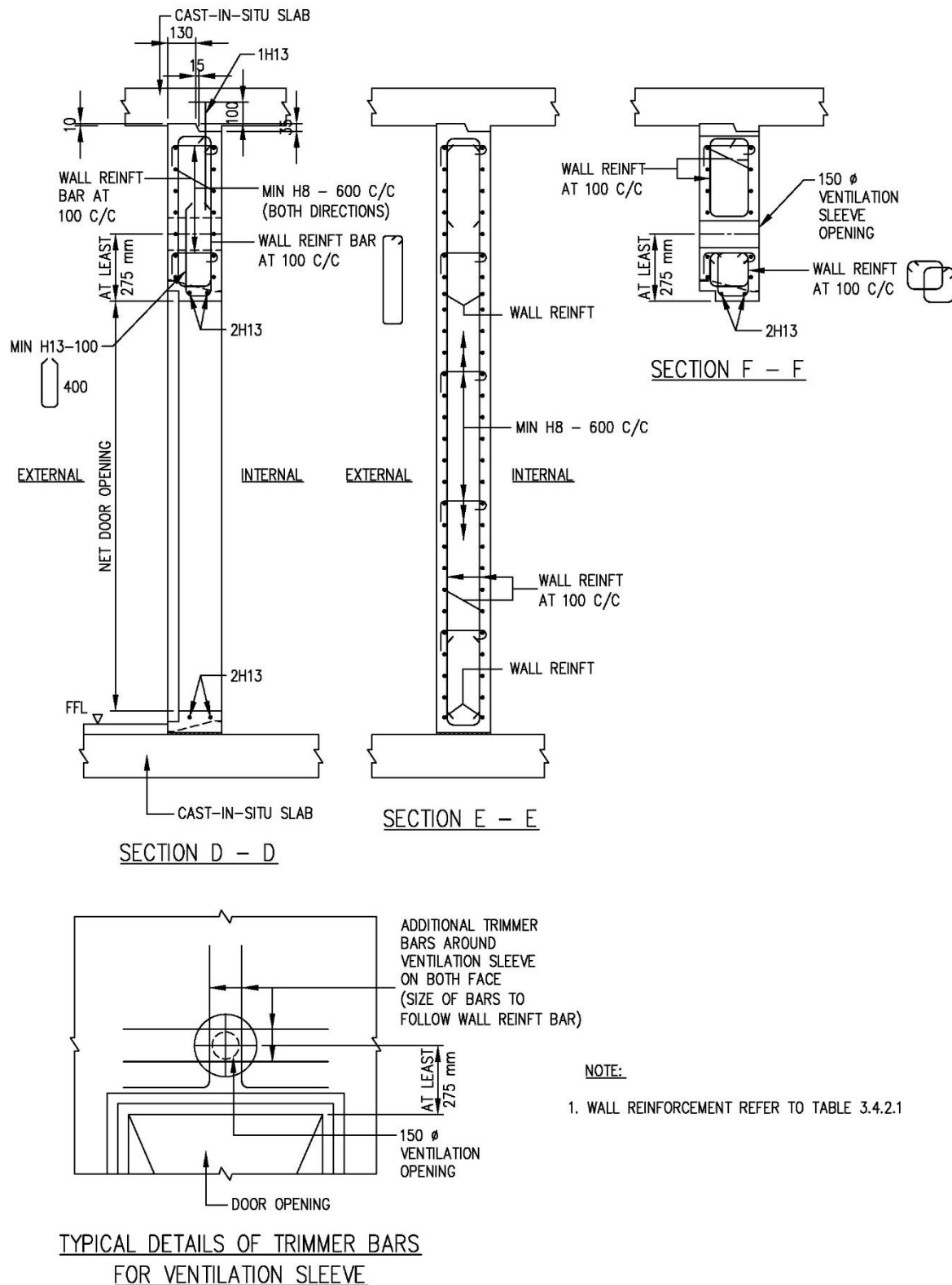


FIGURE 3.5.5(c) SECTIONS OF PRECAST SS DOOR FRAME PANEL WITH VENTILATION SLEEVE ABOVE IT (TYPE 1)

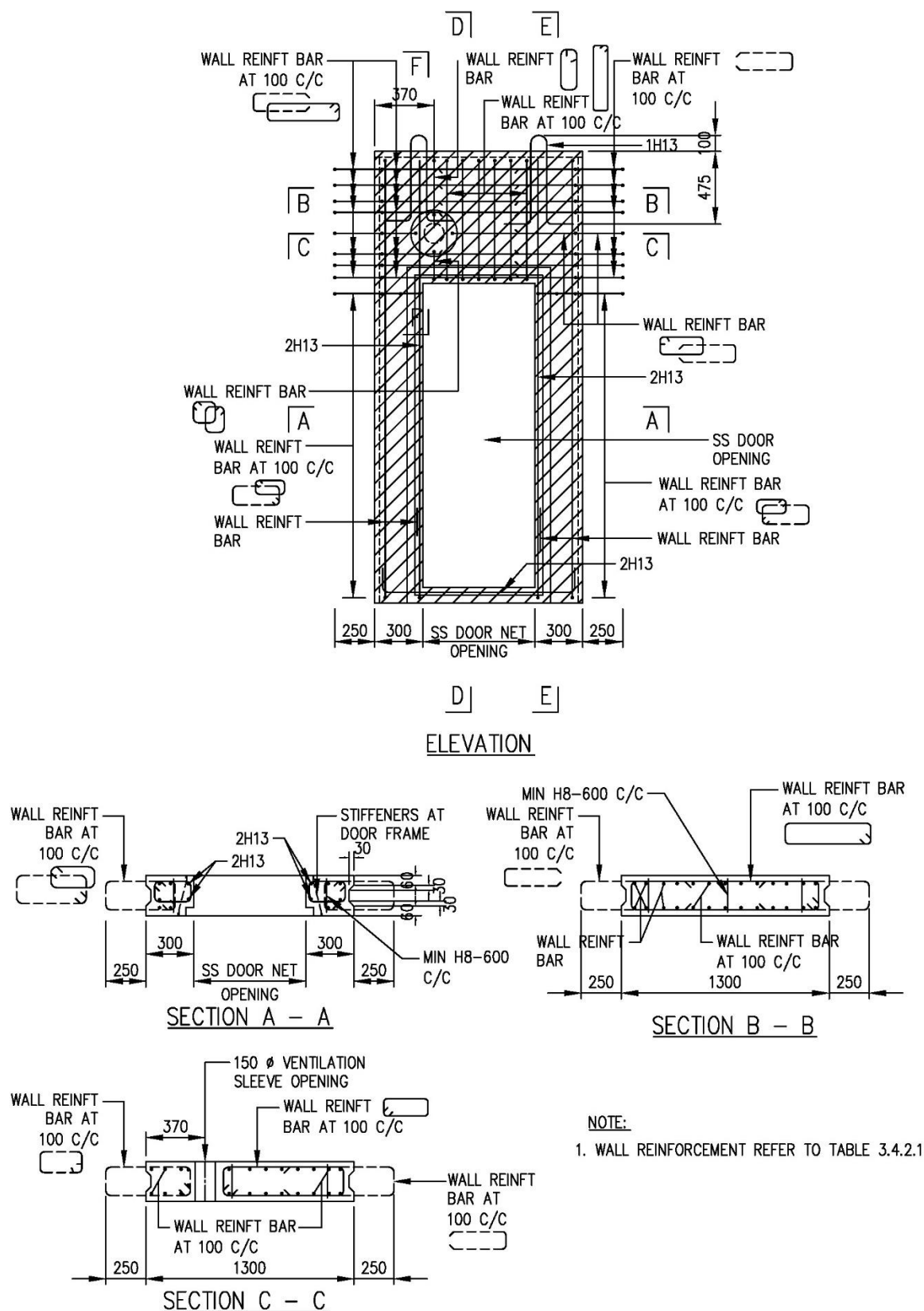


FIGURE 3.5.5(d) DETAILS AND SECTIONS OF PRECAST SS DOOR FRAME WITH VENTILATION SLEEVE ALONG ITS SIDE (TYPE 1)

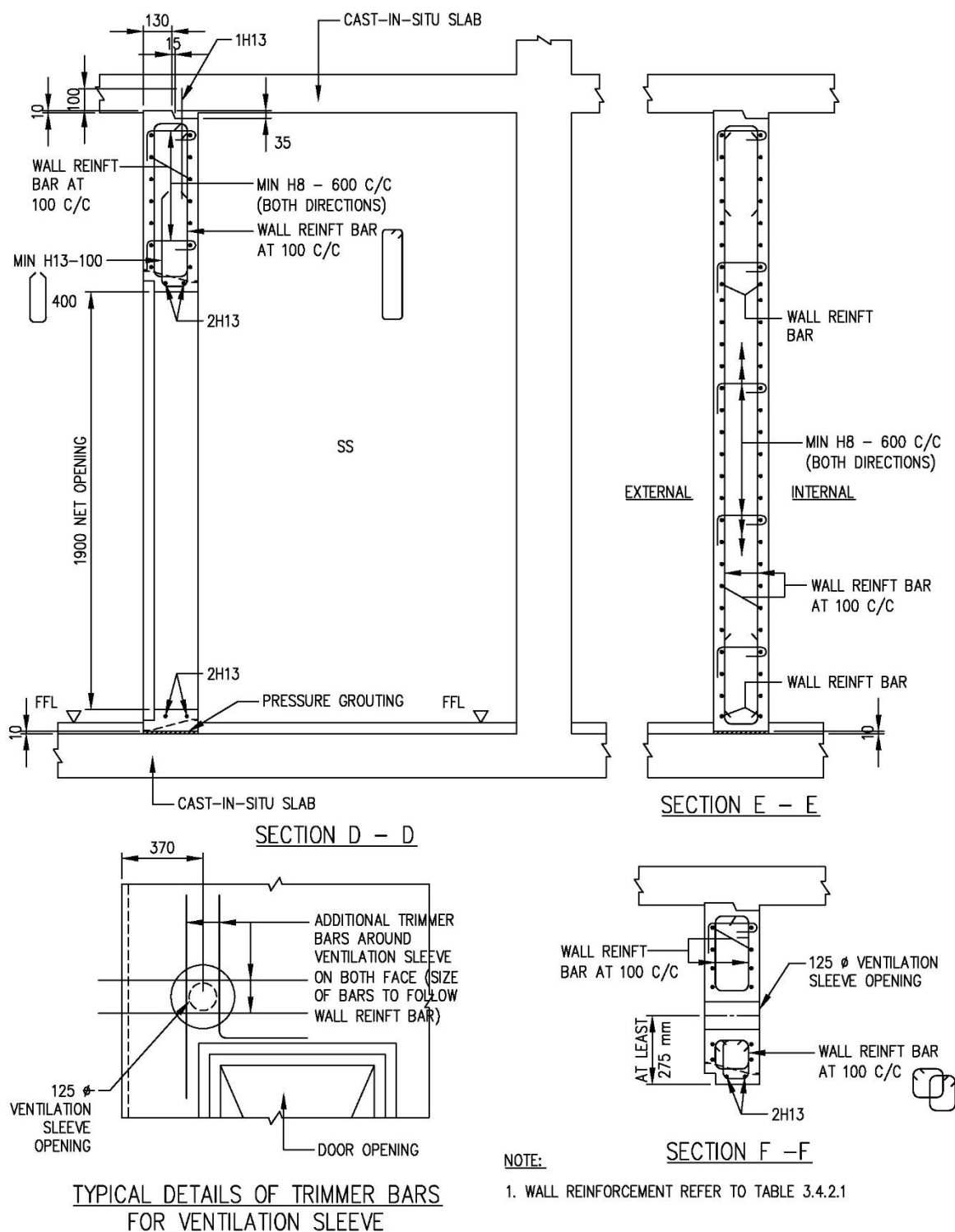
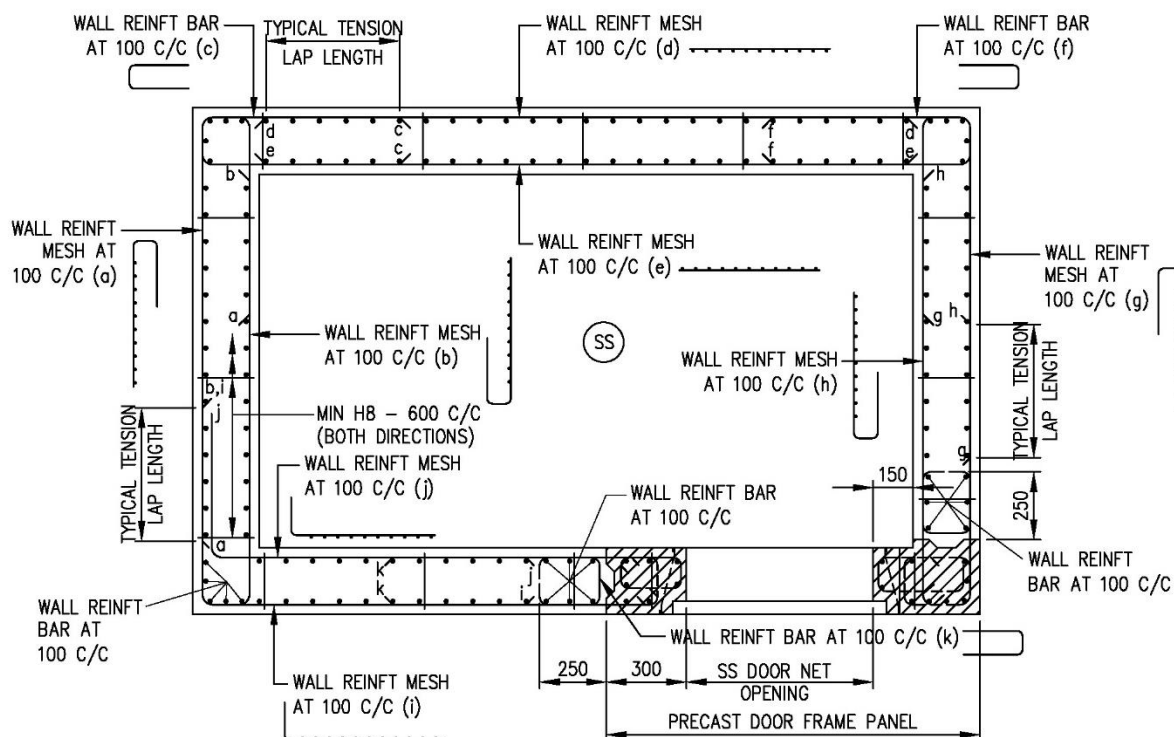


FIGURE 3.5.5(e) DETAILS AND SECTIONS OF PRECAST SS DOOR FRAME WITH VENTILATION SLEEVE ALONG ITS SIDE (TYPE 1)



NOTE:

1. WALL REINFORCEMENT REFER TO TABLE 3.4.2.1

FIGURE 3.5.5(f) PLAN OF SS WITH PRECAST SS DOOR FRAME PANEL

(TYPE 2)

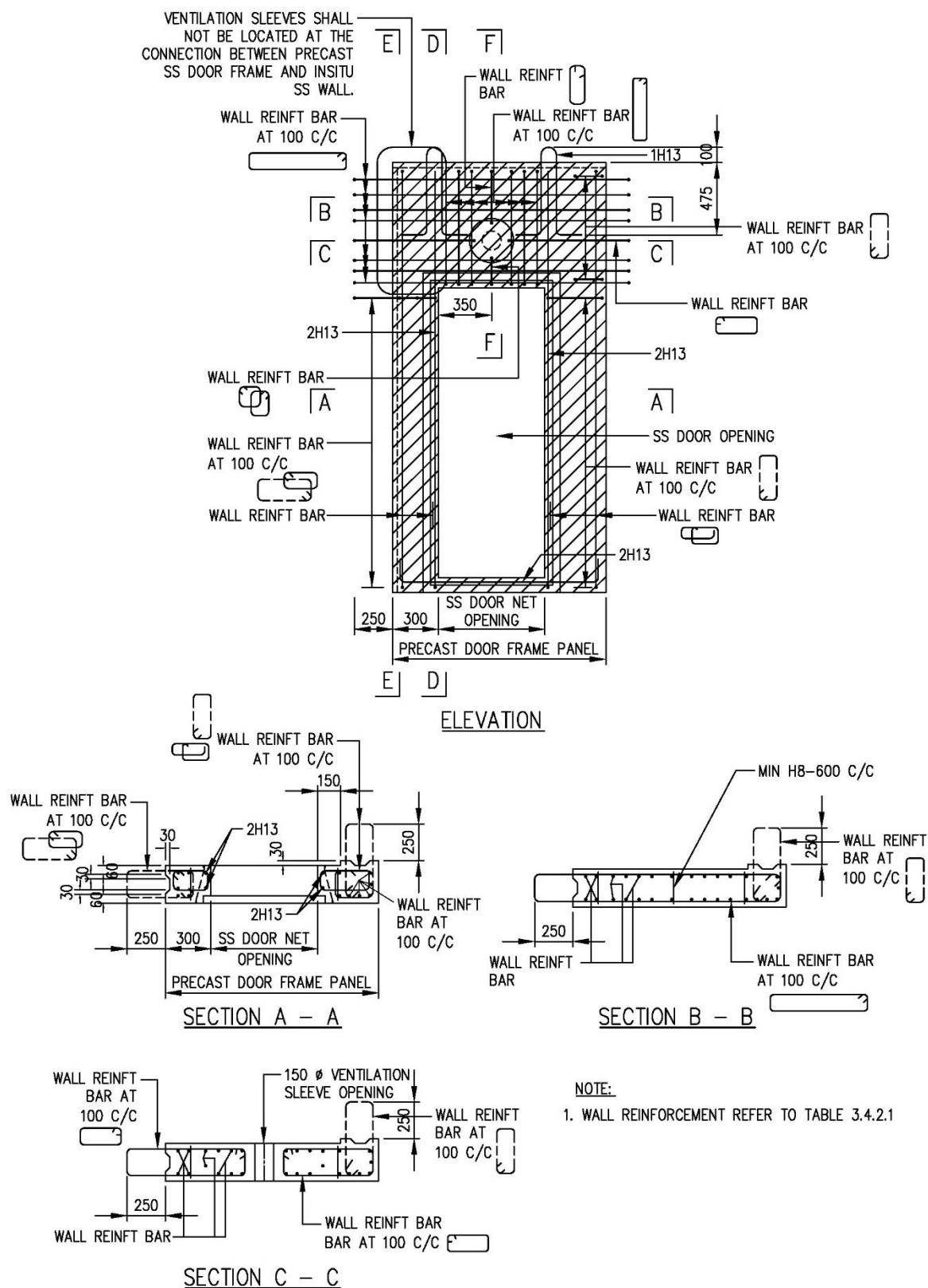


FIGURE 3.5.5(g) DETAILS AND SECTIONS OF PRECAST DOOR FRAME PANEL WITH VENTILATION SLEEVE ABOVE IT (TYPE 2)

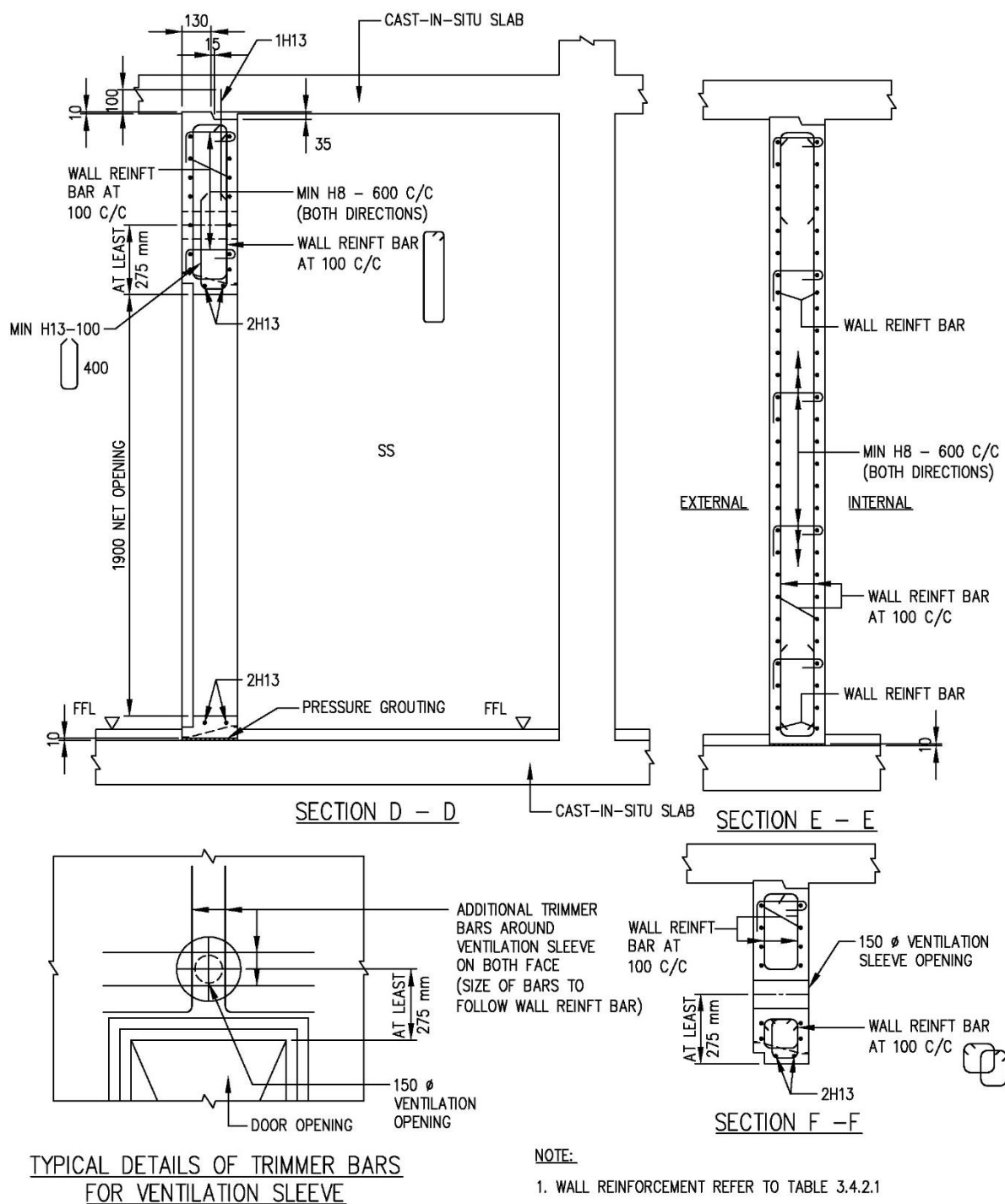


FIGURE 3.5.5(h) SECTIONS OF PRECAST SS DOOR FRAME PANEL WITH VENTILATION SLEEVE ABOVE IT (TYPE 2)

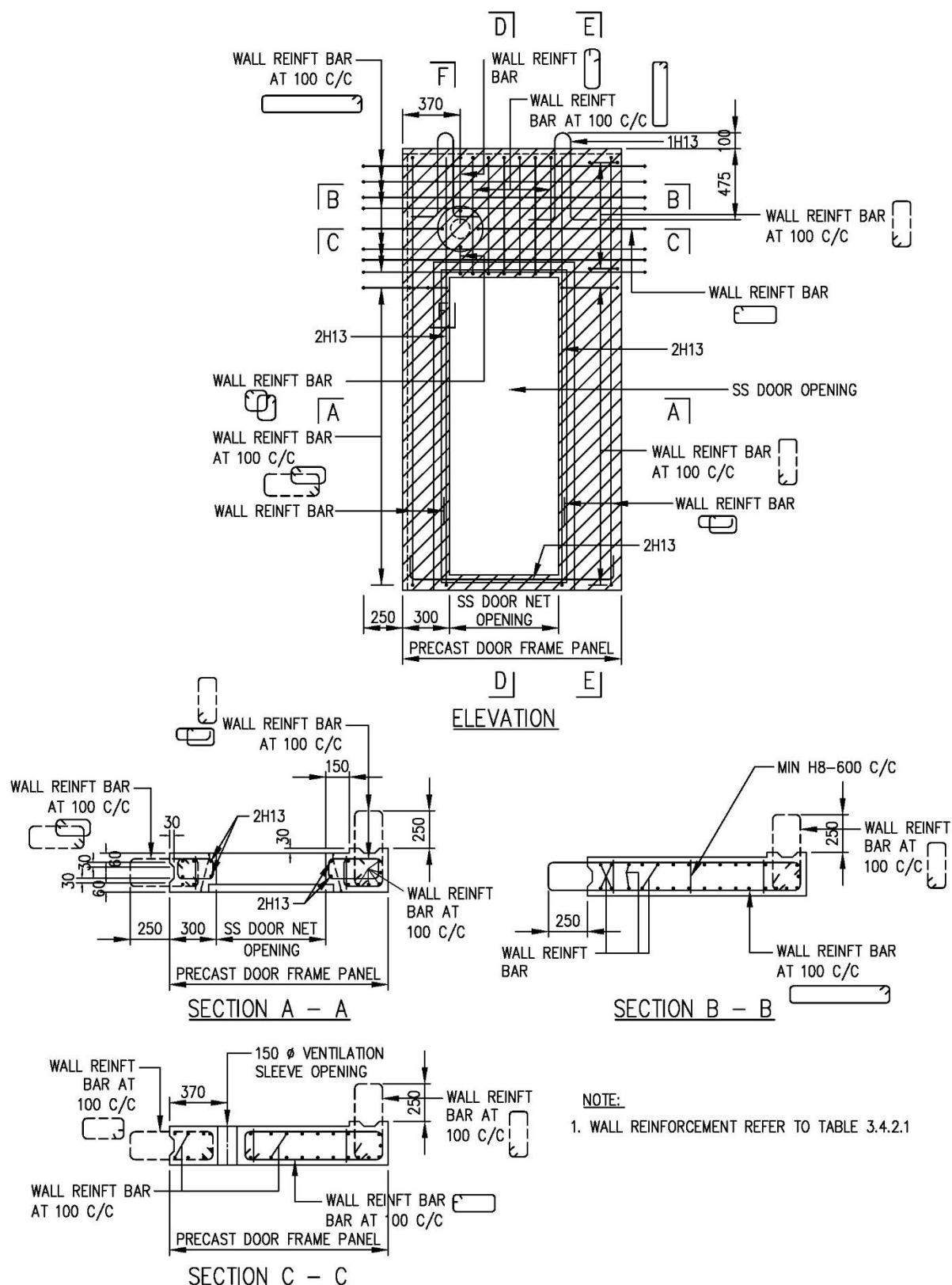


FIGURE 3.5.5(i) DETAILS AND SECTIONS OF PRECAST SS DOOR FRAME PANEL WITH VENTILATION SLEEVE ALONG ITS SIDE (TYPE 2)

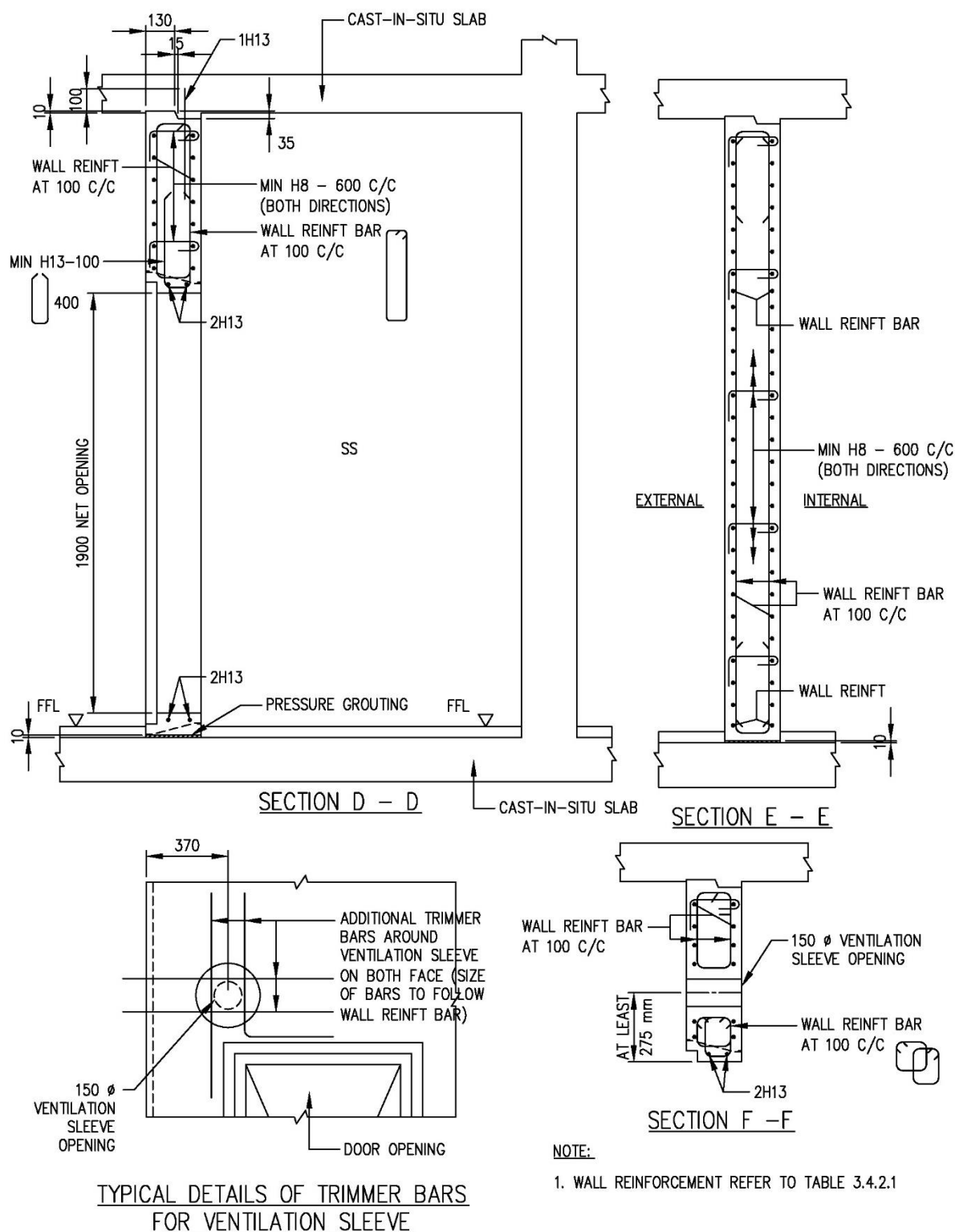
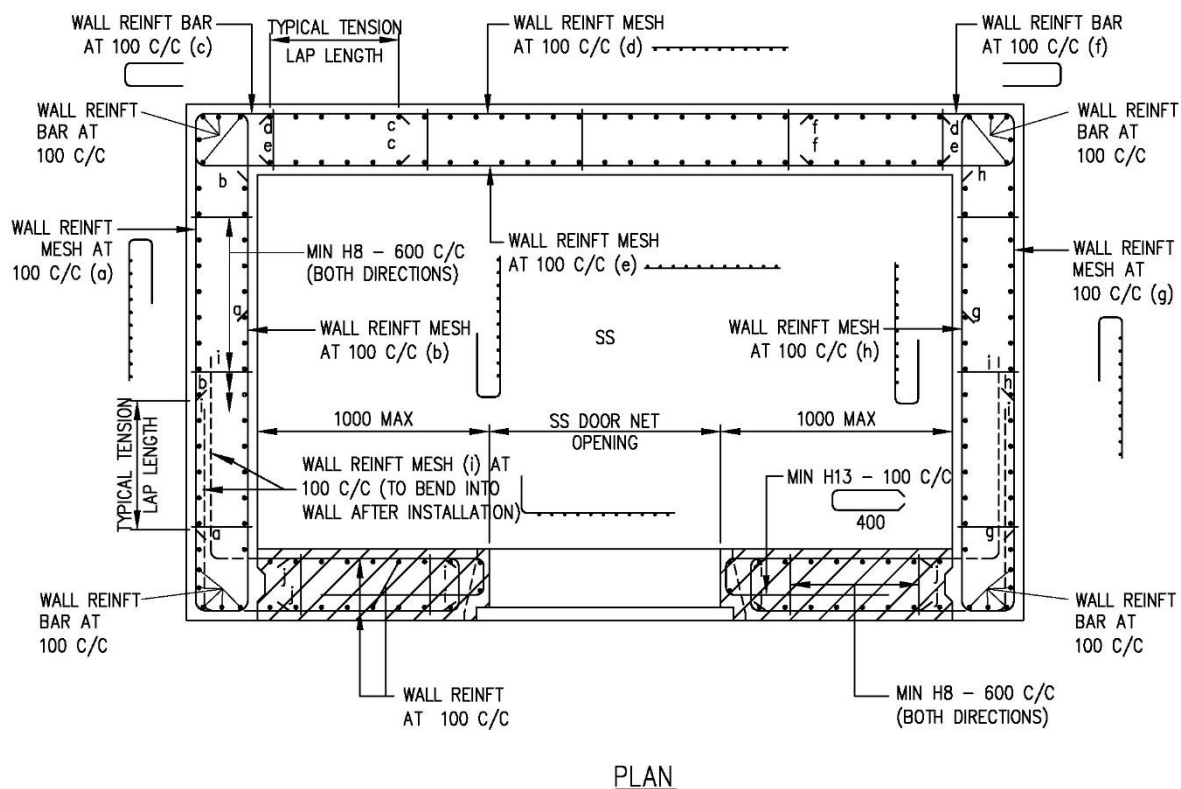


FIGURE 3.5.5(i) SECTIONS OF PRECAST SS DOOR FRAME PANEL WITH VENTILATION SLEEVE ALONG ITS SIDE (TYPE 2)



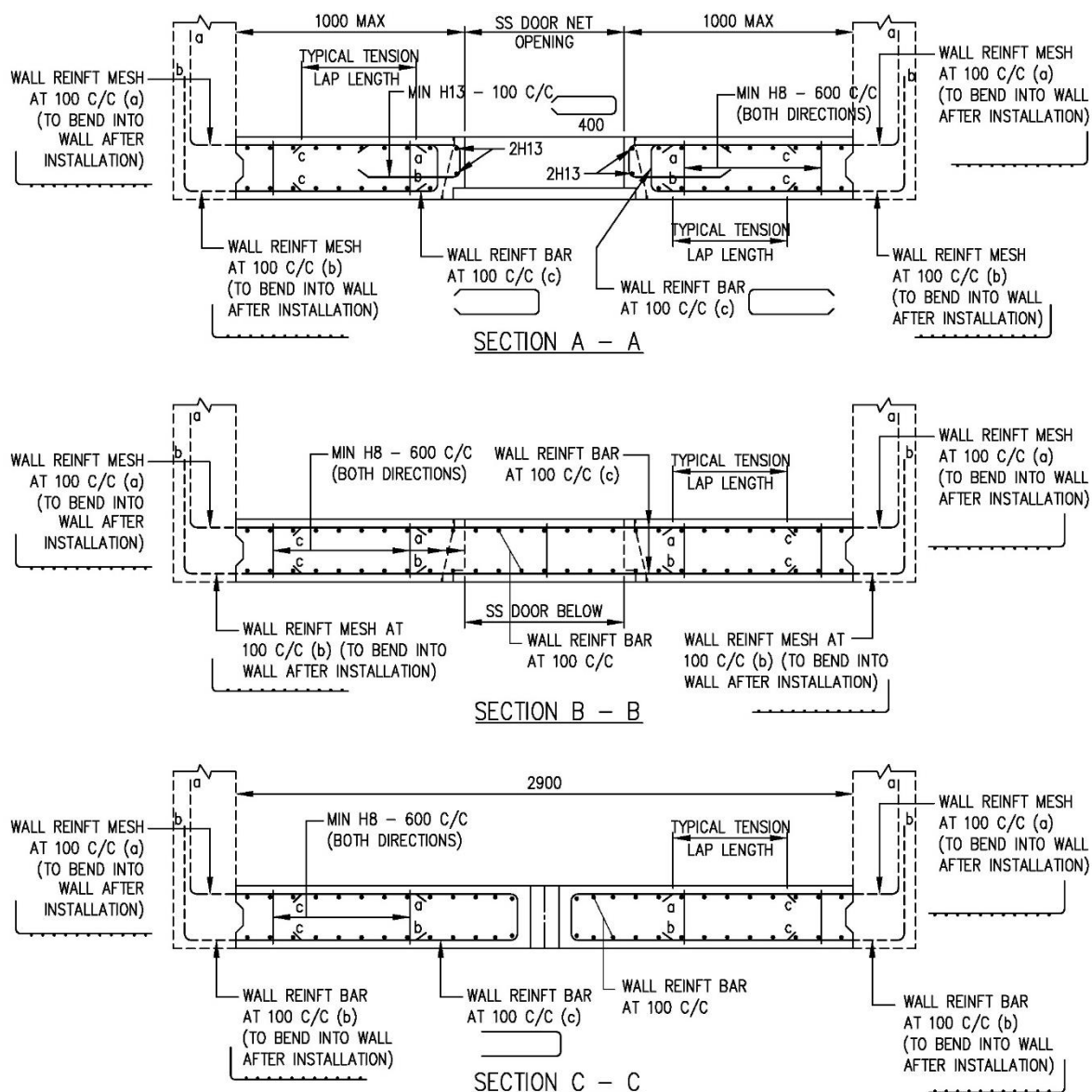
NOTE:

1. WALL REINFORCEMENT REFER TO TABLE 3.4.2.1

FIGURE 3.5.5(k) PLAN OF SS WALLS WITH PRECAST SS DOOR FRAME PANEL (TYPE 3)



FIGURE 3.5.5(1) DETAILS OF PRECAST SS DOOR FRAME PANEL (TYPE 3)



NOTE:

1. WALL REINFORCEMENT REFER TO TABLE 3.4.2.1

FIGURE 3.5.5(m) SECTIONS OF PRECAST SS DOOR FRAME PANEL (TYPE 3)

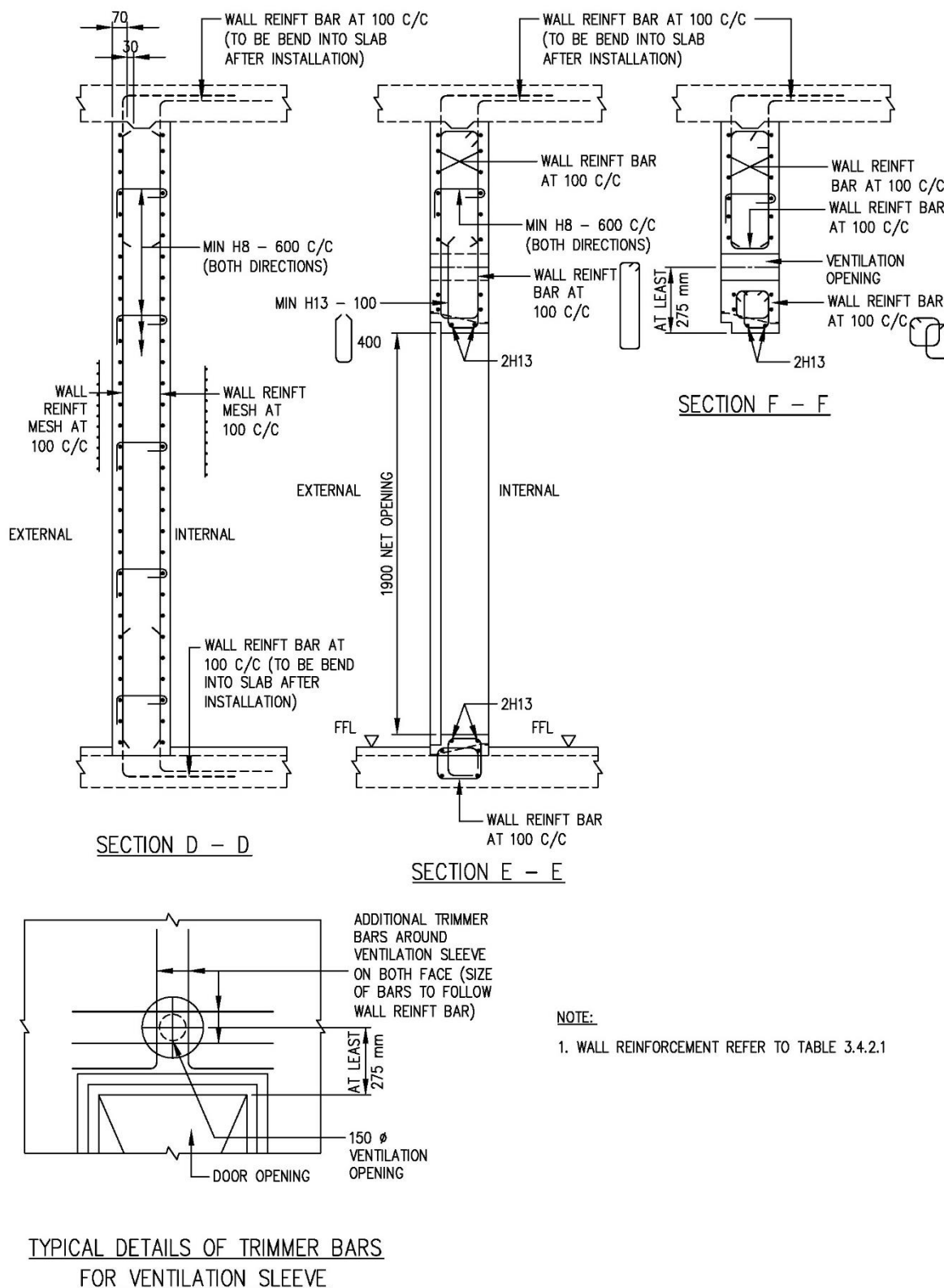
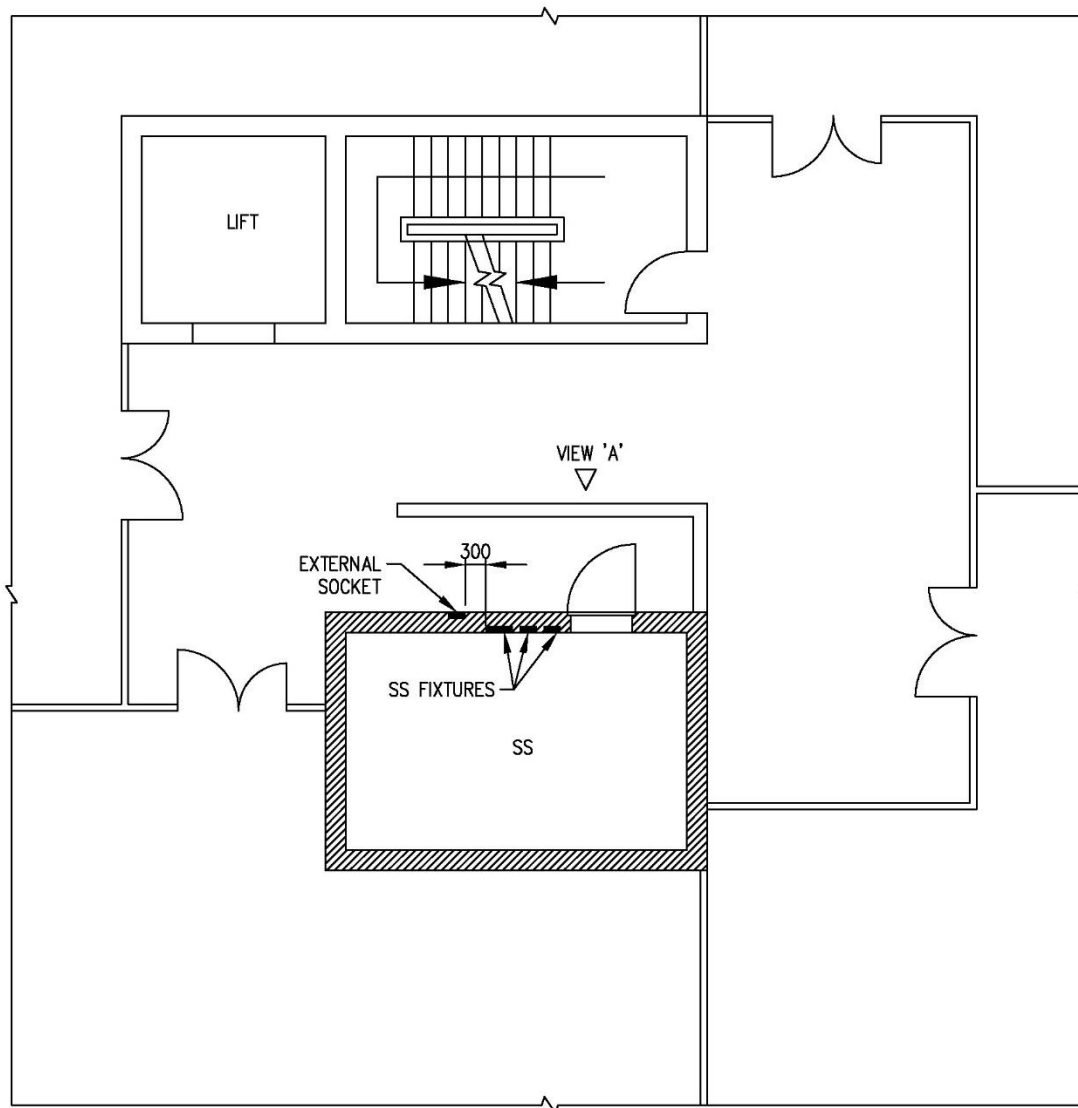
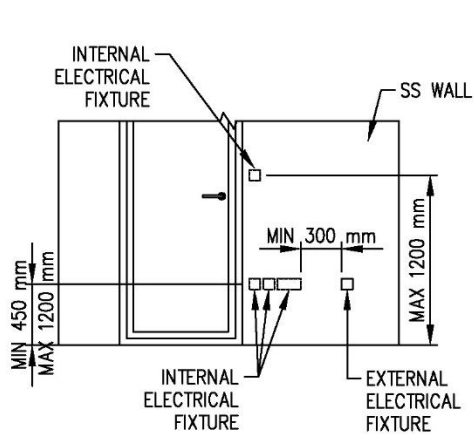


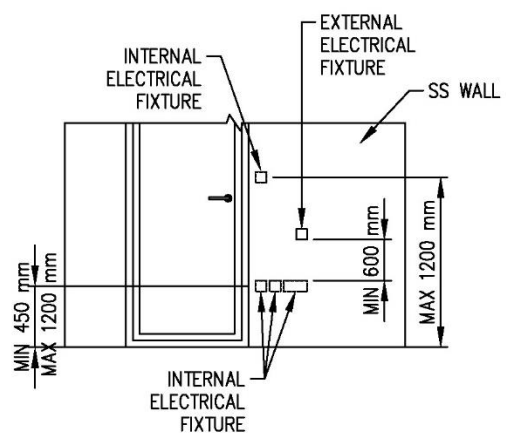
FIGURE 3.5.5(n) SECTIONS OF PRECAST SS DOOR FRAME PANEL (TYPE 3)



PLAN



(ALTERNATIVE 1)



(ALTERNATIVE 2)

FIGURE 3.6.1(a) MOUNTING OF SERVICES ON EXTERNAL WALL OF A SS

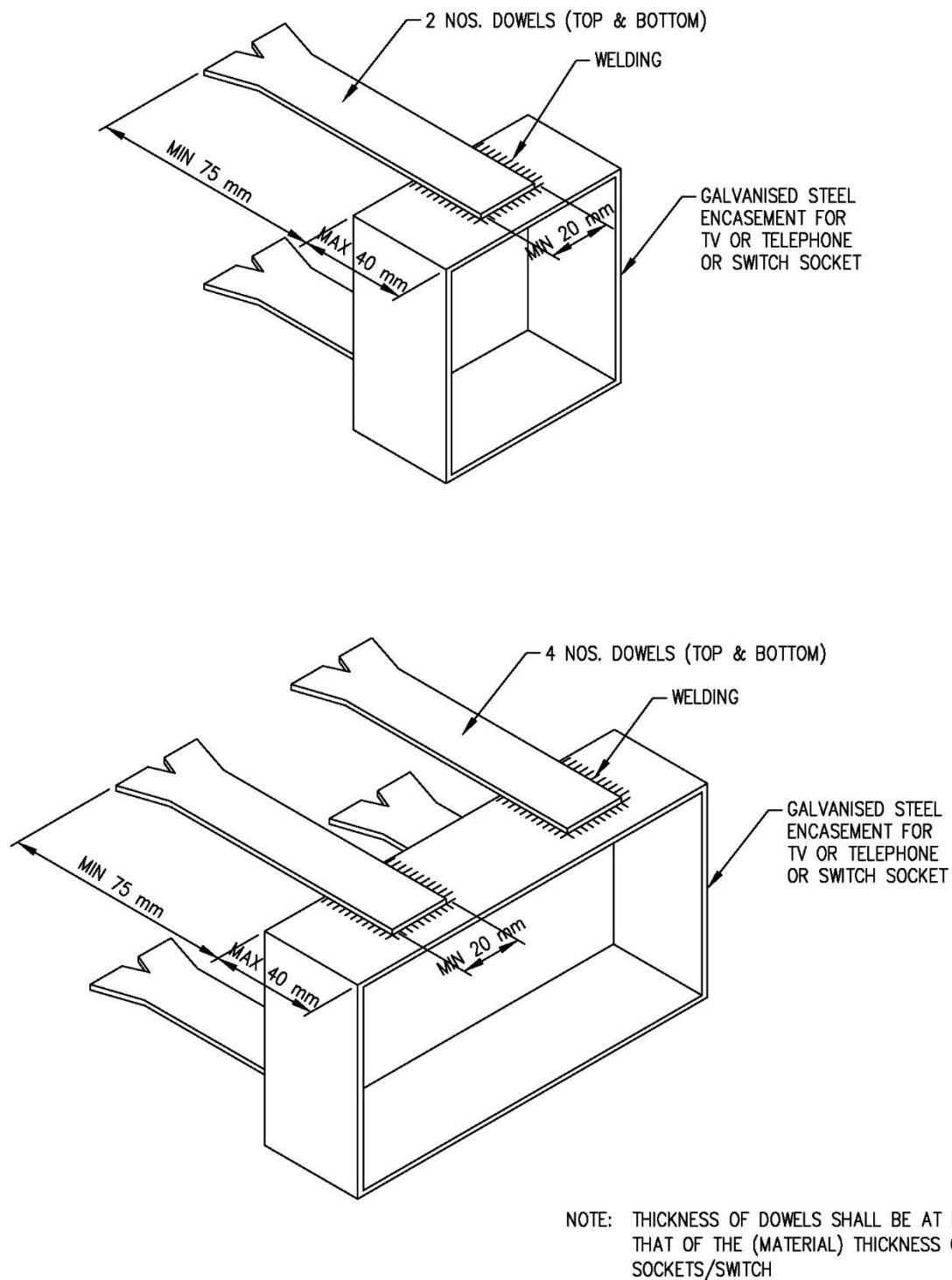
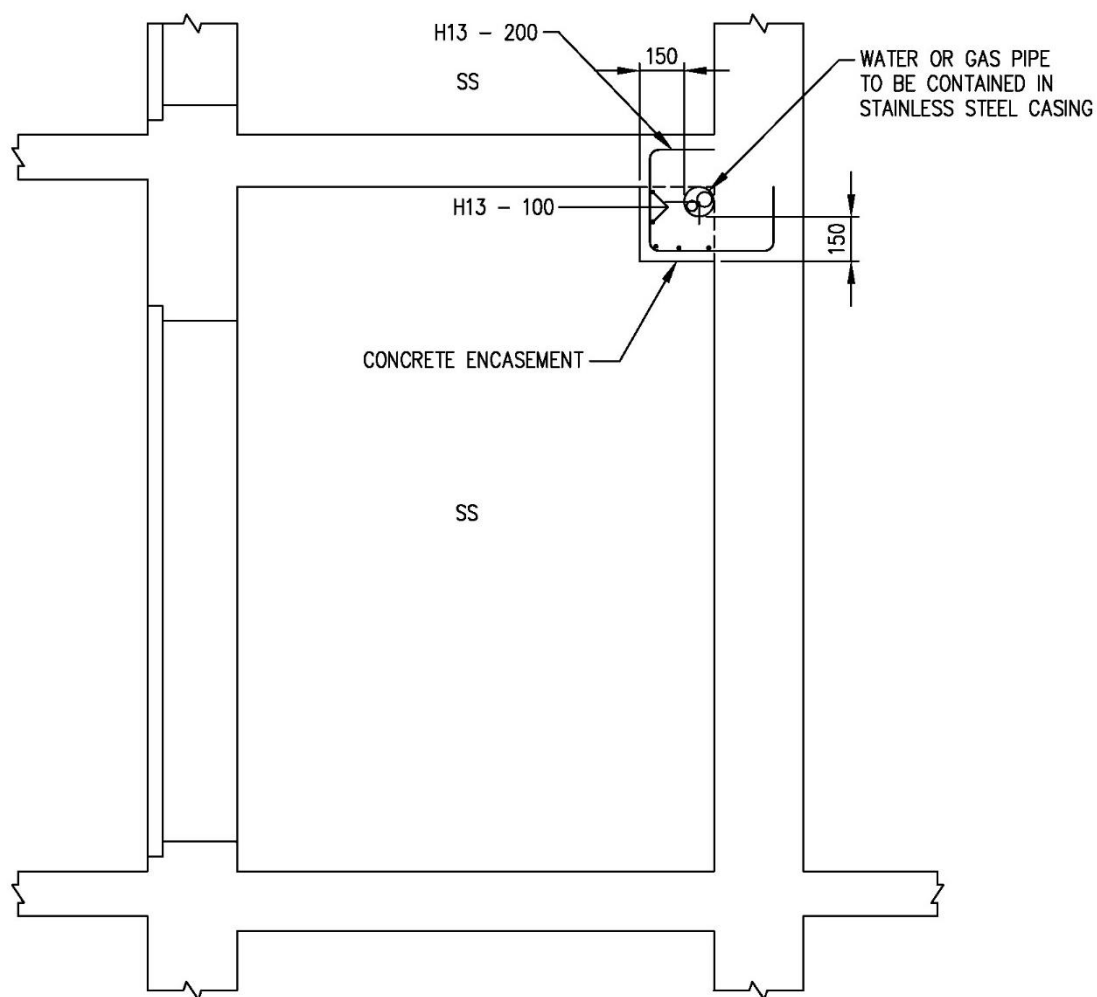
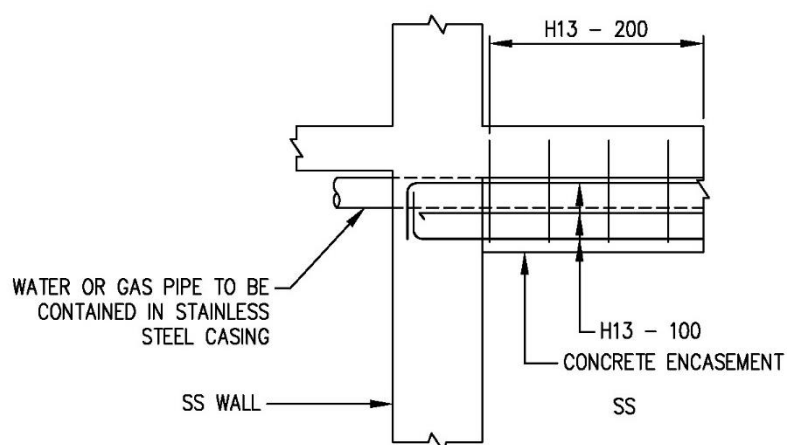


FIGURE 3.6.1(b) TYPICAL DETAILS OF EMBEDDED SOCKET/ SWITCH



SECTION OF SS



END CONNECTION DETAILS

**FIGURE 3.6.2 ENCASEMENT DETAILS OF WATER/ GAS SERVICE PIPES
PENETRATING THROUGH SS WALLS**