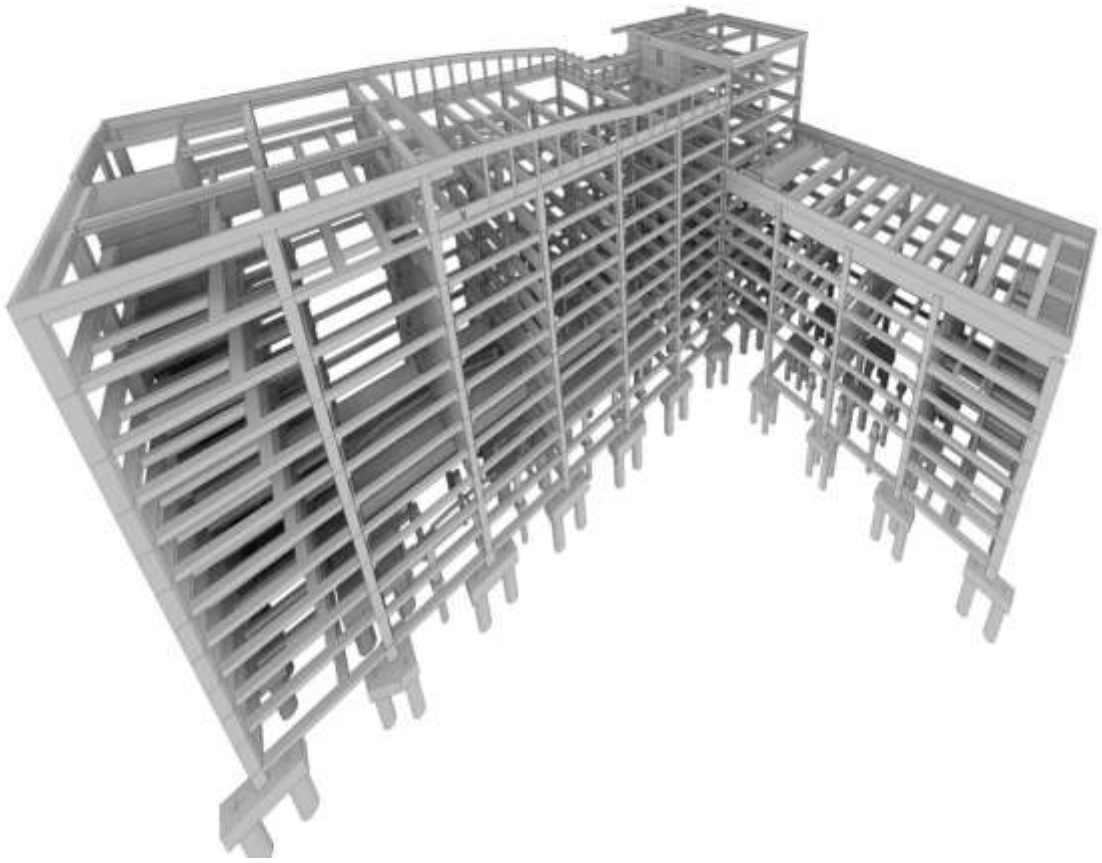
Building and Construction Authority

Code of Practice for Building Information Modelling (BIM) e-Submission

CIVIL & STRUCTURAL (C&S) REQUIREMENTS



Version 1.0

BCA acknowledges the leadership provided by the BIM Steering Committee in support of the production of the Code of Practice for Building Information Modelling (BIM) e-Submission.

This Code of Practice (CP) has been prepared by the Centre for Construction IT on behalf of BCA and the BIM Steering Committee.

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AGENCY- SPECIFIC REQUIREMENTS

1 BCA REQUIREMENTS

The objective of these requirements is to assist Qualified Persons (QP) to develop BIM models for submissions to BCA, for projects involving new developments (including new buildings, infrastructure projects and A&A projects).

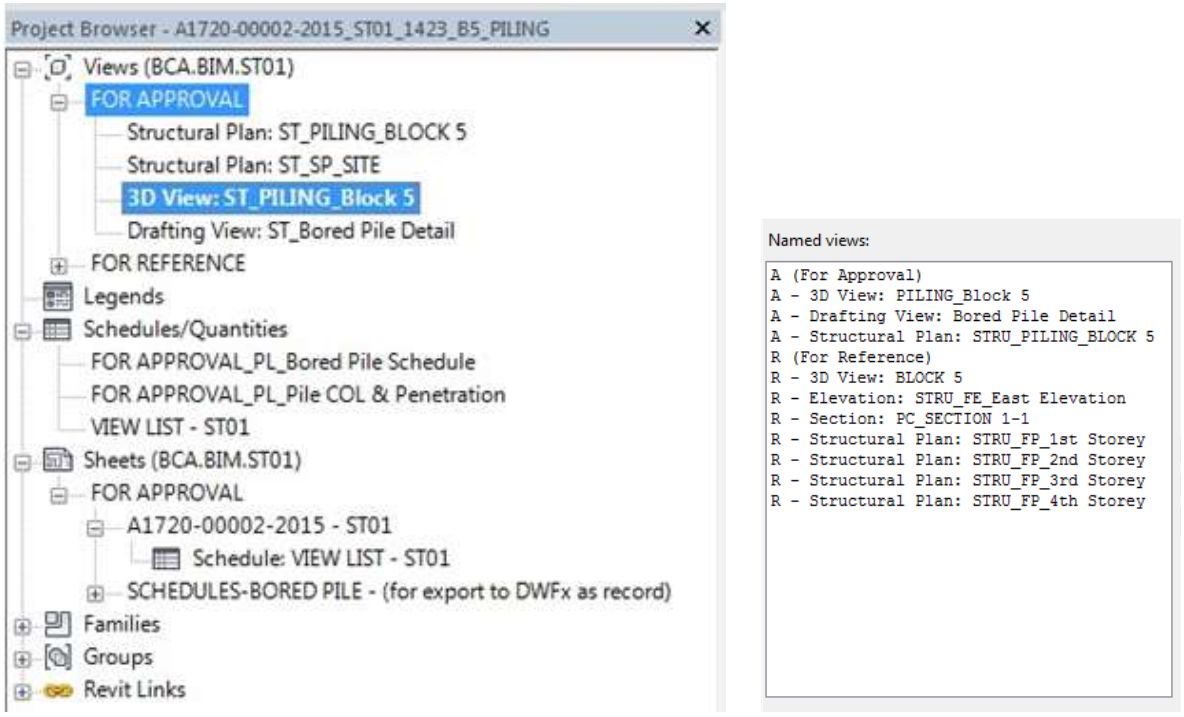
These requirements serve set out the minimum modeling standards and guidelines on the essential information required for regulatory BIM e-submissions in native format.

1.1 General Requirements

1.1.1 File Organization and Cover Page

All BIM generated views for approval and reference shall be clearly identified as per example below (refer to Fig. 1). The plans to be used for reference shall be listed under the "For Reference" label.

Fig. 1 - View List for Approval and for Reference



The cover page (refer to Fig. 2) shall contain the following:

- Project Reference Number, Project Title and QP details
- Stamps and declarations by QP and AC
- List of views, schedules and sheets for approval
- List of views, schedules and sheets for reference
- ST numbers of previous submissions (if applicable) for amendments
- Standard approval stamp and certification for Civil Defence shelter plans in Annex I

Fig. 2 - Sample Cover Page with Title Blocks

All submissions shall be in sheets which shall contain the title block with information as shown in Fig. 2.

1.1.2 File Naming Conventions

Table 1 - File Naming Conventions for ST Submissions

Project ID							Author			Model Part							Subm Version		Soft Version				Related ST	User Defined
A	B	C	D	E	F	_	S	1	_	B	L	K	1	0	A	_	ST02	_	R	1	6	_	ST01 or RPP1	123456

Fig. 3 - File Naming Example

ABCDEF_S1_BLK10A_ST02_R16_ST01_123456.rvt

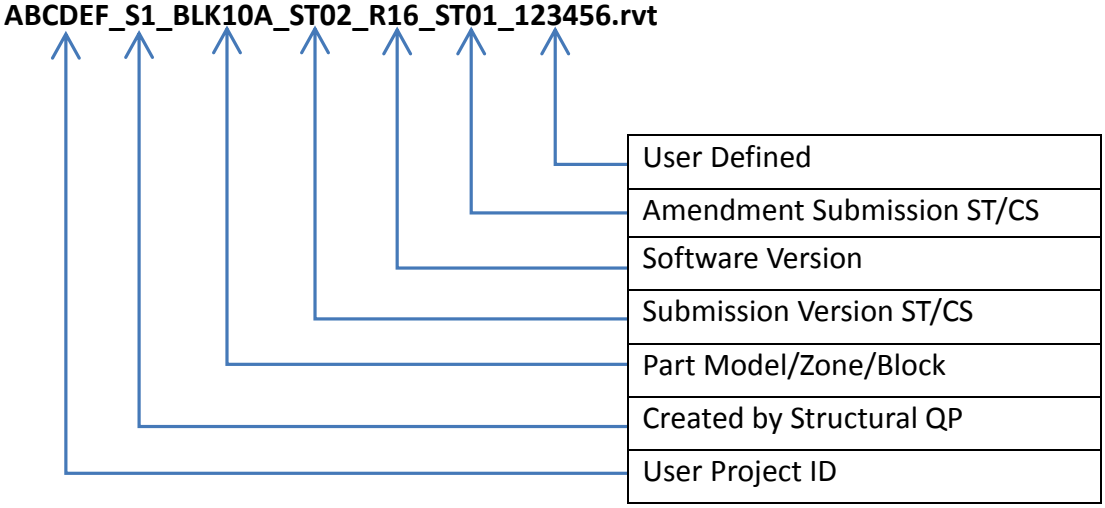


Table 2 - File Naming Codes

Code	Author	Nomenclature
S1	Structural QP1	QP1 (Main)
S2	Structural QP2	QP2 (Others)

Code	Software Version	Acceptable Format
R15	Revit 2015	RVT
R16	Revit 2016	
R17	Revit 2017	
v8i	AECOsim SS4-SS6	DGN
T19	Tekla 19	DB1/DMP
T20	Tekla 20	
T21	Tekla 21	

Code	Related ST	Nomenclature
RPP	Record Plan Partial	RPP1
RPF	Record Plan Full	RPF1

1.1.3 BIM Deliverables

The BIM model to be submitted for BCA ST and CS submissions shall meet the requirements specified under the following documents:

- Building Control Act and Regulations
- BCA Advisory Notes and Circulars
- Technical Requirements for Household Shelters and Storey Shelters, Public Shelters and Transit Shelters

The BIM file shall contain the following:

- 3D Views (Model)
- 2D Views
- Schedules
- Sheets for Approval

QP shall refer to each specific list of BIM deliverables in 2D, part model and schedules in Chapter II and III for Structural (ST) Requirements for building works and Chapter IV and V for structural (CS) Requirements for household shelter, storey shelter, staircase storey shelter, public shelter and transit shelters.

A. Structural Physical Model (PM)

a) Structural Physical Model shall consist of all structural elements that are required to be submitted to BCA for approval, shall include but not limited to the following:
   i. Foundation elements e.g. Piles, footings, raft foundation;
   ii. Structural elements such as beams, slabs, columns, walls, permanently left in retaining structures, walls with knock out panels, claddings and curtain walls, underground structures connected to building and MRT station (if any).

b) All plan views, sections and schedules shall be generated from the 3D model.

c) All elements shall be modelled span to span, level by level.

d) All plan views, sections, schedules shall indicate the minimum required information such as gridlines, dimensions between grids and levels, markings and sizes of elements.

e) All elements shall have only one (1) reference level per floor i.e. Structural Floor Level (SFL).

f) All elements shall be geo-referenced to global coordinates (as per SVY21) for x-y coordinates and in Singapore Height Datum (SHD) for z coordinate. This can be

achieved by setting individual global coordinates per element or utilizing BIM software survey and project points to convert local to global coordinates.

g) All elements shall contain required attributes such as element type, element marking, material type and grade (steel, concrete and reinforcements bars), element sizes (BxH), and span (L).
h) All elements shall be able to be filtered according to their element types and displayed separately.
i) All structural details including connection details necessary for construction shall be indicated.
j) All details in the 3D model that are not submitted for approval shall be shown in half tone and indicated as “For Reference”.

B. Floor Plans

The floor plans for the structural elements (e.g. beams, columns, walls, slabs) shall include but not limited to the following:

a) Grids, grid spacing and offset to centreline of elements;
b) Structural element markings, span, sizes and or thickness;
c) Location, extent, profile and dimension of slab drops;
d) Slab (one way or two way span) configurations including number of studs for composite floors; and
e) Slab details showing both top and bottom rebar at the support and span of the slab.

C. Penetrations, Openings and Drops

a) Openings/penetrations formed in the structural elements for running of building services shall be clearly identified and indicated on floor plan and/or sections.
b) Openings for circulation elements like staircase, lift pits and vehicular ramps shall be modelled.
c) Indicative sizes of major openings more than 300x300 for beams and columns and 1000x1000 for walls and slabs for all types of openings shall be modelled. For guidance, any openings in excess of 20% of element face shall be modeled.
d) Floor plans and sections shall include the indication of the location and extent and dimensions of structural drops.

D. Cross and Longitudinal Section Views

Cross and Longitudinal Section Views can be generated in either hybrid or full 3D and shall include the following:

a) Grid, grid spacing and offset to centerline of elements;
b) Elevation markers in structural floor level (SFL);
c) Profile of structural elements indicating location, extent and dimensions of structural drops such as drops in beams and slabs;
d) Reinforcement details of elements if not represented in schedules; and
e) Connection details between structural elements.

E. Details of Structural Elements

a) All elements shall contain minimum required attributes such as element type, element marking, material type and grade (steel, concrete and reinforcement bars) , size of bolts and thickness of welds for steel, sizes (BxH), span (L) etc.
b) Details of structural elements such as reinforcement of beams, columns, slabs can be represented in schedules that are auto-generated from the 3D model.

F. Non Typical Details

Non-typical details can be done in either hybrid details or full 3D objects. Examples of non-typical or critical details are indicated in the following but not limited to:

a) Beam to column connections;
b) Interface between pile and pile caps;
c) Interface and spacing of ground anchors and permanently left-in ERSS structures; and
d) Details of joints for structural steel members.

G. General Notes

The information for the design and construction notes of the projects can be indicated in the cover page or the general notes page and includes but not limited to the following:

a) Material specifications;
b) Instrumentation and monitoring requirements;
c) Design parameters used;
d) Method statements; and
e) Typical sizes and detail of openings/penetrations for building services.

1.1.4 Site and Location Plans

Fig. 4 - Site layout showing reduced annotations at L1

Site and location plans shall include the following details:

a) Geo-referenced location: Project base point and survey points in SVY21 coordinates including dimensions between grids;
b) Block or zone numbers;
c) Mukim numbers;
d) Lot boundary lines, road reserve lines, setback lines;
e) Building layout showing the geometry of the building at the 1F or ground floor;
f) Underground structures connected to building and MRT stations, if any; and
g) Acceptable formats include but not limited to: .dwg/.dxf/.shp.

1.1.5 Amendment Submissions

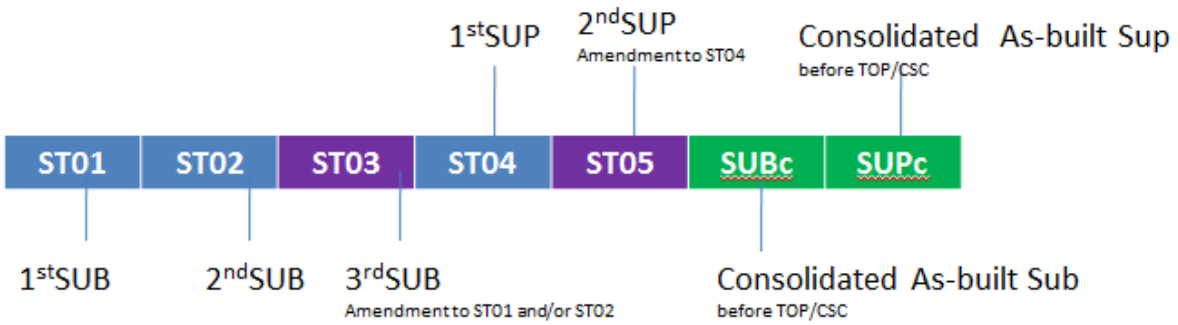
a) Any "material changes" or “structural changes” from approved BIM file shall be submitted as an amendment to the originally approved ST submissions.
b) Amendment submissions shall be added with additional naming fields to distinguish from original submissions. Revision clouds indicating the amendment shall be included. In addition, color scheme as per CP83 standard is allowed.

1.1.6 As-Built/Record Plans Submissions

a) QPs shall submit consolidated as-built substructure and superstructure BIM files of their own scope in both native BIM and IFC format to BCA before TOP application of the project. The as-built BIM file is similar to all approved BIM files consolidated and updated with all immaterial changes.
b) QP for other structural works such as cladding and curtain walls shall submit consolidated as-built BIM files of their own scope of works to BCA.
c) The main QP is advised to consolidate all the BIM models of other QPs to form a federated model.

1.1.7 Model Progression

Fig. 5 - ST plan submission in stages indicating a consolidated substructure and superstructure BIM files before TOP/CSC



Record plans (RP) generated from record models shall be submitted to BCA by each QP showing their own scope of works. Record plans can be submitted progressively as shown above.

Fig. 6 - Model progression for ST1 and ST2.

Legend: FA=for approval; AP=approved; WIP=work in progress

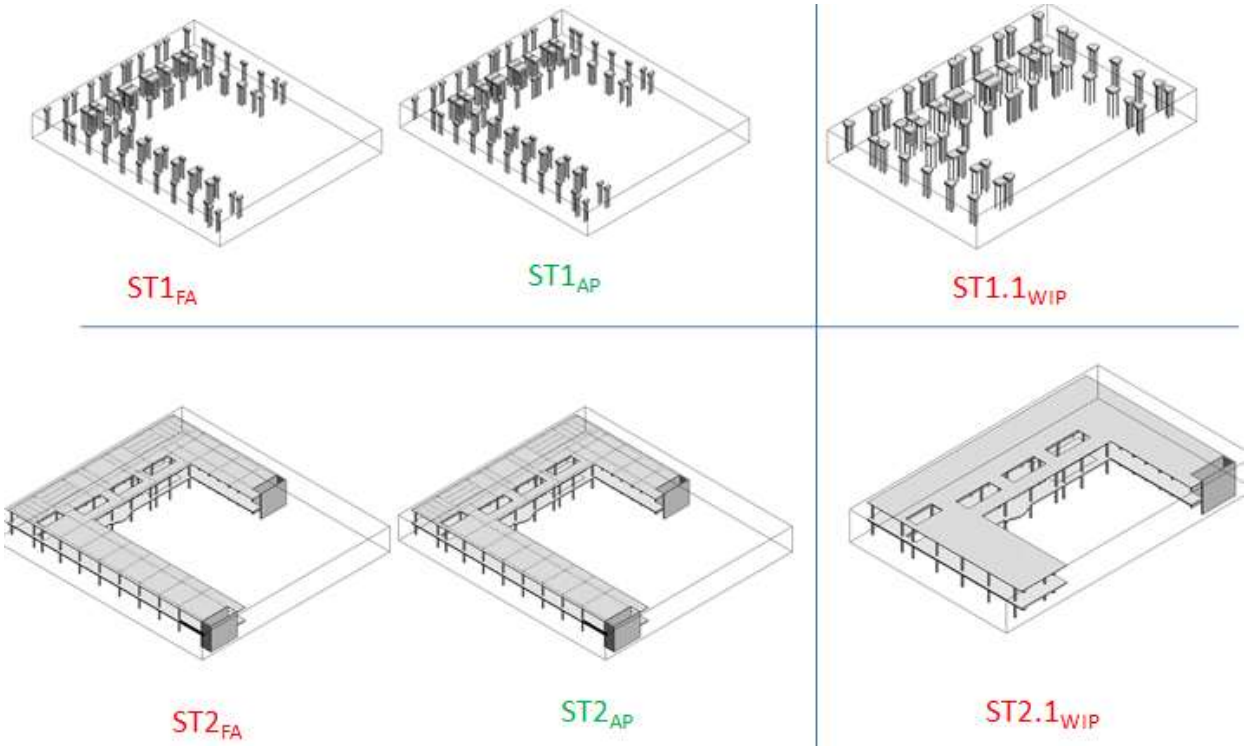


Fig. 7 - Model progression for amendment submissions for approved ST

Legend: FA=for approval; AP=approved; WIP=work in progress; AM=amendment

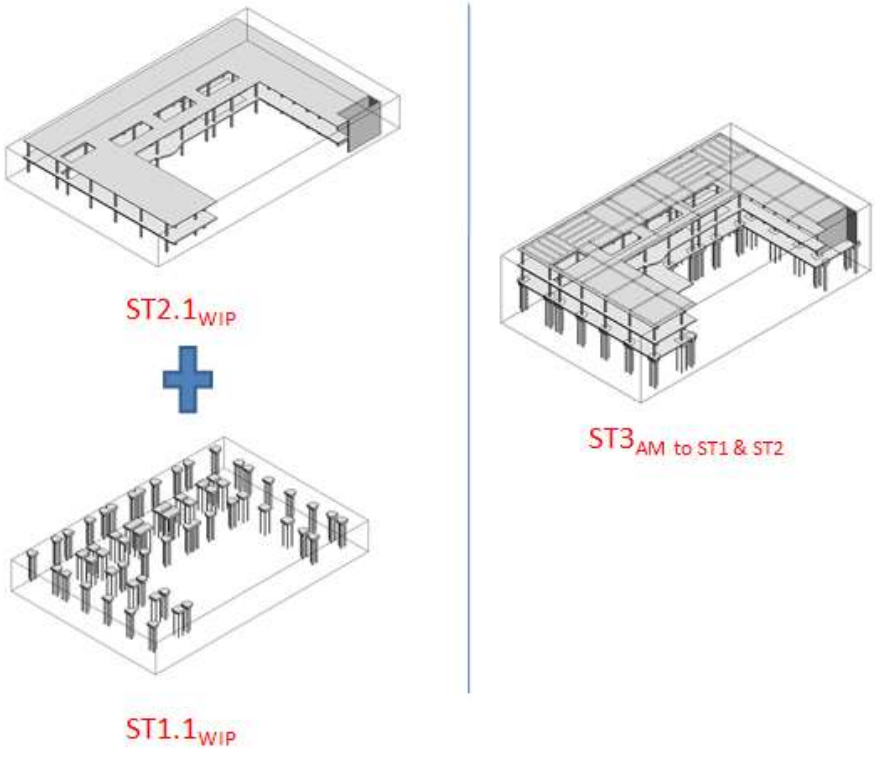


Fig. 8 - Model progression for single and federated options

Legend: FA=for approval; WIP=work in progress

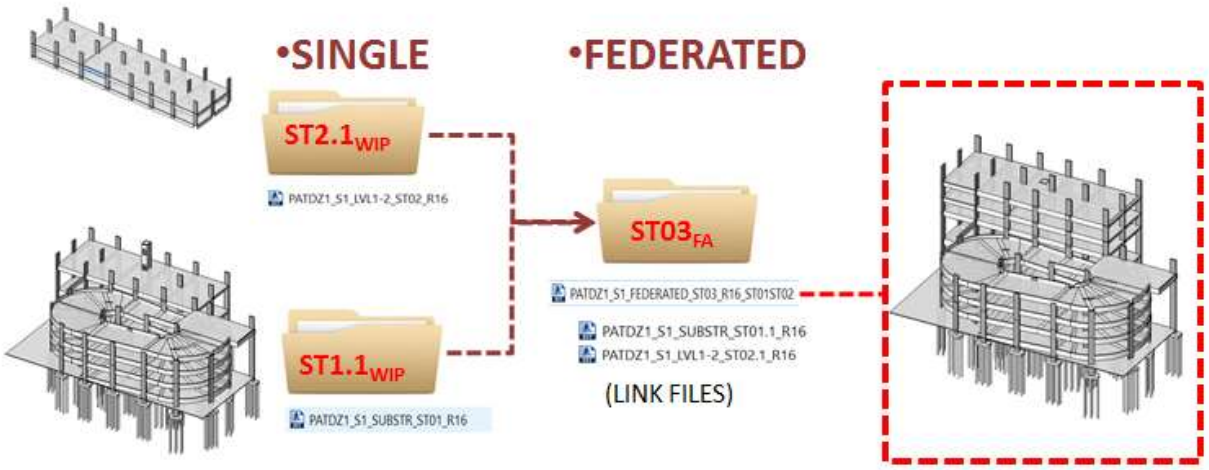


Fig. 9 - Model progression QP1 and QP2 including consolidated record models

Legend: FA=for approval; AP=approved; WIP=work in progress; RP= record plans

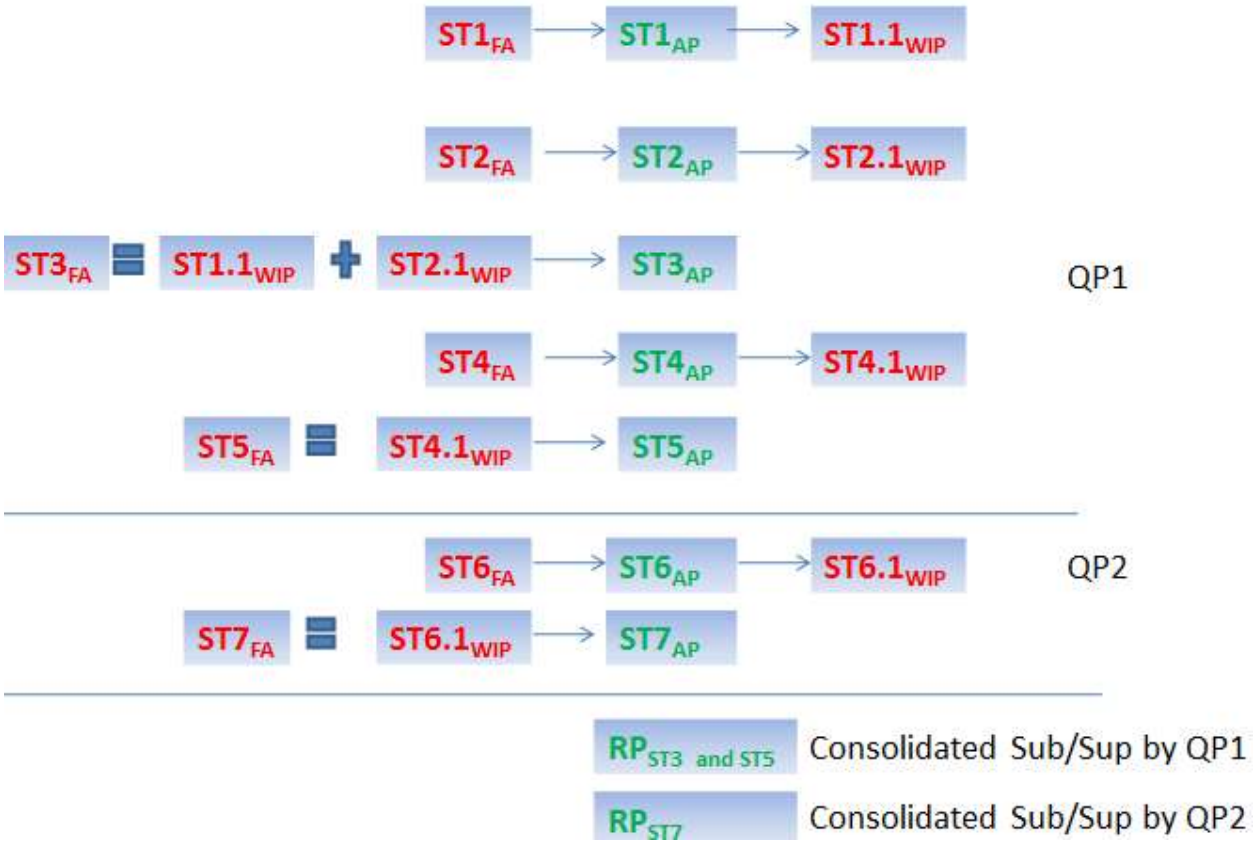
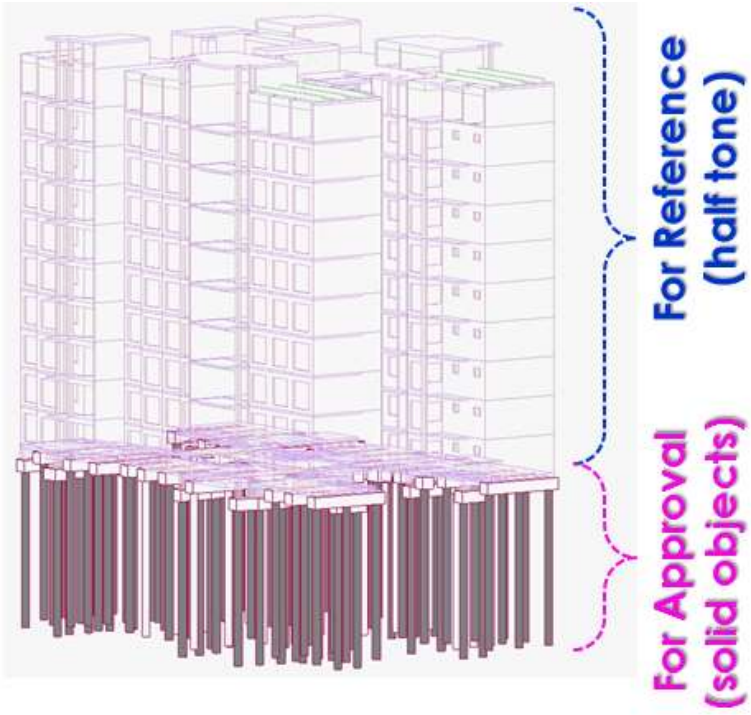


Fig. 10 - For Approval and For Reference as solid and half tone elements per ST



1.2 ST Requirements

1.2.1 BCA Substructure Submission Requirement (BCA SUB/GEO Submissions)

BCA Substructure and Geotechnical Submission Requirements

(Required Views, but not limited to)

2D Views	3D Views	Schedules
• *Site and Location Plan** • *General Notes** • *Typical Details** • Non Typical Details • Floor Plans • Elevation Views • Cross & Longitudinal Section Views	• Structural Physical Model (PM) showing all structural elements • Digital Terrain Model (DTM) • Geotechnical Parameters Dummy Object • Penetrations/Openings • Record Plans (RPP/RPF)	Schedules for all structural elements not limited to: • Pile Schedule • Pile Cap Schedule • Retaining Wall Schedule • Basement Slab Schedule • Beam Schedule • Column/Wall Schedule
All 2D Views and Schedules shall be placed on sheets		

*Items with * can be submitted as CAD drawings as a drafting view*

A. Geotechnical Parameters Dummy Object

QP shall create a dummy object to represent geotechnical parameters derived from the soil investigation (SI) report.

Dummy object shall provide a link to the bore holes (Excel sheet) used for design.

Table 4 - Borehole information (in Excel spreadsheet)

PROJ_ID	PROJ_NAME	PROJ_ CLNT	HOLE_ ID	HOLE_ STAR	HOLE_ NATE	HOLE_ NATN	HOLE_ GL	HOLE_ FDEP	ROCK_ HEAD	ROCK_ TYPE	FORMATION
A0677-00001-2015	Soil Investigation Works at No.XX XXX Road, SG XXXXXX	Mr. XXX	BH1	15/7/2015	13169.723	36010.451	6.514	45	33.5	Granite	Bukit Timah Granite

B. Substructure Schedules

Pile schedule shall be generated from objects/elements attributes and not as Excel spreadsheets or inserted CAD files. The schedules shall include but not limited to:

a) Pile type, pile marking and pile size;
b) Working load and grade of concrete;
c) Main rebar and links;
d) Penetration length from existing ground and cut off levels indicated as Singapore Height Datum (SHD) levels; and
e) Demolished, existing or new foundation elements.

Table 5 - Sample pile cap dimensions and rebar schedule

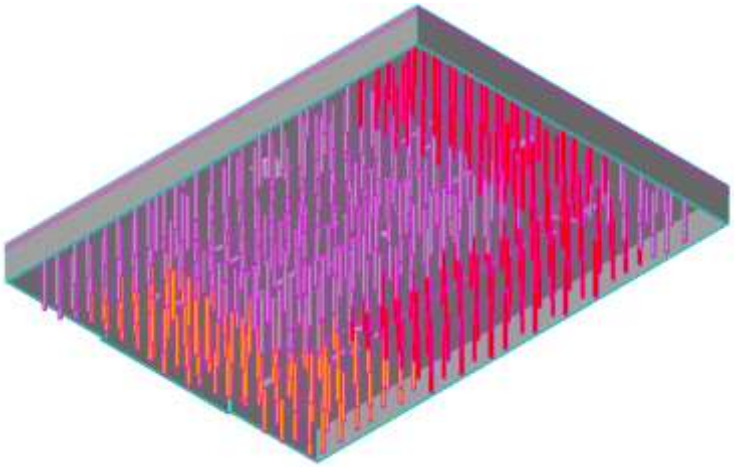
PILECAP TYPE	PILE DIAMTER (mm)	PILECAP DIMENSION (mm)				DEPTH (mm)	REINFORCEMENT				
		A	a	B	b		B1	B2	S1	T1	T2
PC-A1	700	1000	500	1000	500	1000	5T20	5T20	T10-200	5T20	5T20
PC-A2	900	1300	650	1300	650	1000	6T20	6T20	T10-200	6T20	6T20
PC-A3	1000	1400	700	1400	700	1000	6T20	6T20	T10-200	6T20	6T20
PC-A4	1200	1600	800	1600	800	1000	7T20	7T20	T13-200	7T20	7T20
PC-A5	330	730	365	730	365	1000	3T16	3T16	T10-200	3T16	3T16

C. Color Assignments

Coloured/Hatch/Fill Patterns can be used to show the following:

a) Dead Load values;
b) Live Load values;
c) Bore Hole zones; and
d) Existing, New, Demolished Elements as per colours specified under the CP for BIM e-Submission: General Requirements.

Fig. 11 - Isometric view showing borehole zones



D. As-Built Pile Information

The as built pile information shall be submitted in a standardized excel spreadsheet as per the following format:

Table 6 - Pile Excel Table

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Project Name:												Date:				
2	Project Reference:																
3	PE Company:												Registered Surveyor Company:				
4	PE Name:												Registered Surveyor Name:				
5	PE No:												Registered Surveyor No:				
6																	
7	No.	Pile No	Pile Type	N-Easting (m)	N-Northing (m)	As Built Length from CDL (m)	Cut off Level (mCD)	Toe Level (mCD)	Diameter/ Longest Side (m)	Width (m)	Project Title	Developer	Remark	Design Penetration Length from CDL (m)	Percentage Difference	Design Socketing Length (m)	Actual Socketing Length (m)
8	1	BP300	Precast	30918.210	29226.632	39.175	-11.2546	-50.4296	0.30	0.3	Project A	Dev1		48	-2.1%	5	4
9	2	BP302	Bored Pile	30918.374	29223.782	39.164	-10.216	-49.38	1.00		Project A	Dev1		38	2.6%	6	3
10	3	BP301	Timber	30919.489	29216.216	43.180	-15.123	-58.308	4.00	2.4	Project B	Dev1		42	2.8%	3	7
11								0							#DIV/0!		
12								0							#DIV/0!		
13								0							#DIV/0!		
14								0							#DIV/0!		
15								0							#DIV/0!		
16								0							#DIV/0!		

1.2.2 BCA Superstructure Submission Requirements (BCA SUP Submissions)

BCA Superstructure Submission Requirements

(Required Views, but not limited to)

2D Views	3D Views	Schedules
• *General Notes** • *Typical Details** • *Typical Connections** • Non Typical Connections • Floor Plans • Cross & Longitudinal Section Views • Elevation Views • Color/Hatch/Fill Patterns	• Structural Physical Model (PM) showing all structural elements • Penetrations/Openings • Record Plans (RPP/RPF) • Hypermodel	Schedules for all structural elements not limited to: • Beam Schedule • Column Schedule • Wall Schedule • Slab Schedule
All 2D Views and Schedules shall be placed on sheets		

*Items with * can be submitted as CAD drawings as a drafting view*

A. Typical Details

a) Non-structural drops in slabs or beams;
b) Lintel beams for wall openings;
c) Beam elevation profiles showing cantilever, mid-span and continuous members; reinforcement detailing;
d) Column profiles showing extent from foundation to roof including reductions; and
e) Roof rafters/purlins/tie rods connection details.

B. Other Details of Superstructure Works

a) Precast structural elements;
b) Post tension elements including tendon profile;
c) Steel or timber space frames joined by proprietary ball connections; and
d) Cross laminated timber (CLT) and glulam.

Fig. 12 - Tendons for post tension element

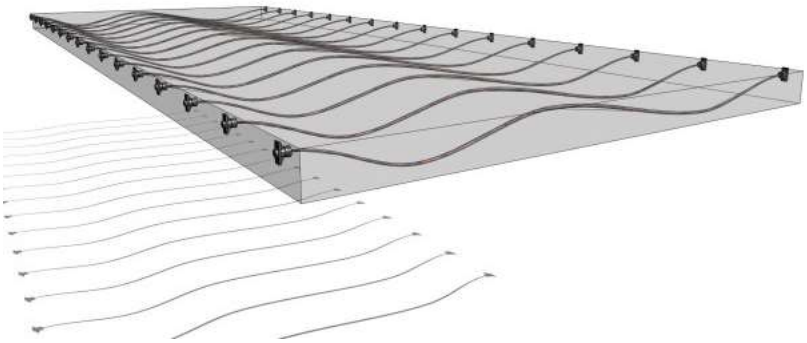


Fig. 13 - Exploded view of CLT structure showing Primary Load Bearing PLB objects

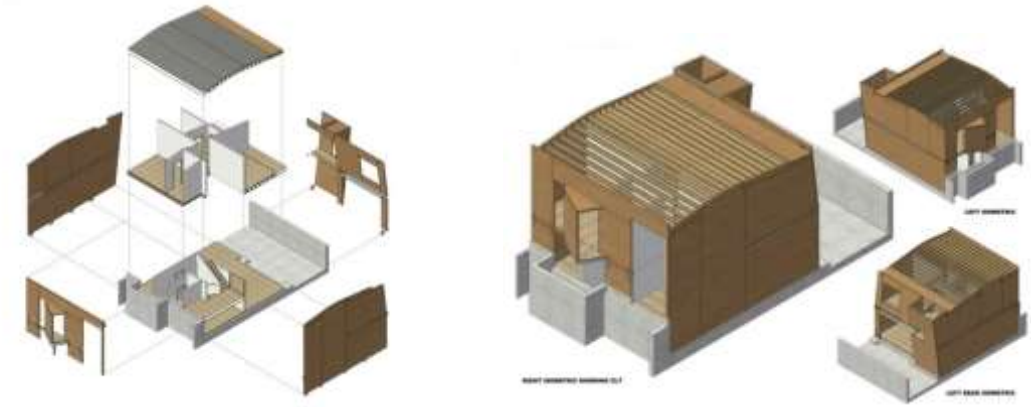
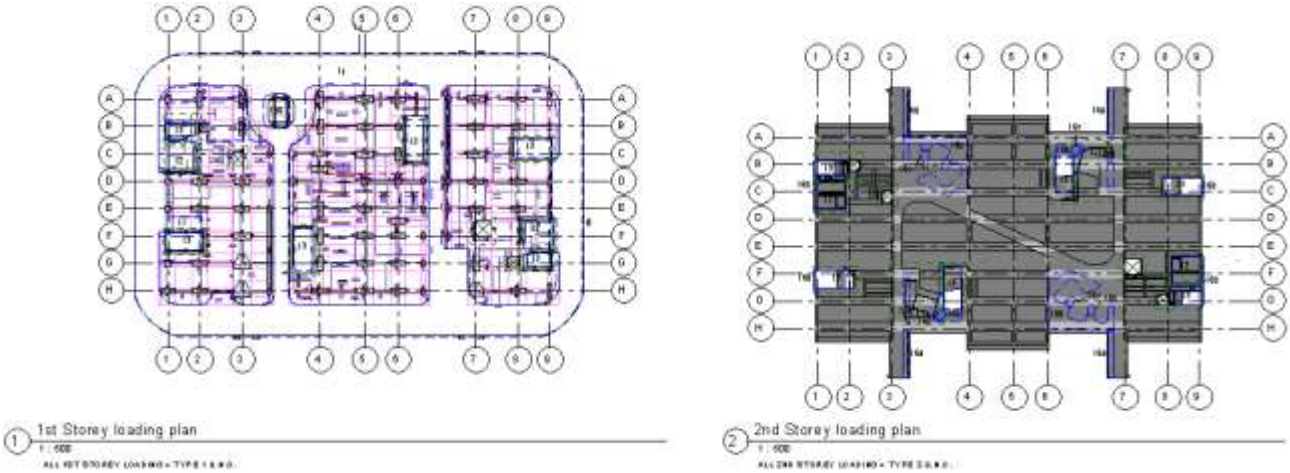


Fig. 14 - BIM generated Floor Plans



C. Non Typical Details

Critical connections for key structural elements can be done using hybrid detailing and/or full 3D element detailing:

a) Interface between steel/timber truss terminations to supporting columns;
b) Inclined, splayed and lattice columns;
c) One-off steel bolted and/or welded connections;
d) Cantilever elements with 6m span or greater;
e) Transfer columns to beam/floor connection details; and
f) Corbel and haunch for precast elements.

Fig. 15 - Critical Elements highlighted in 3D and schedules

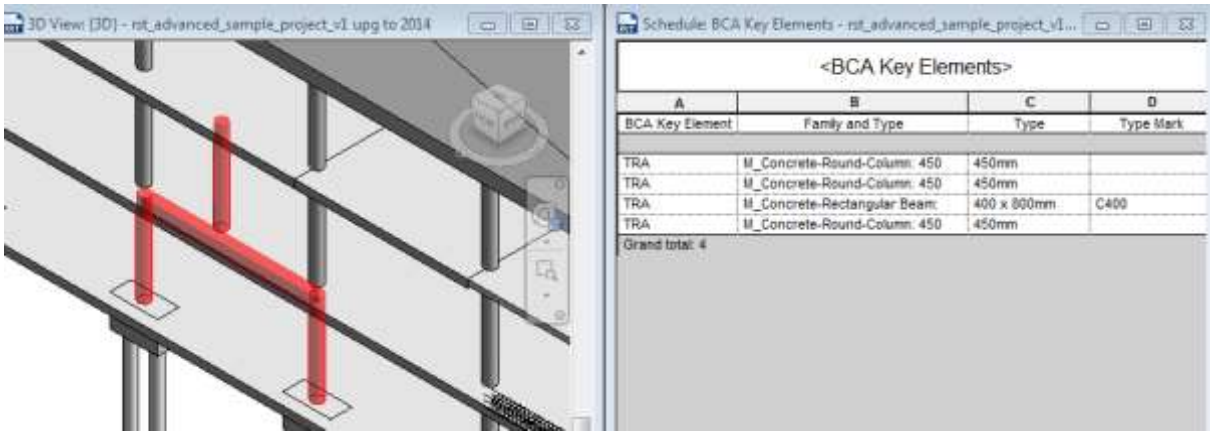


Fig. 16 - Critical Joints showing bolted connection of steel beams to column

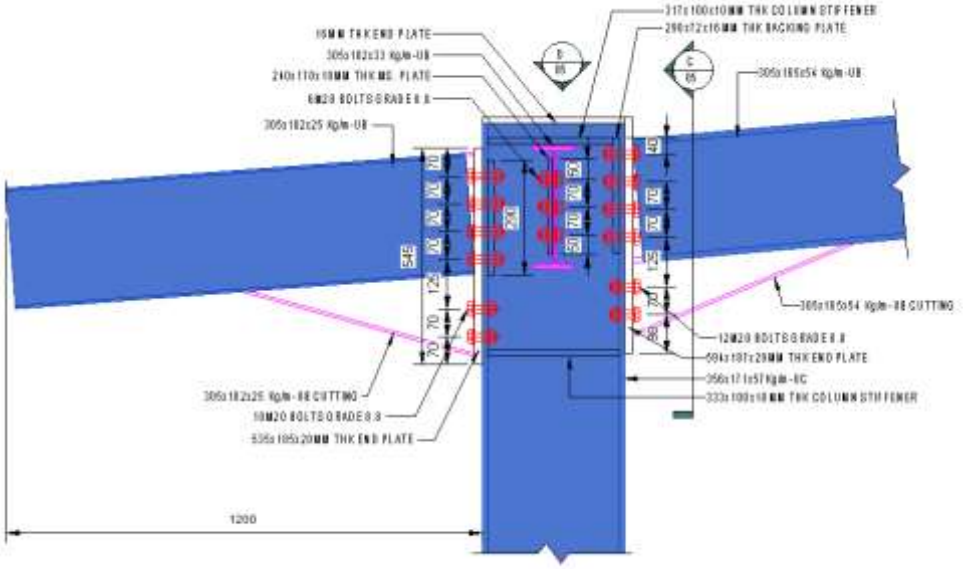


Fig. 17 - Highlighted structural beam with embedded rebar as attributes/properties

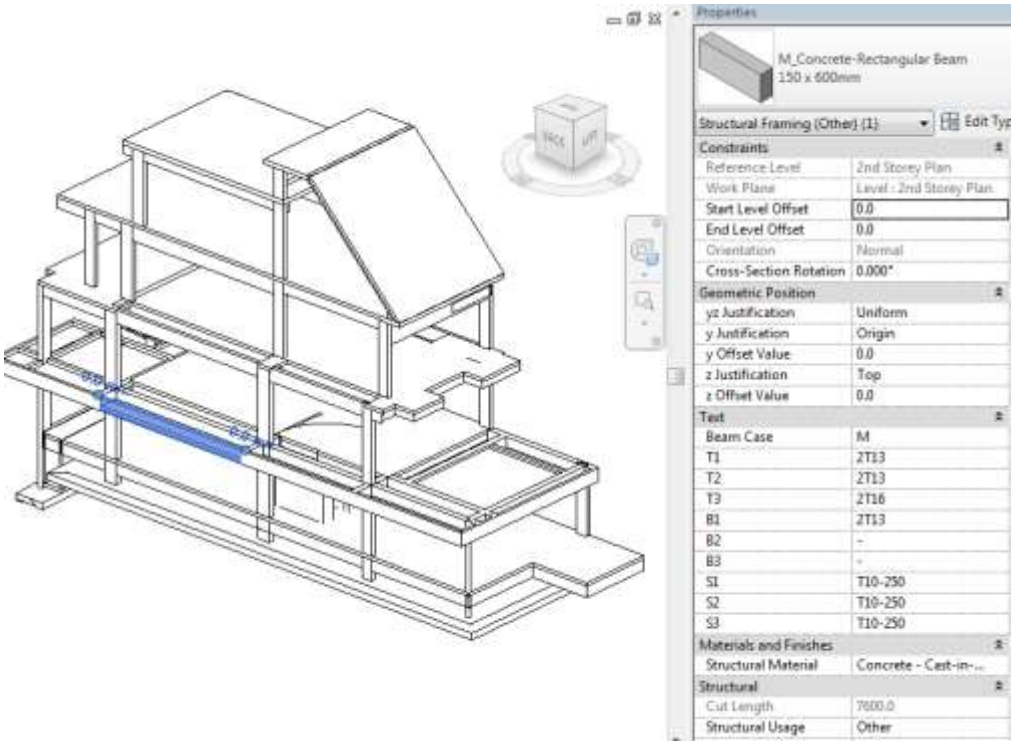


Fig. 18 - BIM generated rebar schedule

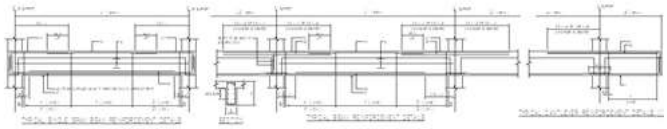
<Structural Beam Schedule_Storey 1>

A	B	C	D	E	F	G	H
No	Mark	Type	Beam Case	T1	T2	T3	B1
1	1HB1	300 x 650mm	L	3T13	3T13	2T13	3T13
2	1HB2	300 x 650mm	M	3T13	3T13	3T16	3T13
3	1HB3	300 x 650mm	M	3T16	3T13	3T13	3T13
4	1HB4	300 x 650mm	R	3T13	3T13	3T13	3T13
5	1HB5	250 x 650mm	C	3T20	-	-	3T13
6	1HB6	250 x 650mm	R	3T13	3T13	3T13	3T16
7	1HB7	250 x 650mm	S	3T13	-	-	3T13
8	1HB8	250 x 650mm	S	3T13	-	-	2T32
9	1HB9	300 x 650mm	C	3T20	-	-	3T13
10	1HB10	300 x 650mm	M	3T13	3T13	3T13	3T13
11	1HB11	300 x 650mm	M	3T13	3T13	3T13	3T13
12	1HB12	300 x 650mm	R	3T13	3T13	3T16	3T13
13	1HB13	150 x 600mm	S	2T13	2T13	2T13	2T13
14	1HB14	300 x 650mm	S	3T13	-	-	3T13
15	1HB15	250 x 650mm	S	3T13	-	-	3T13
16	1VB1	250 x 650mm	S	3T13	-	-	3T13
17	1VB2	300 x 650mm	S	3T16	-	-	3T32
18	1VB3	300 x 650mm	S	3T16	-	-	3T25
19	1VB4	250 x 650mm	L	3T13	3T13	3T13	3T13
20	1VB5	250 x 650mm	R	3T13	3T13	3T13	3T13
21	1VB6	300 x 650mm	L	3T13	3T13	3T32	3T20
22	1VB7	300 x 650mm	R	3T32	3T25	3T25	3T13
23	1VB8	300 x 650mm	S	3T16	-	-	3T32
24	1VB9	300 x 650mm	S	3T25	-	-	3T25
25	1VB10	250 x 650mm	S	3T13	-	-	3T13

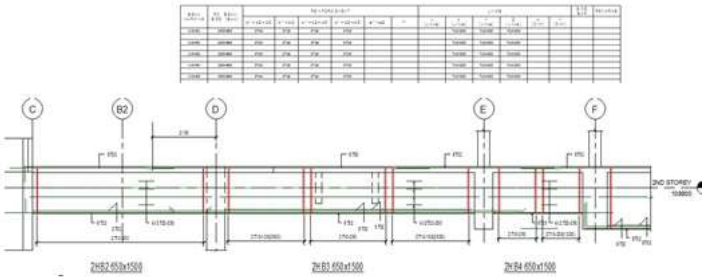
D. Structural Detailing Options

Fig. 19 - QP three (3) options for structural detailing in native BIM

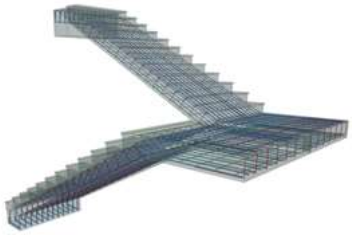
Option 1: 2D Schedules



Option 2: Hybrid
(3D objects + 2D Annotations)



Option 3: 3D Connections



E. Superstructure Element Schedule

a) Regular, up stand or down hang beam/girder rebar showing top, bottom, extra, torsion and links;
b) Column rebar showing main, links, development/anchorage;
c) Slab rebar showing main top and bottom including additional rebar for crack control;
d) Wall rebar showing main rebar and links; and
e) Prefabricated and pre-qualified rebar cages;

1.3 Structural Requirements for Household Shelter (HS), Storey Shelter (SS) and Staircase Storey Shelter (SSS)

1.3.1 General Requirements

The design and detail of household shelter shall comply with Technical Requirements of Household Shelter. For storey shelter and staircase storey shelter, the design and detail shall comply with Technical Requirements for Storey Shelters.

The structural plan shall contain a site plan, the floor plans, sections and elevations of household shelter (HS), storey shelter (SS) and staircase storey shelters (SSS) showing design information and dimensions generated from the native BIM model. HS, SS and SSS plan shall be indicated with the same project reference number. The abbreviation, CS should be used for shelter structural plans respectively. For example, A9999-12345-2001-CS01 should be used for shelter building and structural plans respectively.

For subsequent amendment submissions made to the approved shelter plans or re-submission of shelter plans after receipt of Notice of Disapproval (NOD) issued by BCA, the plans shall be indicated with respective plan type suffix and unique numbers in their application. For example, if shelter building plans CS01 has been used and subsequent amendment submissions shall be indicated with CS02.

Civil Defence Shelters (HS/SS/SSS) Submission Requirements

(Required Views, but not limited to)

2D Views	3D Views	Schedules

• *Site Plan**
• *General Notes**
• *Typical Details**
• *Typical Connections**
• Floor Plans
• Cross and Longitudinal Section Views
• Elevation Views
	• Structural Physical Model (PM) showing the following:
	  ○ Household Shelters (HS)
	  ○ Storey Shelters (SS)
	  ○ Staircase Storey Shelter (SSS)
	• Non Typical Connections
	• Penetrations/Openings
		Schedules for all structural elements not limited to:
		• Wall Schedule
		• Slab Schedule
		• Reinforcement Schedule
		• Blast Door Schedule
		• Blast Hatch Schedule
		• Rescue Hatch Schedule
		• Ventilation Sleeve Schedule

All 2D Views and Schedules shall be placed on sheets		

*Items with * can be submitted as CAD drawings as a drafting view*

A. Site Plan

The site plan shall include the location map, general notes and standard typical details

B. General Notes

The general note shall include essential information such as material type and grade, the standard typical detail such as steel reinforcement, curtailment marking, anchorage and tension lapped lengths.

C. Structural Physical Model (PM)

a) Structural Physical Model of the building with HS, SS, and SSS shall include all surrounding concrete & steel members (trellis, canopy, ledge, down hang beams, tie beams, shielding walls etc.) which are provided and used for protection of HS, SS, and SSS.

b) HS, SS, and SSS have to be modelled as part of the buildings.

c) All ventilation sleeves, shelter door and blast door openings shall be modelled for all HS, SS, and SSS structures.
d) Where water and gas services are located near or adjacent to HS, SS and SSS, they shall be included as part of the 3D model.
e) Transfer structures (beams, slabs and walls), if any, supporting household storey shelter shall be modelled. Take note the use of transfer beam is allowed for household storey shelter only.
f) HS, SS and SSS wall and slab dimensions and reinforcement. This applies to design of cast in-situ or precast HS, SS, and SSS.
g) Ceiling slab immediately outside the HS, SS and SSS
h) Household shelter HS, SS, and SSS slab which are integrated with pile cap or footing.
i) Detailing of HS, SS, and SSS tower
j) Any structures above and/or surround HS, SS, and SSS shall be included as part of the model.

D. Floor Plans for HS, SS and SSS

The floor plan generated from the model shall show the design information and dimensions for HS, SS and SSS as follows:

a) The concrete grade and yield stress of welded steel fabric mesh and steel reinforcement bars
b) The location and marking of HS, SS and SSS
c) The location, dimension and details of gas and water riser adjacent or near to HS, SS and SSS
d) The external and internal dimension of HS, SS and SSS
e) The thicknesses of HS, SS and SSS wall and slab (ground, intermediate and roof slab)

In addition, additional design information and dimensions required for SS and SSS are:

a) The distance between external face of SS or SSS entrance door and the edge of building line
b) The thickness, dimension and steel reinforcement details of shielding wall fronting SS or SSS entrance door
c) The clear distance between shielding wall and SS or SSS entrance door

d) The thickness, dimensions and steel reinforcement details of the internal wall of SSS
e) The thickness, dimension and steel reinforcement details of mechanical ventilation shaft for SSS
f) The dimensions and steel reinforcement detail around the horizontal and vertical blast hatch (for SSS) and rescue hatch (for SS)
g) The dimension and steel reinforcement detail of reinforced concrete roof structures over the mechanical ventilation shaft above main roof level.
h) The dimensions/thickness of and reinforcement details in strengthened slab outside and above SS/SSS door.

E. Cross Sections for HS, SS, and SSS

The sections in two directions generated from model shall include:

a) The vertical section of the entire HS, SS and SSS tower showing storey height, dimensions and reinforcement details.
b) The horizontal section (or plan) of HS, SS and SSS wall showing steel reinforcement, curtailment marking, anchorage and lap length. The thickness, internal and external width and length of HS, SS and SSS shall also be indicated (see Annex II, Figure 1a, 1b, 2a and 3a).
c) The vertical section of HS, SS and SSS wall and slab showing steel reinforcement bar size, spacing, anchorage and lap length. The slab thickness shall also be shown (see Annex II, Figure 1c, 1d, 2b, 2c and 2d).
d) The horizontal section (or plan) of HS, SS and SSS precast concrete door frame showing steel reinforcement, anchorage and tension lapped lengths (see Annex II, Figure 3a, 3b, 4a, 4b, 5a and 5c).
e) Shear link details on horizontal and vertical section of HS, SS, SSS wall and slab (see Annex II, Figure 6).
f) The cross sectional details of openings such as the blast door opening, ventilation openings and services penetrations including their location, size and steel reinforcement details around them (see Annex II, Figure 7); and
g) The cross sectional details of electrical services such switches and lighting point, switched socket outlet, telephone outlet. TV and radio outlets including their location, size and steel reinforcement details around them (see Annex II, Figure 8).

In addition sections for SSS shall include the following:

a) The cross sectional details of openings of horizontal and vertical blast hatch including its location, size and steel reinforcement details around them;
b) The reinforced concrete roof structures over the mechanical ventilation shaft above main roof level showing steel reinforcement bar size, spacing, anchorage and tension lapped lengths.

F. Elevations

a) The steel reinforcement bars around the ventilation sleeve opening (see Annex II, Figure 9)
b) The steel reinforcement bars around switches and lighting point, switched socket outlet, telephone outlet. TV and radio outlets (see Annex II, Figure 8)

H. Schedules

a) Schedule of reinforcement bars for the HS, SS and SSS shall be provided with types of rebar, rebar size, rebar spacing, curtailment marking to meet the technical requirement. Table below shows schedule of reinforcement.

Table 7 - Steel reinforcement bar size and spacing for each curtailment marking

Curtailments of welded steel fabric mesh and steel bars						
Curtailment marking	a	b	e	f	g	h
Steel Mesh	D10	D10	D10	D10	D10	D10
Curtailments and steel bars						
Curtailment marking	c	d	m	i		
Steel bar	H10-100	H10-100	H10-100	H10-100		

b) Schedules of wall, column, beam and slab for the HS, SS and SSS shall be provided with the dimension of length, width and height to meet the technical requirement.
c) Schedules of blast door, blast hatch, rescue hatch, ventilation sleeve for the HS, SS and SSS shall be provided with the dimension of length, width and height to meet the technical requirement.

1.4 Structural Requirements for Transit Shelter (TS)

1.4.1 General Requirements

The Qualified Person (QP) shall familiarize himself with the CD Shelter Requirements for MRT Stations before preparing the Structural BIM submission for MRT Transit CD shelters. The submission shall comprise native BIM 3D models, 2D plans, sections and elevations that are illustrative with details and dimensions, to demonstrate compliance with the CD shelter requirements. The submission shall comprehensively cover important aspects of the shelter.

Civil Defence Transit Shelters (TS) Submission Requirements

(Required Views, but not limited to)

2D Views	3D Views	Schedules

• *General Notes**
• Shelter Layout
  ○ Floor Plans
  ○ Cross and Longitudinal Section Views
  ○ Elevation Views
	Full Physical Model (PM) showing the following:
	  ○ Shelter Structure including Strike Points
	  ○ Entrance Areas
	  ○ CD Doors and Supporting Structure
	  ○ Air Shafts and Bomb Pits
	  ○ Services Penetrations in Entrance Areas
		Schedules for all structural elements not limited to:
		  • Reinforcement Schedule of Supporting Structure around all CD Doors

All 2D Views and Schedules shall be placed on sheets		

*Items with * can be submitted as CAD drawings as a drafting view*

A. TS Full Model

The 3D model shall show the entire CD shelter, and shall include the following:

a) Entrance and exit configurations;
b) Strike point location (massing elements or dummy object) ;
c) Entrance hinged doors (EHDs), or sliding doors (SLDs) and door chambers if used in place of EHDs;
d) PT doors including any related bypass areas; and
e) Air shafts with bomb pit configurations.

B. TS Plans, Sections and Elevations

The 2D plans, sections and elevations shall illustrate clearly the following:

a) Entrance area layout leading from opening at ground level (or elsewhere) to the EHD and PT door,
b) Strike point line and distance measured from the strike point to the EHD and PT door,
c) Wall and slab thicknesses, in particular, those around the CD doors, and
d) Size of openings and type of services penetrations such as MCTs, puddle flanges, etc. in walls or slabs next to or in the vicinity of the CD doors.
e) The BIM generated views shall show all associated dimensions, labels, spacing, etc. and shall demonstrate compliance with the CD Shelter Requirements for MRT Stations. The same shall apply if a sliding door and chamber are used in place of the EHD.

C. TS Entrance Areas Part Model

For each entrance area leading to a CD door, a part 3D model shall be provided to illustrate clearly the following:

a) Entrance configuration from opening at ground (or elsewhere) to the CD doors
b) Strike point line;
c) Entrance hinged door (EHD) or, sliding door and door chamber if used in place of EHD;
d) PT door including any related bypass area; and

e) Openings for services penetrations such as for air ducts, pipes, electrical cables, trunkings and conduits in walls or slabs next to or in the vicinity of the CD doors.

D. TS Entrance Areas Plans, Sections and Elevations

The 2D plans, sections and elevations shall illustrate clearly the following:

a) Entrance area layout leading from opening at ground level (or elsewhere) to the EHD and PT door,
b) Strike point line and distance measured from the strike point to the EHD and PT door,
c) Wall and slab thicknesses, in particular, those around the CD doors, and
d) Size of openings and type of services penetrations such as MCTs, puddle flanges, etc. in walls or slabs next to or in the vicinity of the CD doors.
e) The BIM generated views shall show all associated dimensions, labels, spacing, etc. and shall demonstrate compliance with the CD Shelter Requirements for MRT Stations. The same shall apply if a sliding door and chamber are used in place of the EHD.

E. CD Doors and Supporting Structure Part Model

Part 3D models of the CD doors (EHD, SLD, or PT) and its supporting structure shall be provided to illustrate clearly the following:

a) Supporting structure (walls, slabs, corbels, lintels, etc.) and its reinforcement bars (rebar) to resist CD door line loads, including interfacing bars with door frame;
b) Door frame including fish tails, holding bars, anchor studs, etc.;
c) Top and bottom maintenance pits (for EHD);
d) Floor levels and kerbs;
e) Floor and wall hooks for chain block shackles (for EHD and/or SLD);
f) SLD chamber (if SLD is used); and
g) Openings for services penetrations such as for air ducts, pipes, electrical cables, trunking and conduits in walls or slabs next to or in the vicinity of the CD doors.
h) Models shall show buildability and no obstructions between the rebar and the door frame parts.

F. CD Doors and Supporting Structure Plans, Sections and Elevations

The 2D plans, sections and elevations shall illustrate clearly the same as required above under *Part 3D Model* but shall in addition, show all associated dimensions, rebar sizes, rebar spacing, labels, etc. to demonstrate compliance with the *CD Shelter Requirements for MRT Stations*.

G. CD Doors Supporting Structure Schedule

Table 8 - Steel reinforcement bar size and spacing for each curtailment marking

Curtailments and welded steel fabric mesh and steel bars						
Curtailment marking	a	b	e	f	g	h
Steel Mesh	D10	D10	D10	D10	D10	D10
Curtailments and steel bars						
Curtailment marking	c	d	m	i		
Steel bar	H10-100	H10-100	H10-100	H10-100		

H. Air Shafts and Bomb Pits Part Model

For each air shaft and its bomb pit, a Part 3D model shall be provided to illustrate clearly the following:

a) Air shaft configuration from opening at ground level (or elsewhere) to the plant room interface; and
b) Bomb pit.

I. Air Shafts and Bomb Pits Plans, Sections and Elevations

The 2D plans, sections and elevations shall illustrate clearly the following:

a) Air shaft layout from opening at ground (or elsewhere) to the plant room interface;
b) Wall and slab thicknesses;
c) Air shaft and bomb pit dimensions; and
d) The BIM generated views shall show all associated dimensions, labels, spacing, etc. to facilitate review and shall demonstrate compliance with the CD Shelter Requirements for MRT Stations.

J. CD Technical Requirements for S10-S29 Public Shelters

Where a transit CD shelter is to be designed and built based on the CD Technical Requirements for S10-S29 Public Shelters, or Addition and Alteration (A&A) works are carried out on such S10-S29 Shelters, the Qualified Person (QP) shall familiarize himself with the aforementioned document before preparing the Structural BIM submission.

The submissions shall comprise native BIM 3D models, 2D plans, sections and elevations that are illustrative with details, dimensions, spacing, labels, schedules, material types, etc. to show compliance with the Technical Requirements for S10-S29 Public Shelters. The level of detail and information shown in the 2D plans, sections and elevations shall be similar as that of traditional (2D) structural plan submissions.

The QP shall consult the Transit Shelter Engineering Department of BCA for clarification.

1.5 Structural Requirements for Public Shelter (PS)

1.5.1 General Requirements

The Qualified Person (QP) shall familiarize himself with the Technical Requirements for S1-S5 Public Shelter before preparing the Structural BIM submission for public shelters. The submission shall comprise native BIM 3D models, 2D plans, sections and elevations that are illustrative with details and dimensions, to demonstrate compliance with the public (CD) shelter technical requirements. The level of detail and information shown in the 2D plans, sections and elevations shall be similar as that of traditional (2D) structural plan submissions.

The submission shall comprehensively cover important aspects of the shelter described in the following sections.

The QP shall consult the Civil Defence Shelter Engineering Department of BCA for clarification.

Civil Defence Public Shelters (PS) Submission Requirements

(Required Views, but not limited to)

2D Views	3D Views	Schedules

• *General Notes**
• *Typical Details**
• *Typical Connections**
• Non Typical Connections
• Floor Plans
• Cross and Longitudinal Section Views
• Elevation Views
	• Full Physical Model (PM) showing the following:
	  ○ Public Shelter
	  ○ Entrance Areas
	  ○ CD Doors and Supporting Structure
	  ○ Air Shaft
	• Penetrations/Openings
		Schedules for all structural elements not limited to:
		• Beam, Column, Slab and Wall Schedule
		• Reinforcement Bars Schedule
		• CD Door, Hatch, Window Schedule
		• CD Valve Schedule

All 2D Views and Schedules shall be placed on sheets		

*Items with * can be submitted as CAD drawings as a drafting view*

A. PS Structure Full Model

The 3D model shall show the entire CD shelter, and shall include the following:

a) Entrance and exit configurations;
b) Imaginary line of sight to the BD;
c) Blast doors (BD), blast hatches (BH), blast fragmentation door (BFD), blast fragmentation window (BFW) and including any related bypass areas;
d) Gas-tight doors (SSD); and
e) Air shafts.

B. PS Structure Plans, Sections and Elevations

The 2D plans, sections and elevations shall illustrate clearly the following:

a) General layout at CD levels or space associated with the CD shelter.
b) General notes stating the material type and grade (steel, concrete reinforcement bars) use for public shelter.
c) Bounds of protection.
d) Entrance area configurations leading from the opening at ground level (or elsewhere) to the CD doors, including imaginary line of sight to the BD and wall and slab thicknesses.
e) Blast doors (BD), blast hatches (BH), blast fragmentation door (BFD) and blast fragmentation window (BFW), blast valves clearances from adjacent walls, and adjacent wall and slab thicknesses.
f) Ventilation air shafts configurations from opening at ground level (or above ground level) to plant room areas.
g) The dimension and thickness of wall (external and internal) and slab.
h) The reinforcement details for the public shelter wall and slab shall be clearly shown on plan, section and elevation (if any) with curtailment marking, bar size and spacing, lapped and anchorage length. In addition, the spacing of reinforcement bars shall be as shown below in Fig. 20, 21 and 22.
i) Schedule of reinforcement bars for the PS shall be provided with types of rebar, rebar size, rebar spacing, curtailment marking to meet the technical requirements. Table 9 shows the sample of schedule of reinforcement bars.

C. PS Reinforcement Schedule

Table 9 - Steel reinforcement bar size and spacing for each curtailment marking

Curtailments of welded steel fabric mesh and steel bars						
Curtailment marking	a	b	e	f	g	h
Steel Mesh	D16	D16	D16	D16	D16	D16
Curtailments and steel bars						
Curtailment marking	c	d	m	i		
Steel bar	H20-100	H20-100	H20-100	H20-100		

The Reinforcement bars detail around Blast doors (BD), blast hatches (BH), blast fragmentation door (BFD) and blast fragmentation window (BFW), blast valves and Ventilation air shafts and other opening or recess shall be shown on plan, section and/or elevations.

Fig. 20 - Section showing reinforcement spacing of a typical 1-storey public shelter

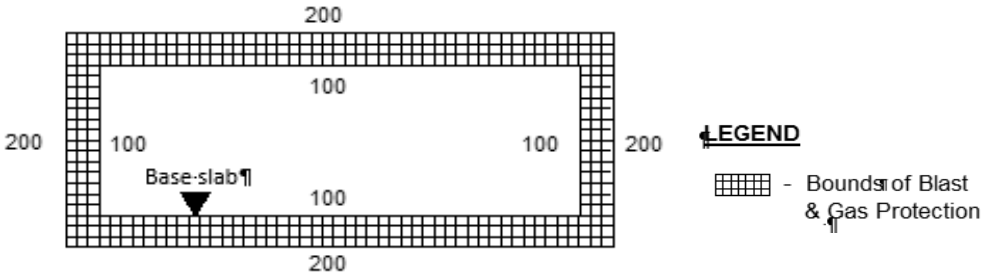


Fig. 21 - Section showing reinforcement spacing of a typical 2-storey public shelter

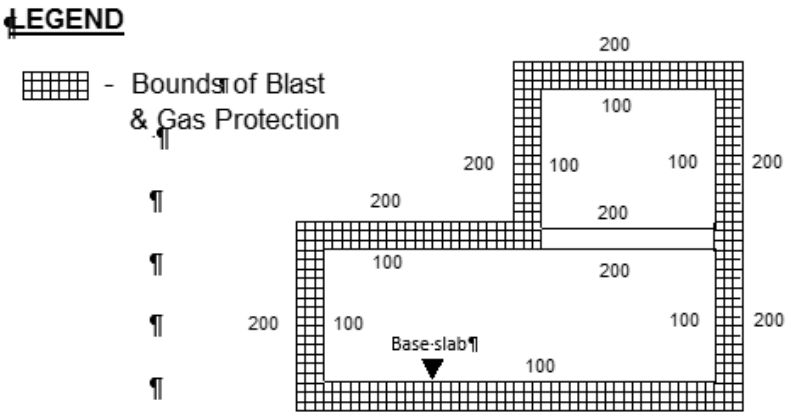
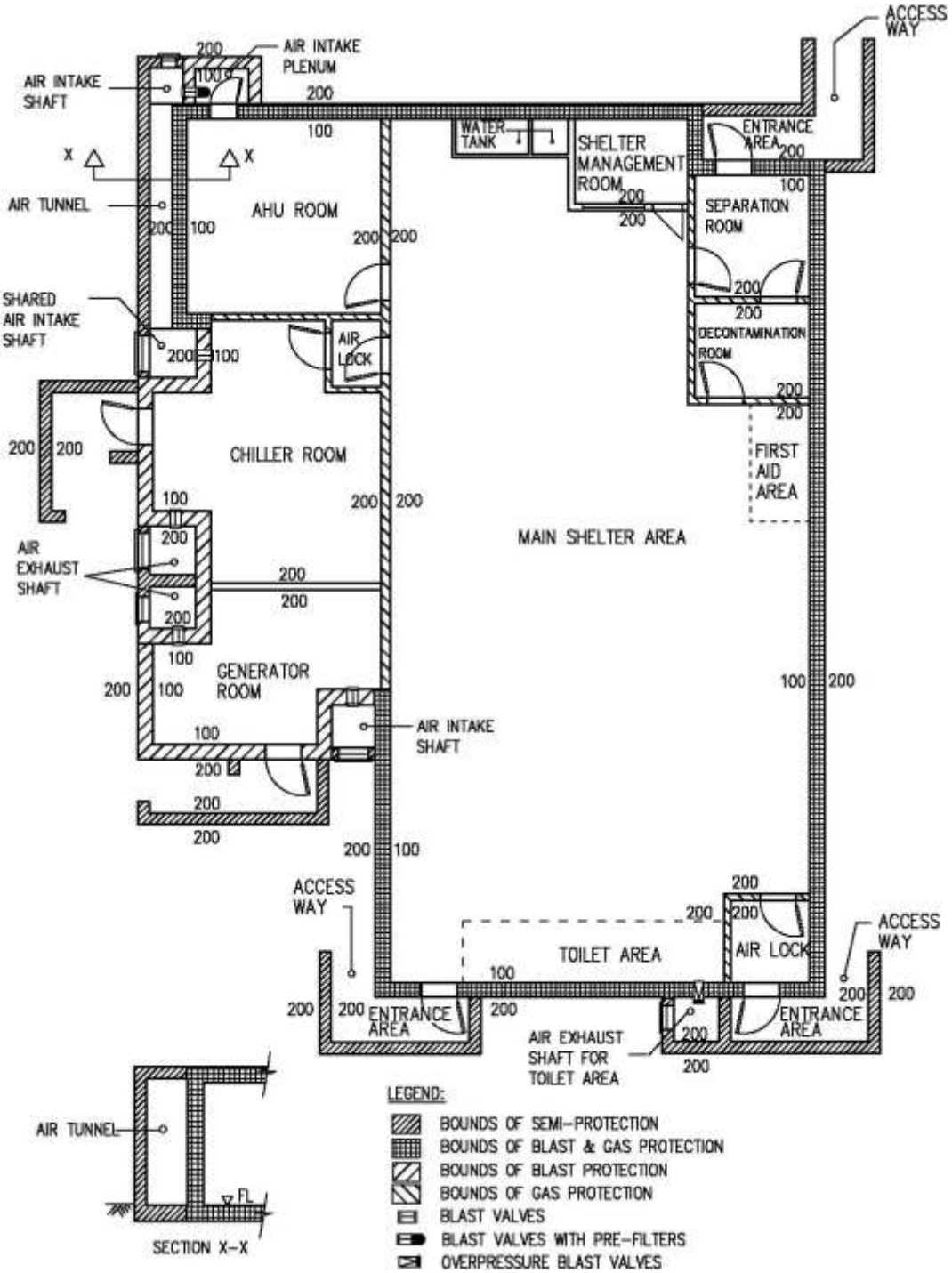


Fig. 22 - Layout of a typical public shelter showing reinforcement spacing



CORE INFORMATION (CI)

Core Information or CI are minimum object attributes/parameters required to be embedded for all load bearing elements. The attributes can either be pre-loaded within objects or fill up by QP or injected via Excel to BIM link.

BOREHOLE ATTRIBUTES

GEOTECHNICAL DUMMY OBJECT		
Attribute Name	Sample Value	Description
PROJ_ID	A0677-00001-2015	Project reference no. of the ST submission
PROJ_NAME	Soil Investigation Works at No.XXXXX Road, Singapore XXXXXX	Project Title
PROJ_CLNT	Mr. XXX	Project client/Data owner
HOLE ID	BH1	Borehole reference identifier(as per original borelog/AGS data)
HOLE_STAR	15/7/2015	Borehole start to drill date
HOLE_NATN	36010.451	Borehole coordinate: Northing
HOLE_NATE	13169.723	Borehole coordinate: Easting
HOLE_GL	6.514	Borehole ground level (RL)
HOLE_FDEP	45	Borehole final depth (m)
ROCK_HEAD	33.5	Rock head depth(if encountered)
FORMATION	Granite	Geological formation

SUBSTRUCTURE ELEMENTS

PILES	
Parameter Name	Sample Value
Pile Mark	P1
Pile Type	Bored, Secant, CBP
Pile Diameter/Size	600 /500x500
Pile X-Easting	30118.210
Pile Y-Northing	29226.632
Pile As Built Length (SHD)	39.175
Pile Cut Off level (SHD)	88.975
Pile Toe Level (SHD)	49.800
Loading (kN)	1500
Material Grade	C40/G550
Remarks/Status	New/Existing/Demolish
Project Title	Condominium
Developer	ABC123

PILE CAP	
Parameter Name	Sample Value
Pile Cap Mark	PC1
Pile Cap Type	2/3/4/5/6/8/10
Pile Cap Size	500x500
Pile Cap X-Easting	30118.210
Pile Cap Y-Northing	29226.632
Group Loading (kN)	4500
Concrete Grade	C40
Remarks/Status	New/Existing/Demolish
Project Title	Condominium
Developer	ABC123

SUBSTRUCTURE SLAB	
Parameter Name	Sample Value
Slab Mark	S1
Slab Type	Composite/InSitu/Suspended
Slab Thickness	300
Slab Openings Size	1000x1000
Slab Direction	1way/2way
Slab X-Easting	30118.210
Slab Y-Northing	29226.632
Concrete Grade	C40
Remarks/Status	New/Existing/Demolish

RETAINING WALL	
Parameter Name	Sample Value
Wall Mark	W1
Wall Type	inSitu/Precast
Wall Thickness	300
Wall Openings Size	1000x1000
Wall X-Easting	30118.210
Wall Y-Northing	29226.632
Concrete Grade	C40
Remarks/Status	New/Existing/Demolish

TUNNELS	
Parameter Name	Sample Value
Tunnel Mark	TU1
Tunnel Type	Shaft/Cavern
TunnelDimensions	500
Tunnel X-Easting	30118.210
Tunnel Y-Northing	29226.632
Concrete Grade	C40
Remarks/Status	New/Existing/Demolish

PIER AND COLUMNS	
Parameter Name	Sample Value
Pier Mark	P1
Pier Type	Column/Caisson/Abutment
Pier Dimensions	600x500
Pier X-Easting	30118.210
Pier Y-Northing	29226.632
Concrete Grade	C40
Remarks/Status	New/Existing/Demolish

STRUCTURAL FRAMING	
Parameter Name	Sample Value
Beam Mark	GR1/1HB1
Beam Type	Cas inSitu/Precast/Girder
Grade Beam Dimension	600x500
GB X-Easting	30118.210
GB Y-Northing	29226.632
Concrete Grade	C40
Remarks/Status	New/Existing/Demolish

OTHER DETAILS OF SUPERSTRUCTURE WORKS	
Parameter Name	Sample Value
Element Mark	A1
Element Type	Ground Treatment/ Slope Protection/Soil Anchors
Element Dimensions	400x600
Element Offset	100
Element X-Easting	30118.210
Element Y-Northing	29226.632
Material Grade	C40
Remarks/Status	New/Existing/Demolish

CRITICAL CONNECTIONS	
Parameter Name	Sample Value
Element Mark	A1
Element Type	Concrete: Rebar/Mesh/Tendon Steel: Bolt/Anchor/Stud/Weld
Element Dimensions	400x600
Element Offset	100
Material Grade	C40
Remarks/Status	New/Existing/Demolish

SUPERSTRUCTURE ELEMENTS

FRAMING	
Parameter Name	Sample Value
Beam Mark	C1
Beam Type	Beam/Girder/Joist/Purlin
Beam Size	600x800
Beam Offset	200
Beam Rotation	30
Construction Method	Cast in Situ/Precast
Concrete/Steel Grade	C40/G550
Remarks/Status	New/Existing/Demolish

COLUMNS/PEDESTAL	
Parameter Name	Sample Value
Column Mark	C1
Column Type	Square/Circular
Column Diameter/Size	600/500x500
Column Offset	200
Column Rotation	30
Construction Method	Cast in Situ/Precast
Loading (kN)	1500
Concrete/Steel Grade	C40/G550
Remarks/Status	New/Existing/Demolish

SUPERSTRUCTURE FLOOR/SLAB	
Parameter Name	Sample Value
Slab Mark	S1
Slab Type	Composite/InSitu/Suspended
Slab Thickness	300
Slab Openings Size	1000x1000
Span Direction	1way/2way
Concrete Grade	C40
Remarks/Status	New/Existing/Demolish

SUPERSTRUCTURE WALLS	
Parameter Name	Sample Value
Wall Mark	W1
Wall Type	InSitu/Precast
Wall Thickness	300
Wall Offset	100
Wall Openings Size	1000x1000
Material Grade	C40
Remarks/Status	New/Existing/Demolish

TRUSS	
Parameter Name	Sample Value
Truss Mark	W1
Truss Type	Pratt/Warren: Bowstring/Scissors; Dual/Mono
Truss Length	20000
Truss Offset	250
Uniform Load (kN/m)	12
Point Load (kN)	5
Material Grade	C40
Remarks/Status	New/Existing/Demolish

CIRCULATION	
Parameter Name	Sample Value
Circulation Mark	ST1
Circulation Type	Staircase/Ramps
Circulation Length	8000
Circulation Offset	250
Circulation Width	1200
Uniform Load (kN/m)	5
Material Grade	C40
Remarks/Status	New/Existing/Demolish

OTHER DETAILS OF SUPERSTRUCTURE WORKS	
Parameter Name	Sample Value
Element Mark	A1
Element Type	Lift/Cladding/Prestress/Post Tension/PPVC/CLT/Glulam
Element Dimensions	400x600
Element Offset	100
Material Grade	C40
Remarks/Status	New/Existing/Demolish

CRITICAL CONNECTIONS	
Parameter Name	Sample value
Element Mark	A1
Element Type	Concrete: Rebar/Mesh/Tendon Steel: Bolt/Anchor/Stud/Weld Timber: CLT/Glulam
Element Dimensions	400x600
Element Offset	100
Material Grade	C40
Remarks/Status	New/Existing/Demolish

CIVIL DEFENCE SHELTER ELEMENTS

HOUSEHOLD SHELTER (HS)	
Parameter Name	Sample Value
HS Door Opening	700x1900
Curtailment Marking	a/b/c/d/e/f/g/h/i/j/k
Steel Mesh	D10/13
Steel Bar	H10-100
Tension Lap Length	300
Rebar Cover	35
Ventilation Sleeve Opening	150
Floor Thickness	175
Wall Thickness	300
Concrete Grade	C40
Construction Method	Cast in Situ/Precast
Remarks/Status	New/Existing/Demolish

STOREY SHELTER (SS)	
Parameter Name	Sample Value
SS Door Net Opening	1000x1900
Curtailment Marking	a/b/c/d/e/f/g/h/i/j/k
Steel Mesh Size	D10/13
Steel Bar Spacing	H10-100
Tension Lap Length	300
Rebar Cover	35
Ventilation Sleeve Opening	150
Floor Thickness	175
Wall Thickness	300
Material Grade	C40
Construction Method	Cast in Situ/Precast
Remarks/Status	New/Existing/Demolish

STAIRCASE STOREY SHELTER (SSS)	
Parameter Name	Sample Value
SSS Door Net Opening	1000x1900
Curtailment Marking	a/b/c/d/e/f/g/h/i/j/k
Steel Mesh Size	D10/13
Steel Bar Spacing	H10-100
Tension Lap Length	300
Rebar Cover	35
Ventilation Sleeve Opening	150
Floor Thickness	200
Wall Thickness	300
Stair Thickness	200
Material Grade	C40
Construction Method	Cast in Situ/Precast
Remarks/Status	New/ Existing/Demolish

TRANSIT SHELTER (TS)	
Parameter Name	Sample Value
Structural Element	Slab, Wall, Beam, Column
Shelter Type	S1, S2, S3, S4, S5
Minimum Dimension	400, 500, 600
Steel Mesh Size	D10/13
Steel Bar Spacing	H10-100
Tension Lap Length	300
Tension Anchorage Length	300
Rebar Cover	35
Ventilation Sleeve Opening	150
Floor Thickness	200
Wall Thickness	300
Stair Thickness	200
Material Grade	C40
Construction Method	Cast in Situ/Precast
Remarks/Status	New/Existing/Demolish

PUBLIC SHELTERS (PS)	
Parameter Name	Sample Value
Door Opening	700x1900
Curtailment Marking	a/b/c/d/e/f/g/h/i/j/k
Steel Mesh	D10/13
Steel Bar	H10-100
Rebar Cover	35
Ventilation Sleeve Opening	150
Floor Thickness	175
Wall Thickness	300
Stair Thickness	200
Material Grade	C40
Construction Method	Cast in Situ/Precast
Remarks/Status	New/Existing/Demolish

COLOUR CODES

The following colours are to be used for superstructure load bearing elements for submission. The colours refer to object outline and not on element face. BCA will issue default BCA templates for all major BIM authoring software to automate the colour assignment via element or category filters.

Critical Key Elements

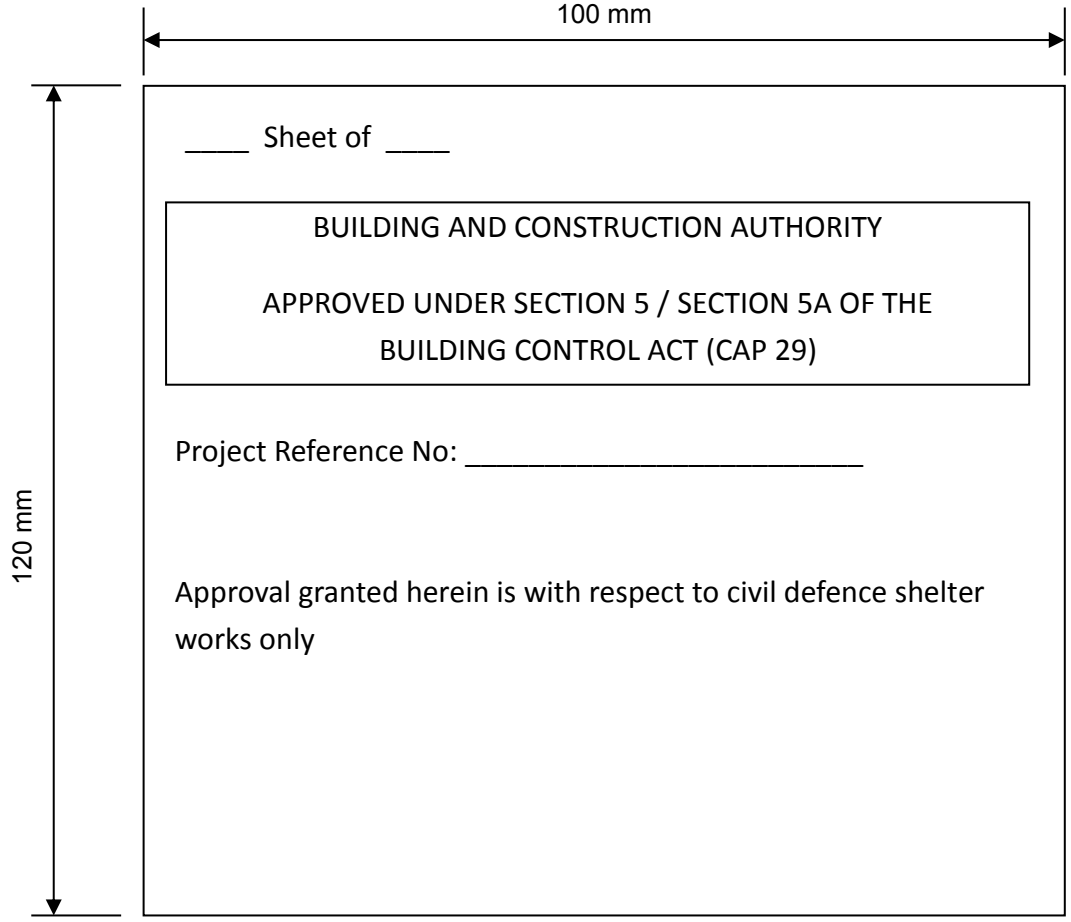
Element Category	Colour	Red	Green	Blue
Cantilever Elements (>6m)		0	0	255
Long Span Structure (>15m)		0	255	0
Transfer Structures		225	0	0
Permanent ERSS		210	180	140

DEFINITION OF TERMS

CO	means Construction Stage where the building works are carried by the contractor
DD	means Detailed Design Stage equivalent to ST and CS submissions
Hypermodel	refers to combined part 3D cross section geometry and annotations
Non Typical Details	are defined as details other than Typical Details
RP	means Record Plans, production of record models/record plans on or before obtaining TOP/CSC
SFL	means Structural Floor Level
SHD	means Singapore Height Datum
Substructure (SUB)	refers to all load bearing structural elements below ground
Superstructure (SUP)	refers to all load bearing structural elements above ground
Typical Details	are defined as repeating details affecting more than 50% of that similar element

ANNEX I. REQUIREMENTS FOR CIVIL DEFENCE SHELTERS

Standard Approval Stamp for Civil Defence Shelter Plans



Standard Certification for Civil Defence Shelter Plans

I, _____, hereby submit the detailed civil defence shelter plans *(and design calculations) prepared by me and certify that:

(a) the preparation of these civil defence shelter plans are in accordance with the Building Control Regulations; and
(b) the civil defence shelter works shown on these plans are designed in accordance with the shelter technical requirements.

2 Total number of civil defence shelter plans submitted: _____ and total number of pages of design calculations: _____.

_____ _____

Qualified Person's Signature and Stamp Date

** Delete where not applicable*

ANNEX II. FIGURES FOR HS, SS AND SSS

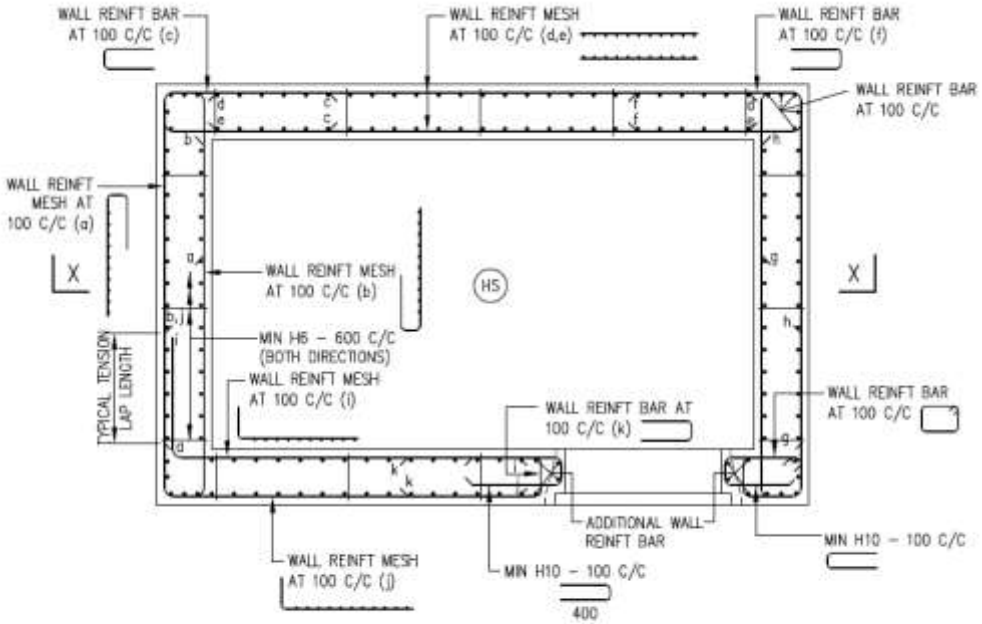


FIGURE 1a. PLAN OF HS WALL AT DOOR OPENING

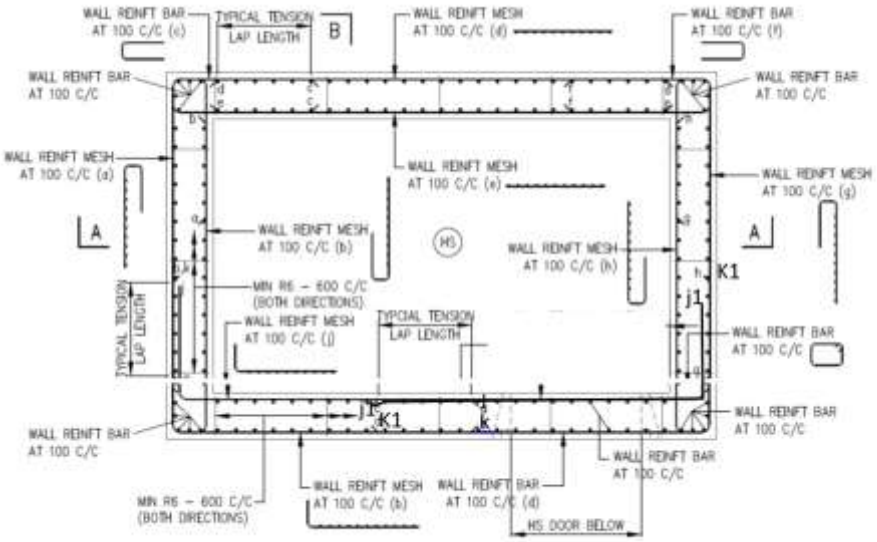


FIGURE 1b. PLAN OF HS AND SS WALL ABOVE DOOR OPENING

TABLE 1a. STEEL REINFORCEMENT BAR SIZE AND SPACING FOR EACH CURTAILMENT MARKING FOR HS (SAMPLE TABLE)

	CURTAILMENT MARKING AND WELDED STEEL FABRIC MESH									
CURTAILMENT MARKING	a	b	d	e	g	h	i	j		
STEEL MESH	D10/13	D10/13	D10/13	D10/13	D10/13	D10/13	D10/13	D10/13		
	CURTAILMENT MARKING AND STEEL BARS									
CURTAILMENT MARKING	c	f	k							
STEEL BAR	H10-100	H10-100	H10-100							

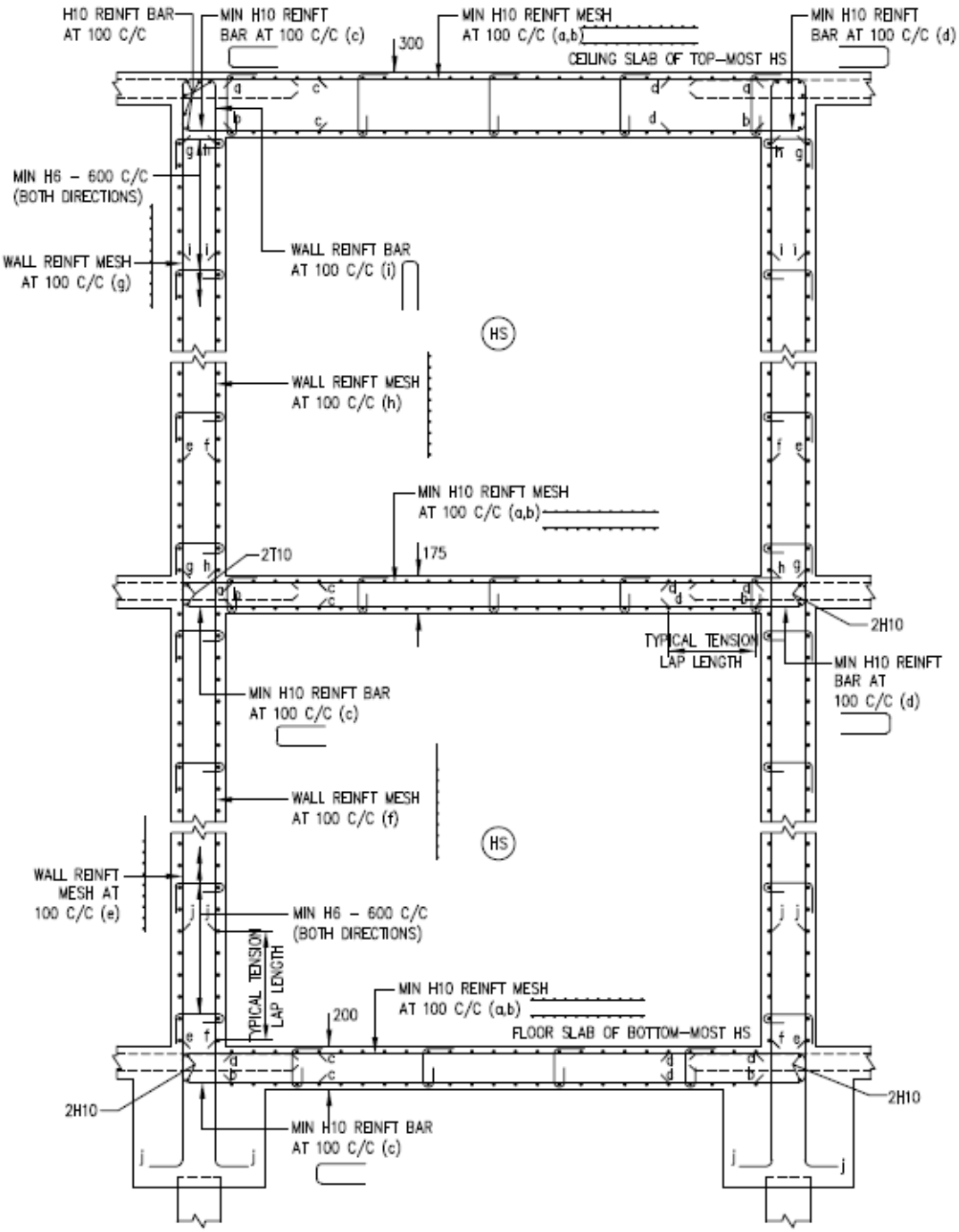


FIGURE 1c. SECTION A-A

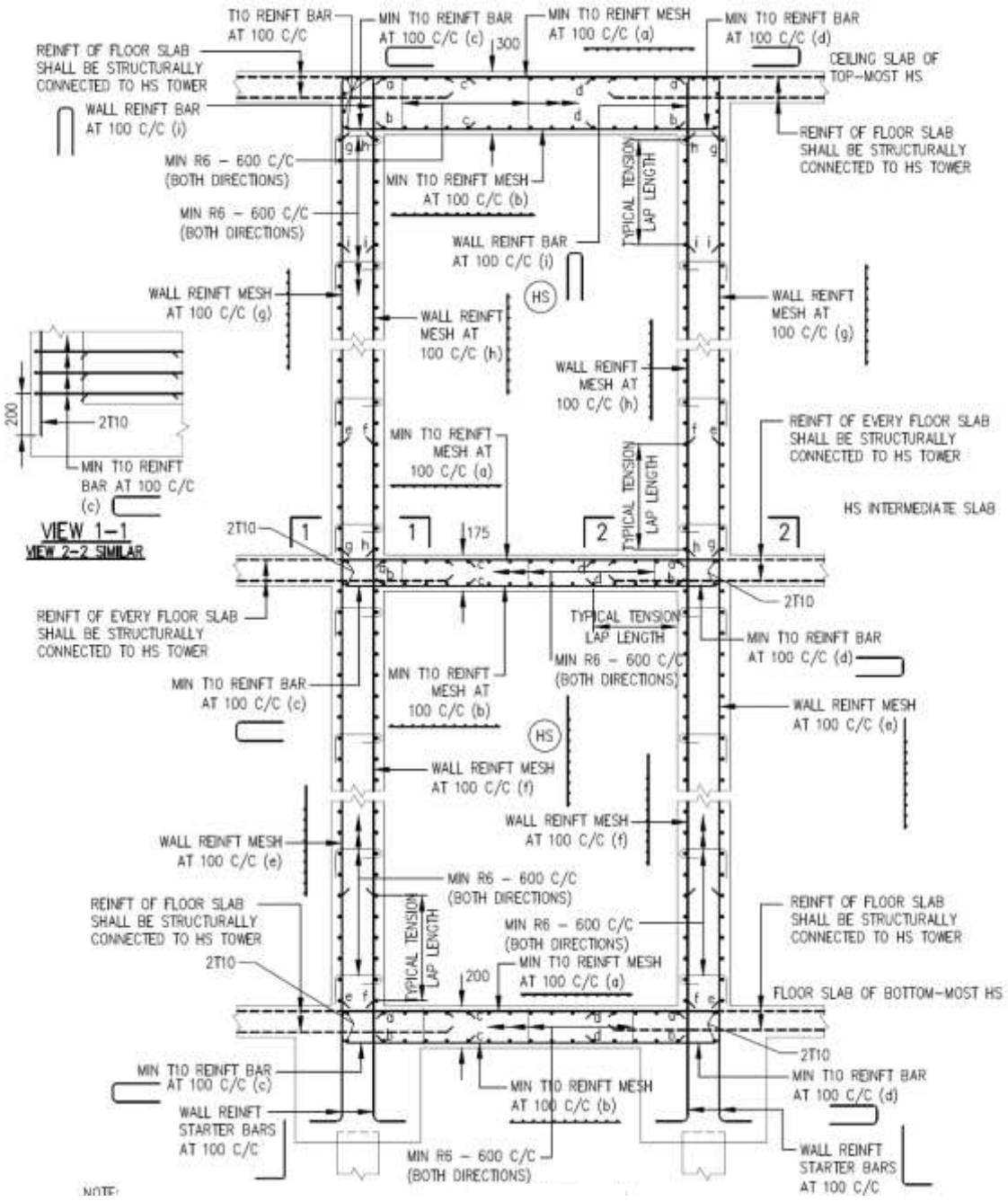


FIGURE 1d. SECTION B-B

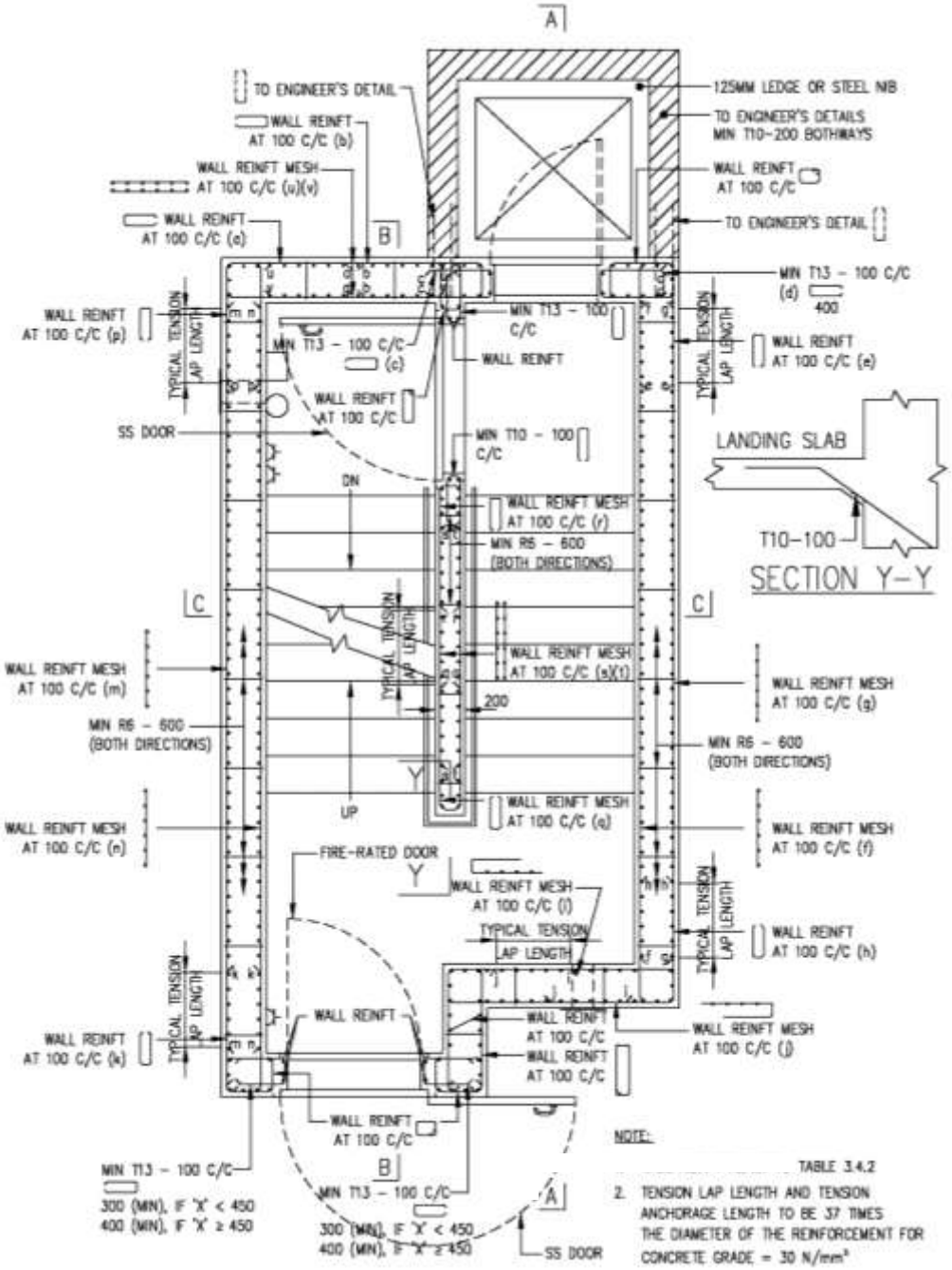
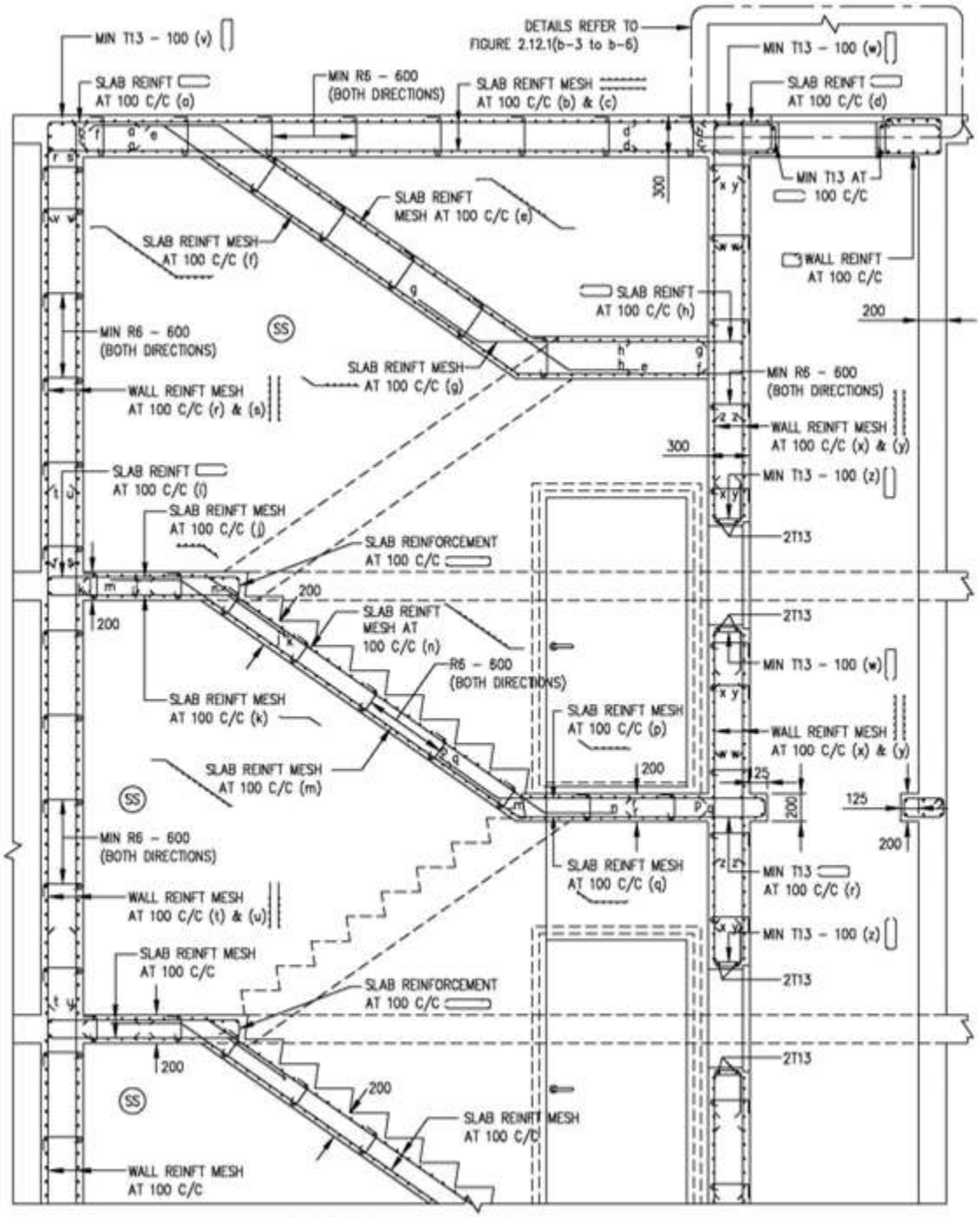


FIGURE 2a. PLAN OF STAIRCASE STOREY SHELTER

TABLE 2a. STEEL REINFORCEMENT BAR SIZE AND SPACING FOR EACH CURTAILMENT MARKING (SAMPLE TABLE)

	CURTAILMENT MARKING AND WELDED STEEL FABRIC MESH									
CURTAILMENT MARKING	f	g	i	j	m	n	u	v		
STEEL MESH	D13/16	D13/16	D13/16	D13/16	D13/16	D13/16	D13/16	D13/16		
	CURTAILMENT MARKING AND STEEL BARS									
CURTAILMENT MARKING	a	b	d	e	h	k	p			
STEEL BAR	H10-100	H10-100	H10-100	H10-100	H10-100	H10-100	H10-100			



NOTE:

FIGURE 2b. SECTION A – A

TENSION LAP LENGTH AND TENSION ANCHORAGE LENGTH TO BE 37 TIMES THE DIAMETER OF THE REINFORCEMENT FOR CONCRETE GRADE = 30 N/mm²

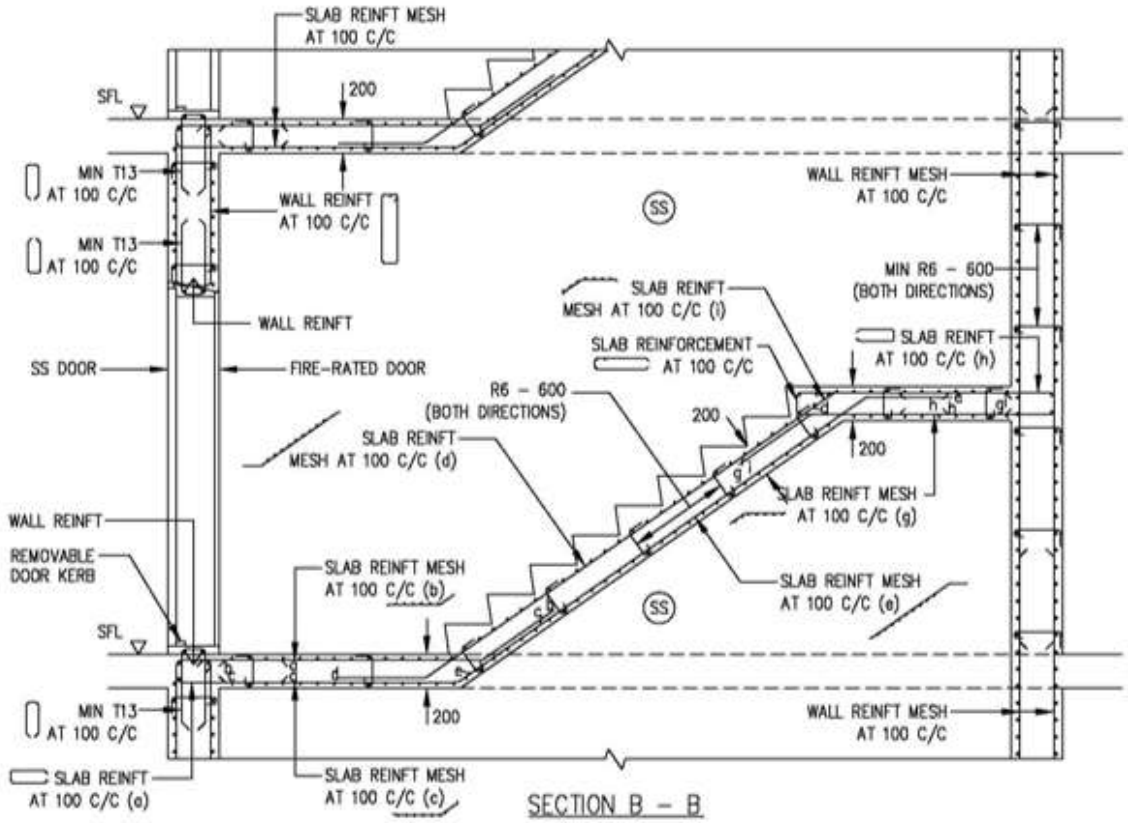


FIGURE 2c. SECTION B-B

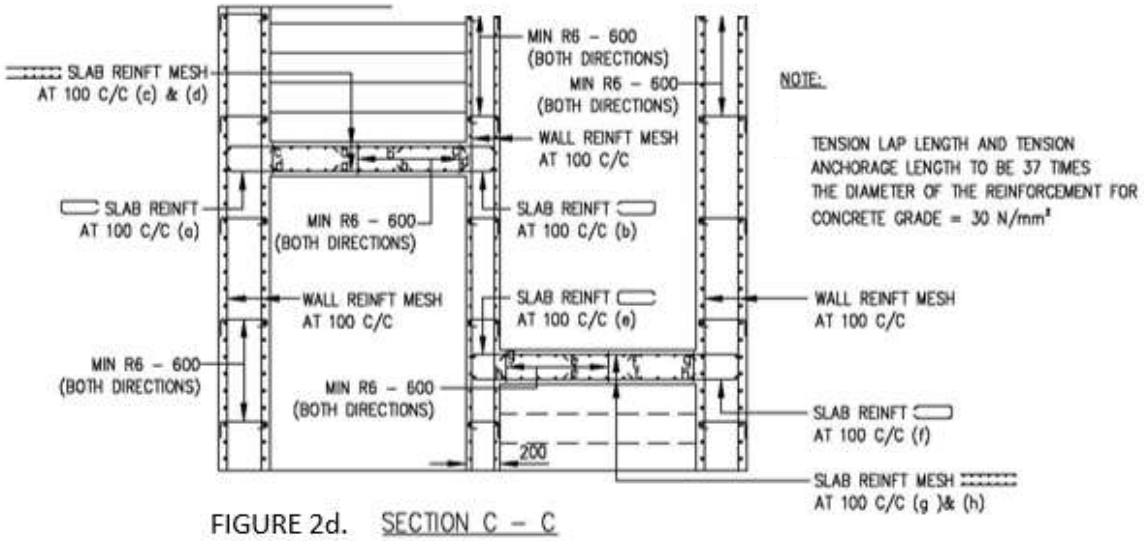


FIGURE 2d. SECTION C - C

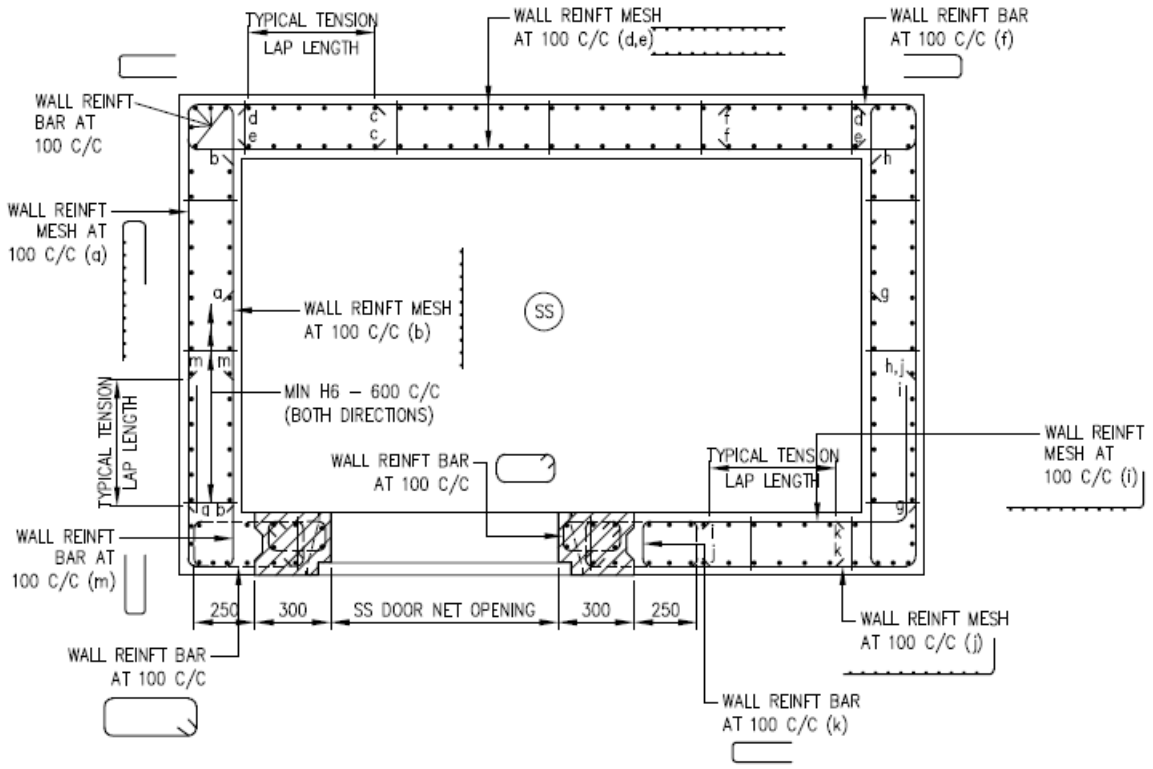


FIGURE 3a. PLAN OF PRECAST HS, SS OR SSS DOOR FRAME (TYPE1)

TABLE 3a. STEEL REINFORCEMENT BAR SIZE AND SPACING FOR EACH CURTAILMENT MARKING (SAMPLE TABLE)

	CURTAILMENT MARKING AND WELDED STEEL FABRIC MESH									
CURTAILMENT MARKING	a	b	d	e	g	h	i	j		
STEEL MESH	D13/16	D13/16	D13/16	D13/16	D13/16	D13/16	D13/16	D13/16		
	CURTAILMENT MARKING AND STEEL BARS									
CURTAILMENT MARKING	c	f	k	m						
STEEL BAR	H10–100	H10–100	H10–100	H10–100						

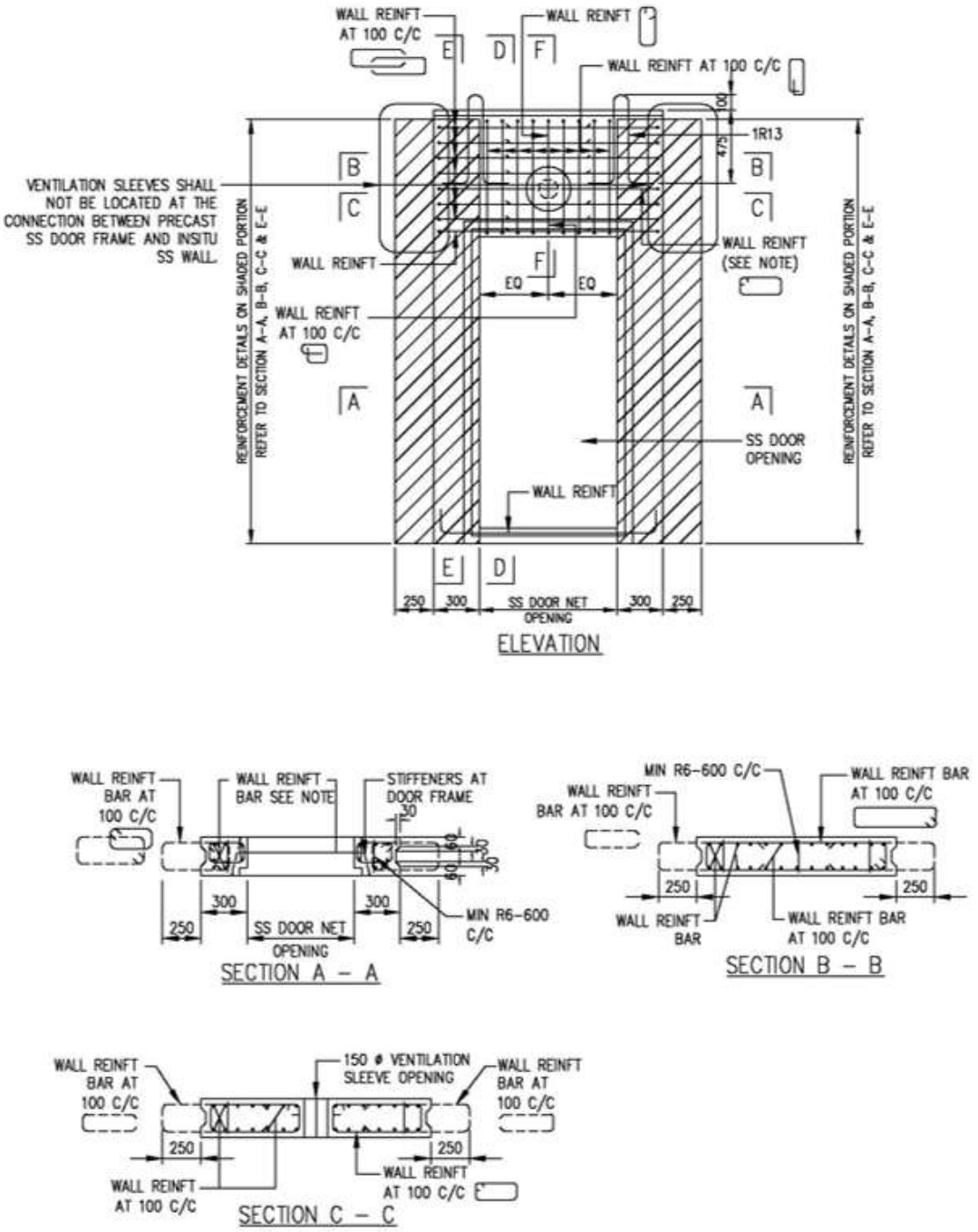


FIGURE 3B. PLAN OF PRECAST HS, SS or SSS DOOR FRAME (TYPE 1)

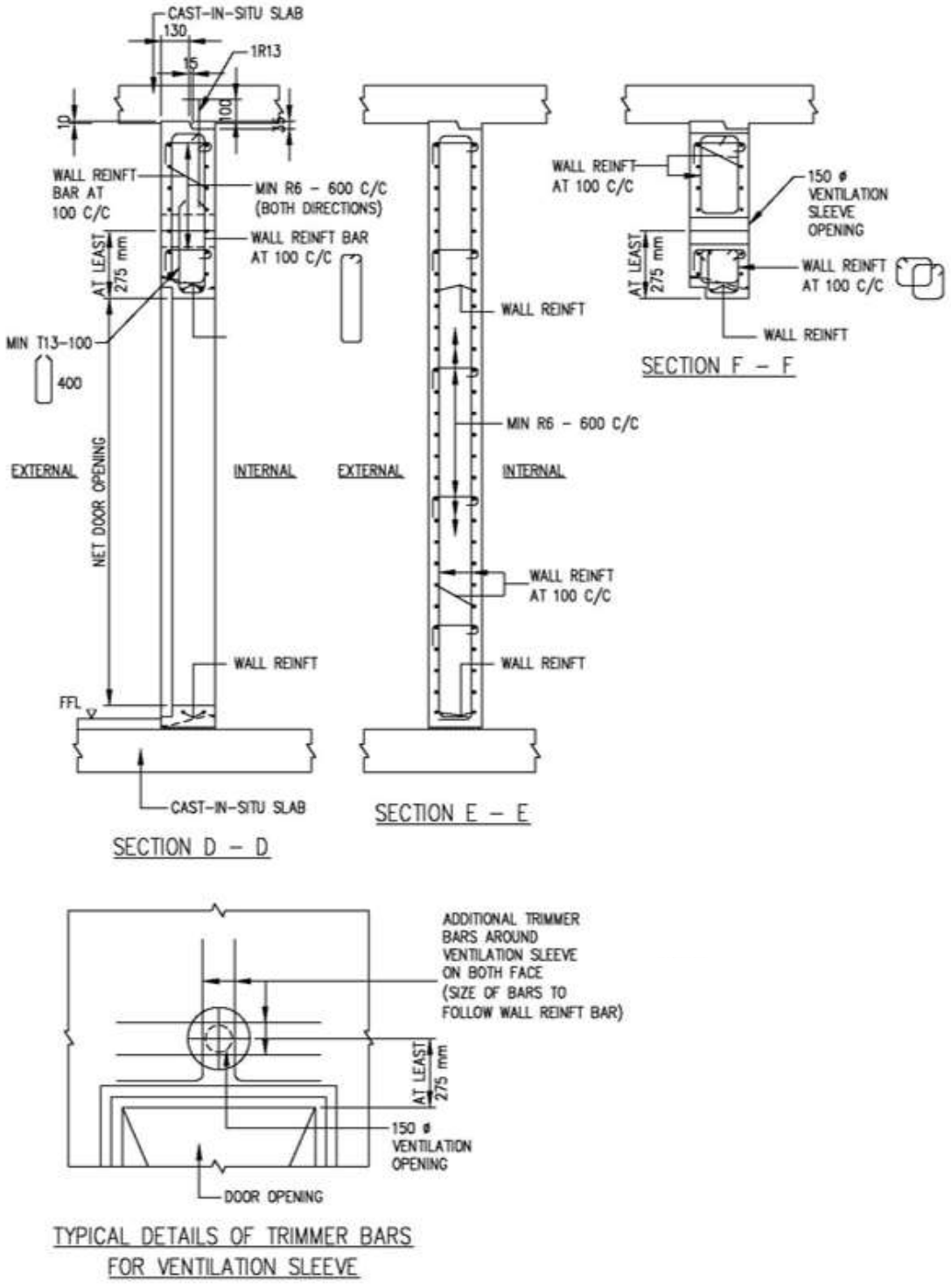


FIGURE 3c. PLAN OF PRECAST HS, SS or SSS DOOR FRAME (TYPE 1)

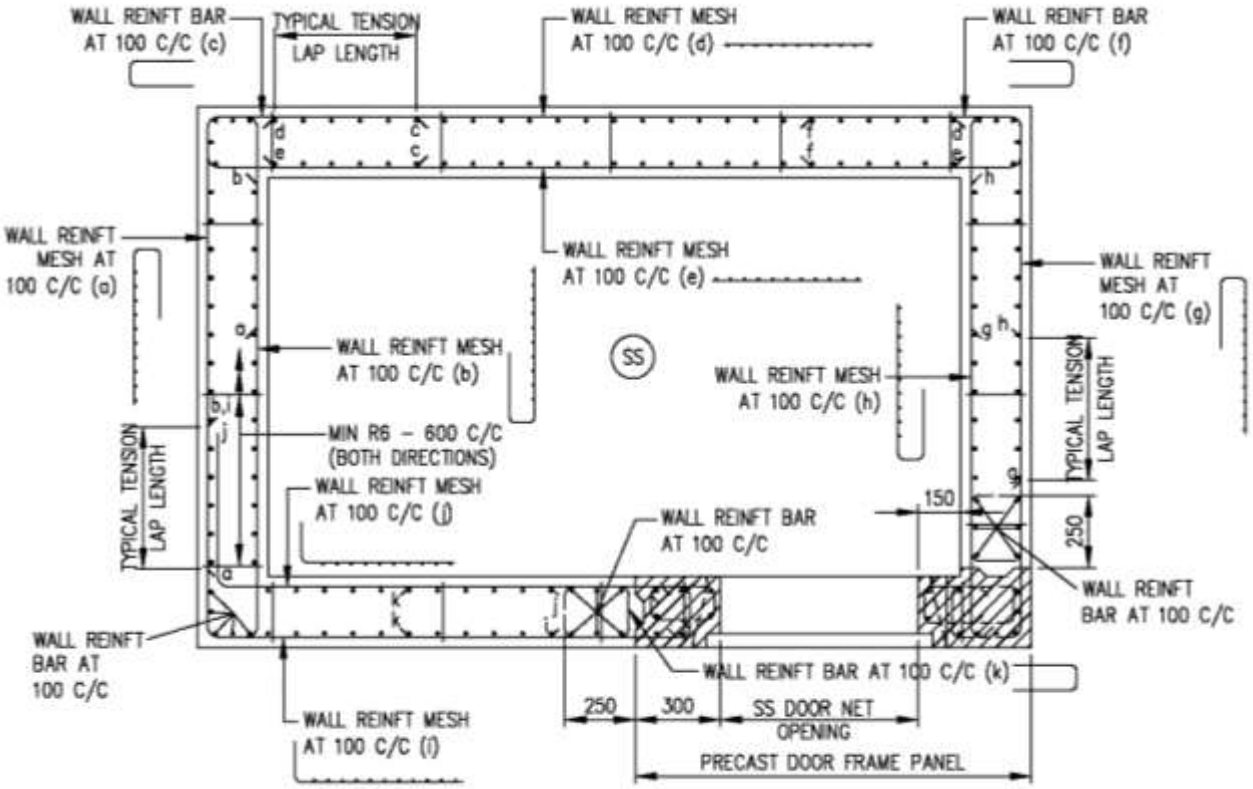


FIGURE 4a. PLAN OF PRECAST HS, SS or SSS DOOR FRAME (TYPE 2)

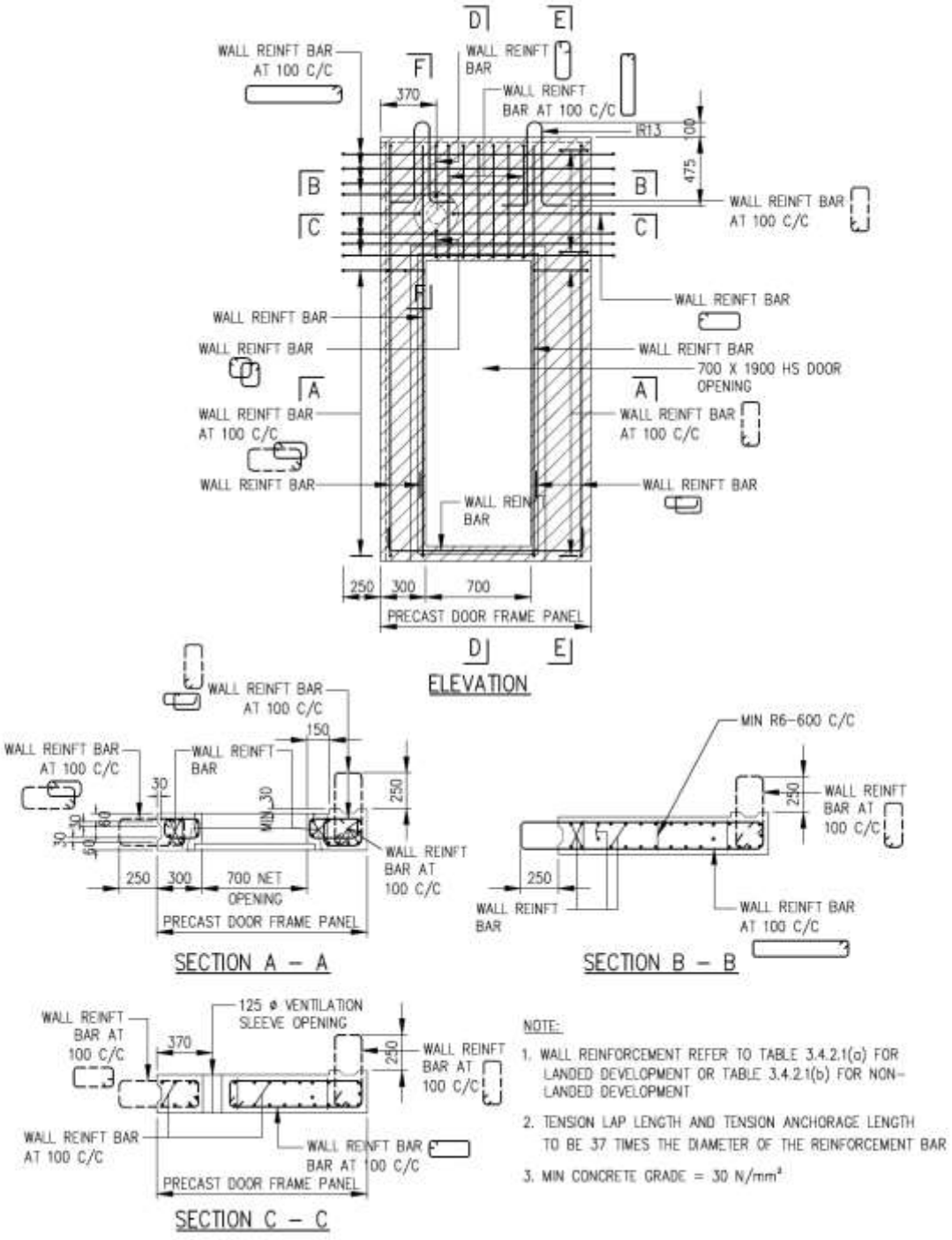


FIGURE 4b. PLAN OF PRECAST HS, SS or SSS DOOR FRAME (TYPE 2)

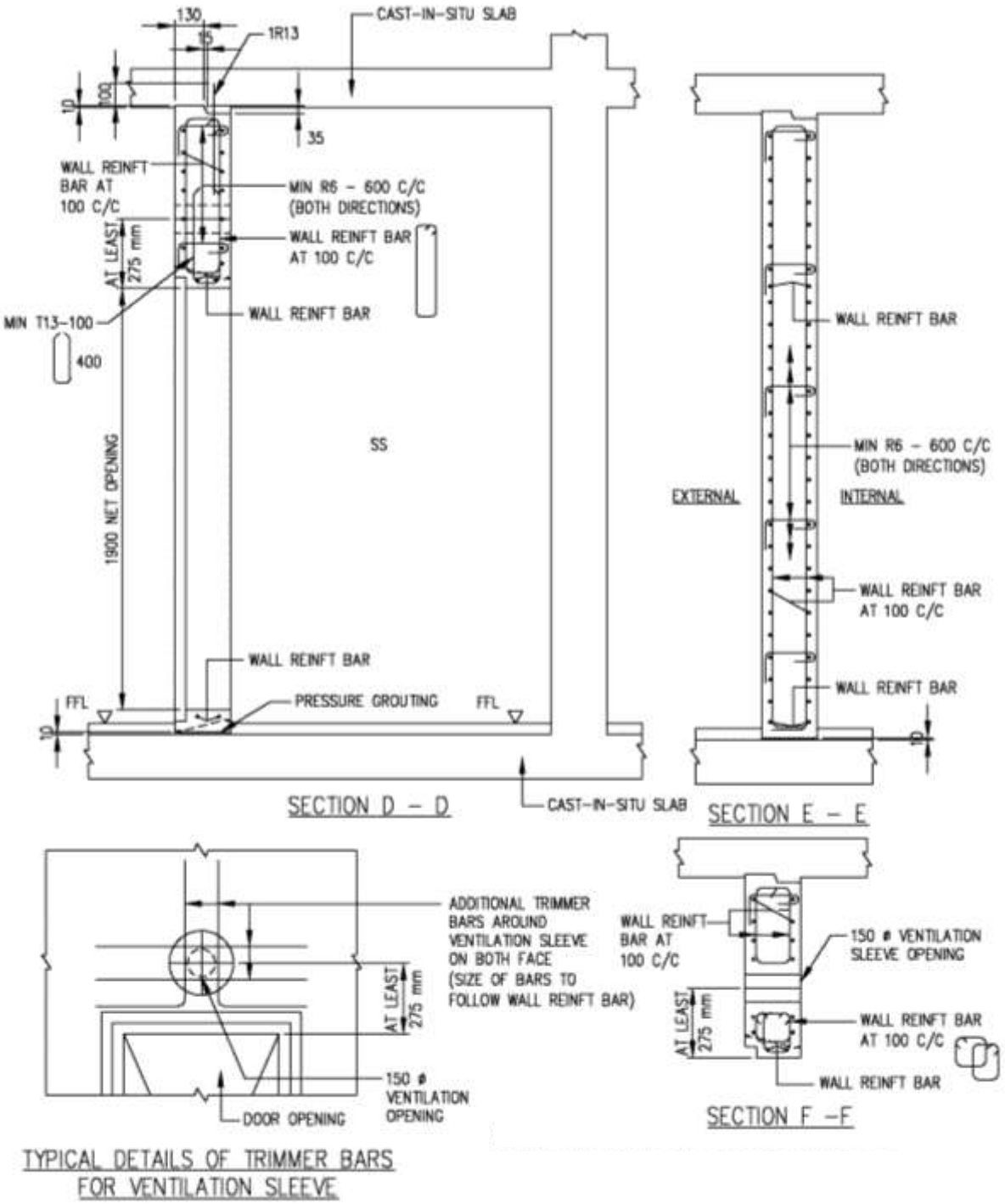
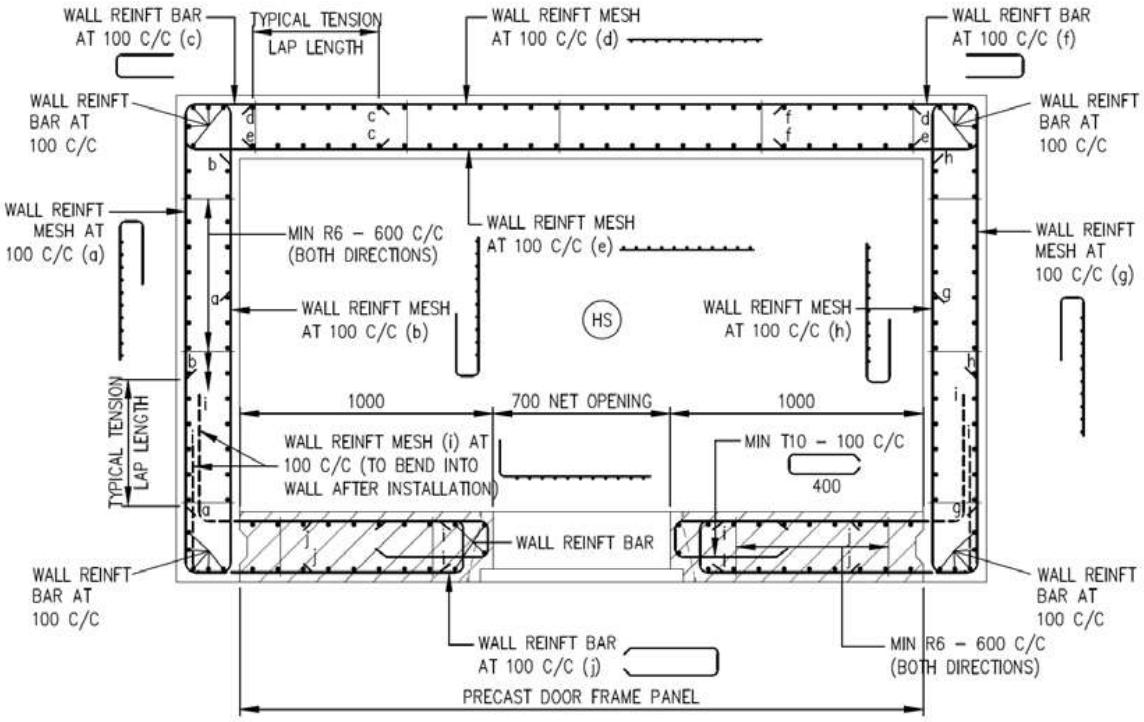


FIGURE 4c. PLAN OF PRECAST HS, SS or SSS DOOR FRAME (TYPE 2)



NOTE:

1. WALL REINFORCEMENT REFER TO TABLE 3.4.2.1(a) FOR LANDED DEVELOPMENT OR TABLE 3.4.2.1(b) FOR NON-LANDED DEVELOPMENT
2. TENSION LAP LENGTH AND TENSION ANCHORAGE LENGTH TO BE 37 TIMES THE DIAMETER OF THE REINFORCEMENT BAR
3. MIN CONCRETE GRADE = 30 N/mm²

FIGURE 5a. PLAN OF PRECAST HS, SS or SSS DOOR FRAME (TYPE 3)

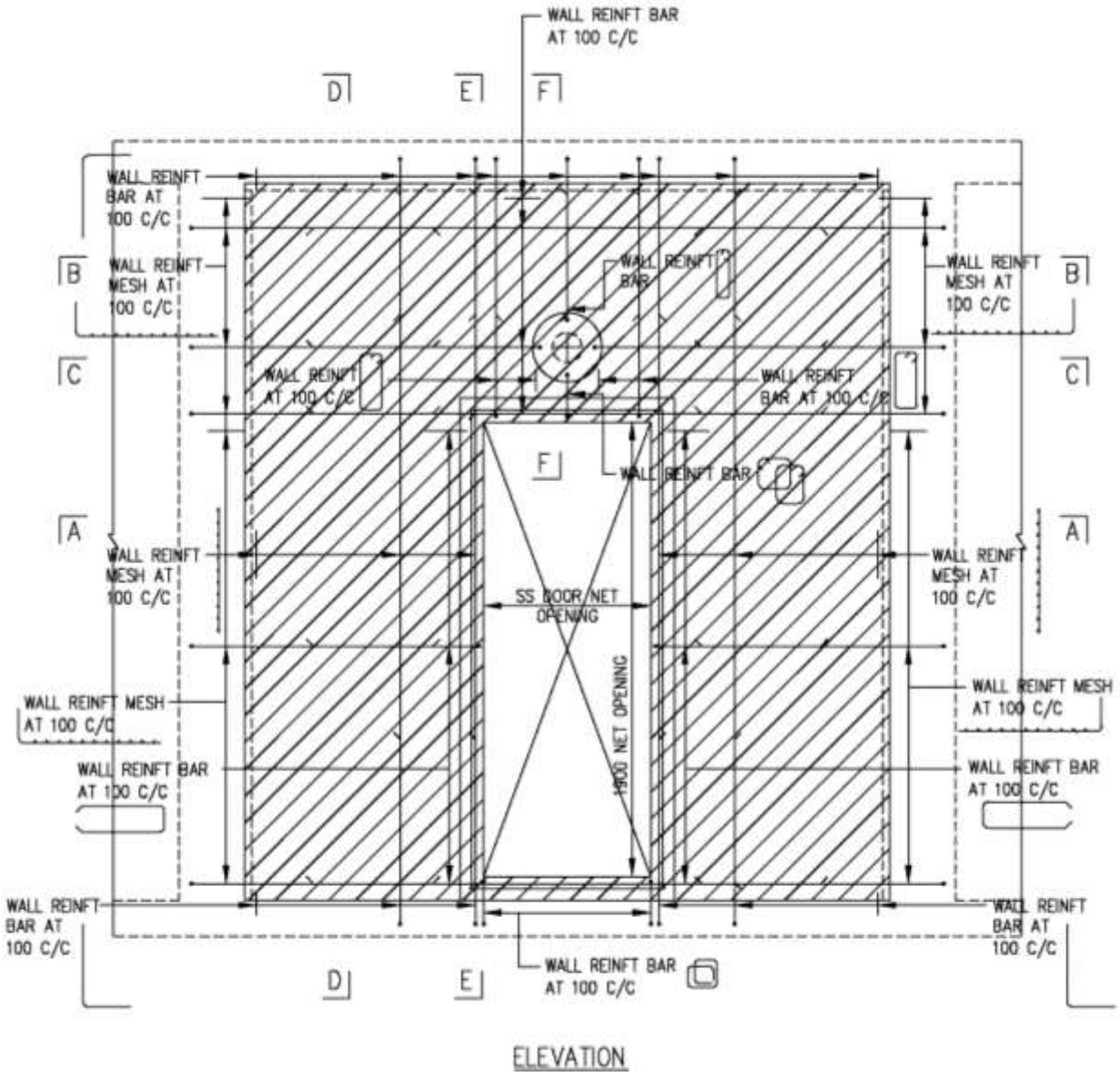


FIGURE 5b. PLAN OF PRECAST HS, SS or SSS DOOR FRAME (TYPE 3)

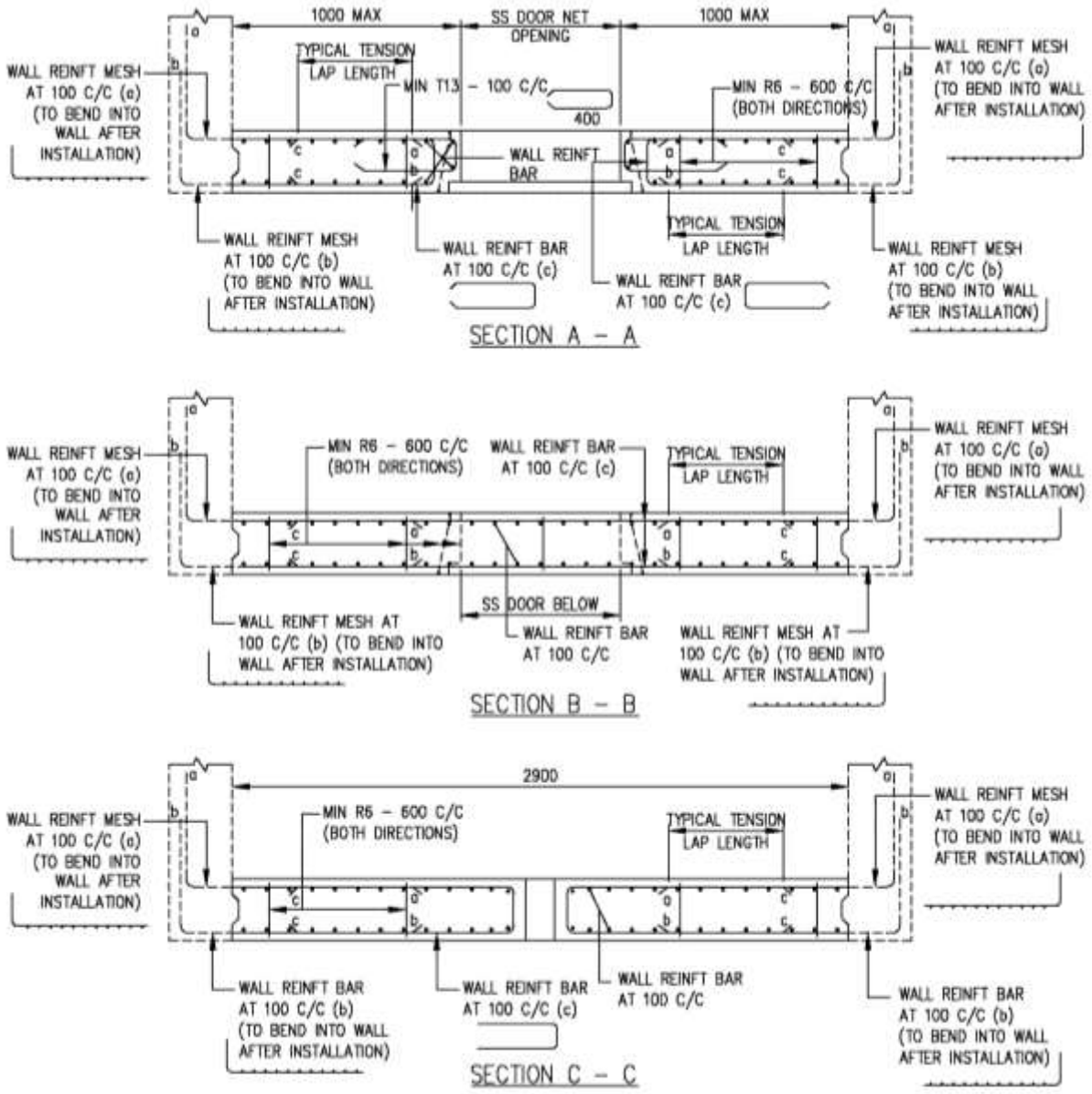


FIGURE 5c. PLAN OF PRECAST HS, SS or SSS DOOR FRAME (TYPE 3)

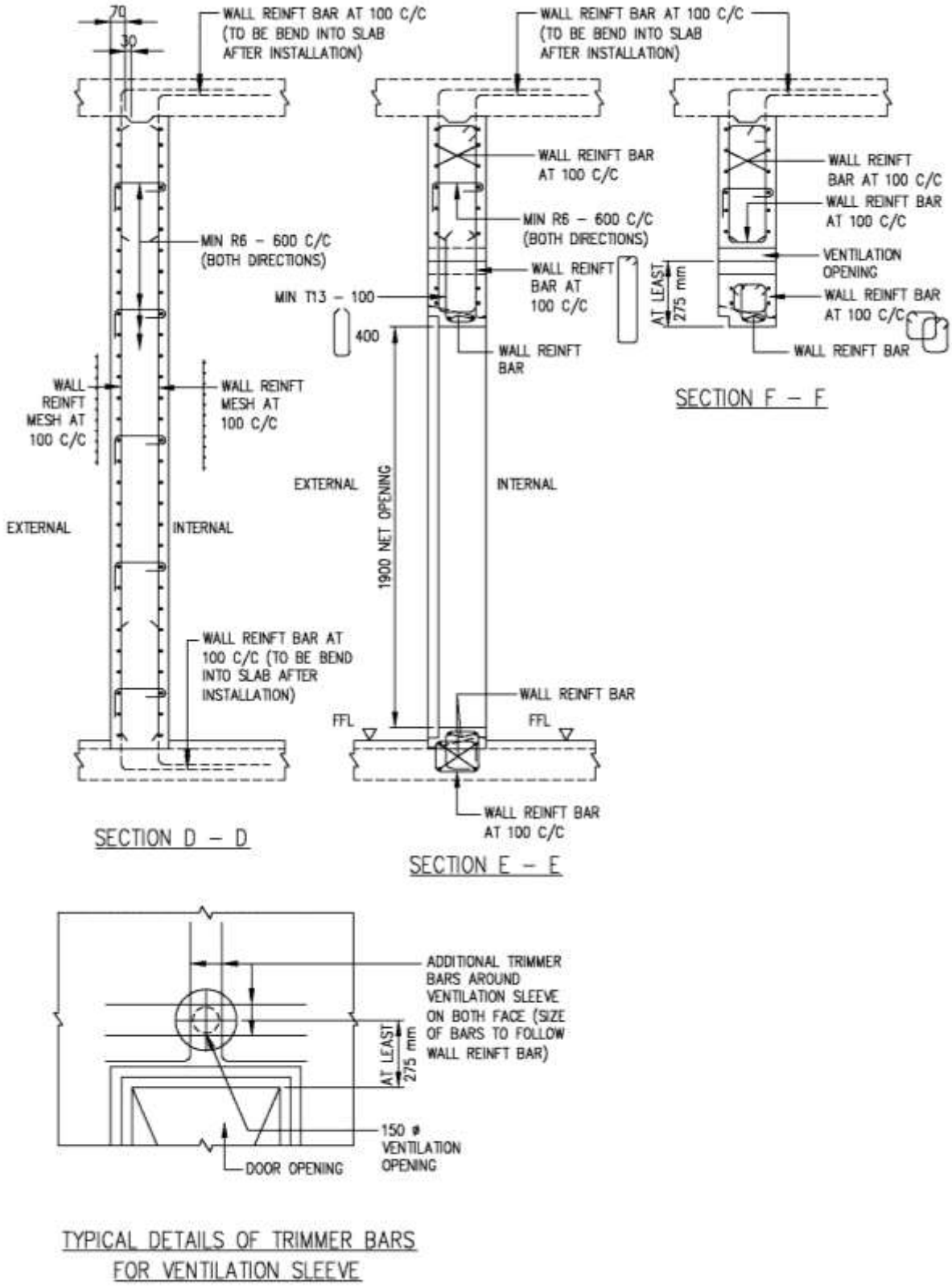


FIGURE 5d. PLAN OF PRECAST HS, SS or SSS DOOR FRAME (TYPE 3)

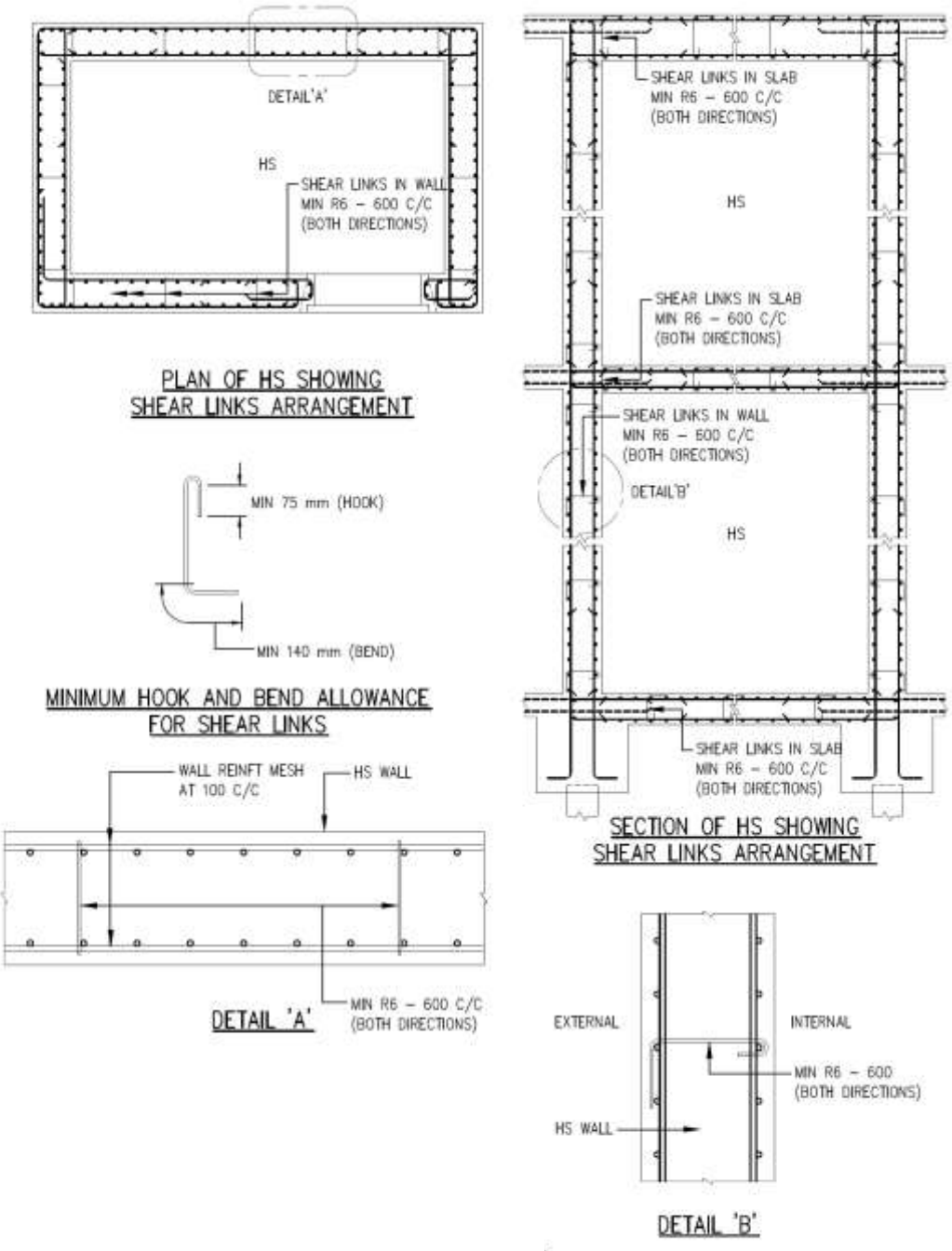


FIGURE 6. SHEAR LINKS DETAILS FOR for HS, SS and SSS WALL AND SLAB

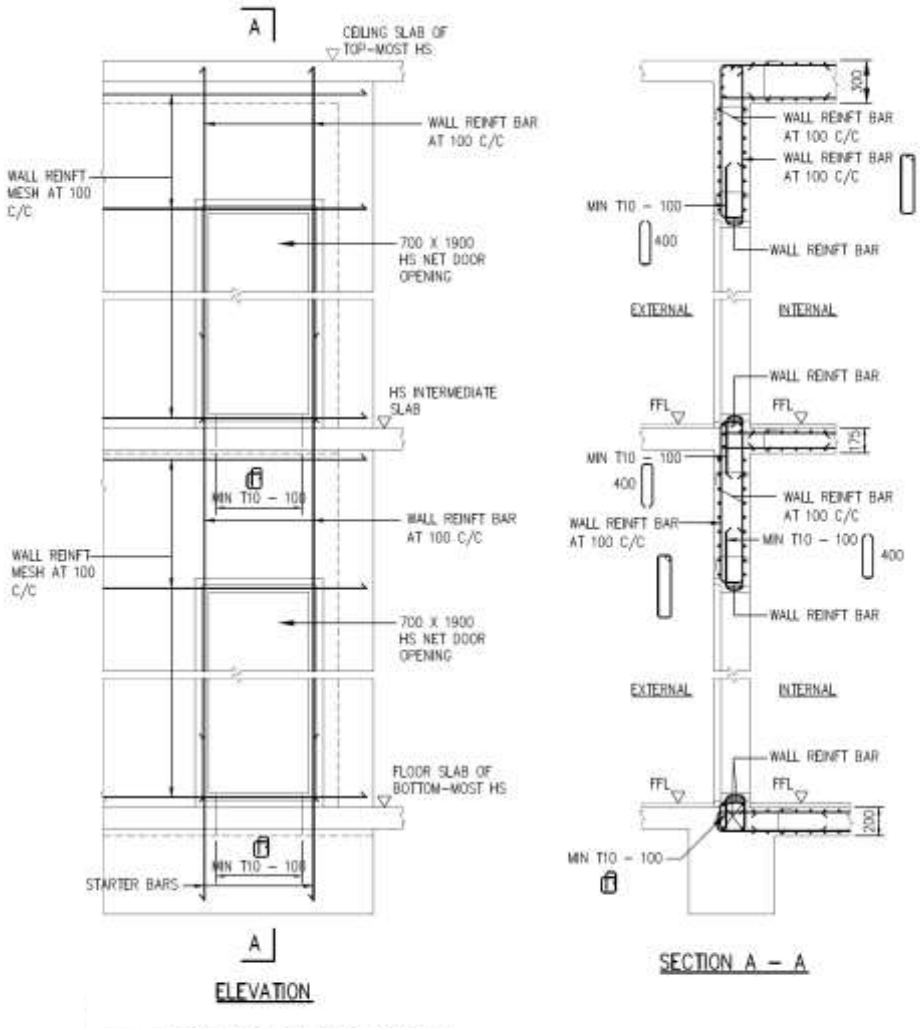


FIGURE 7. STEEL REINFORCEMENT BAR DETAIL FOR HS, SS SND SSS DOOR OPENING

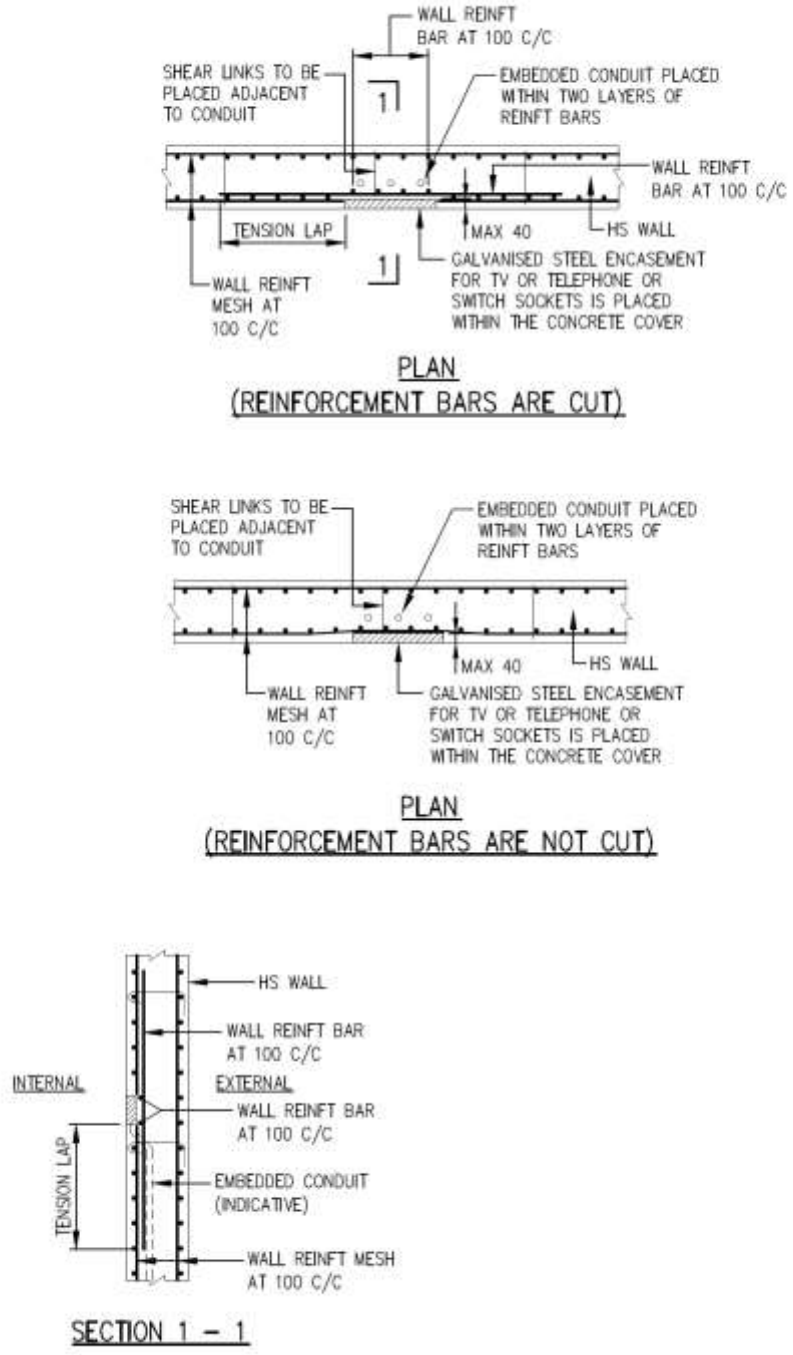


FIGURE 8. STEEL REINFORCEMENT BAR DETAILS FOR SWITCHED OUTLET, TC, RADIO AND POWER POINT

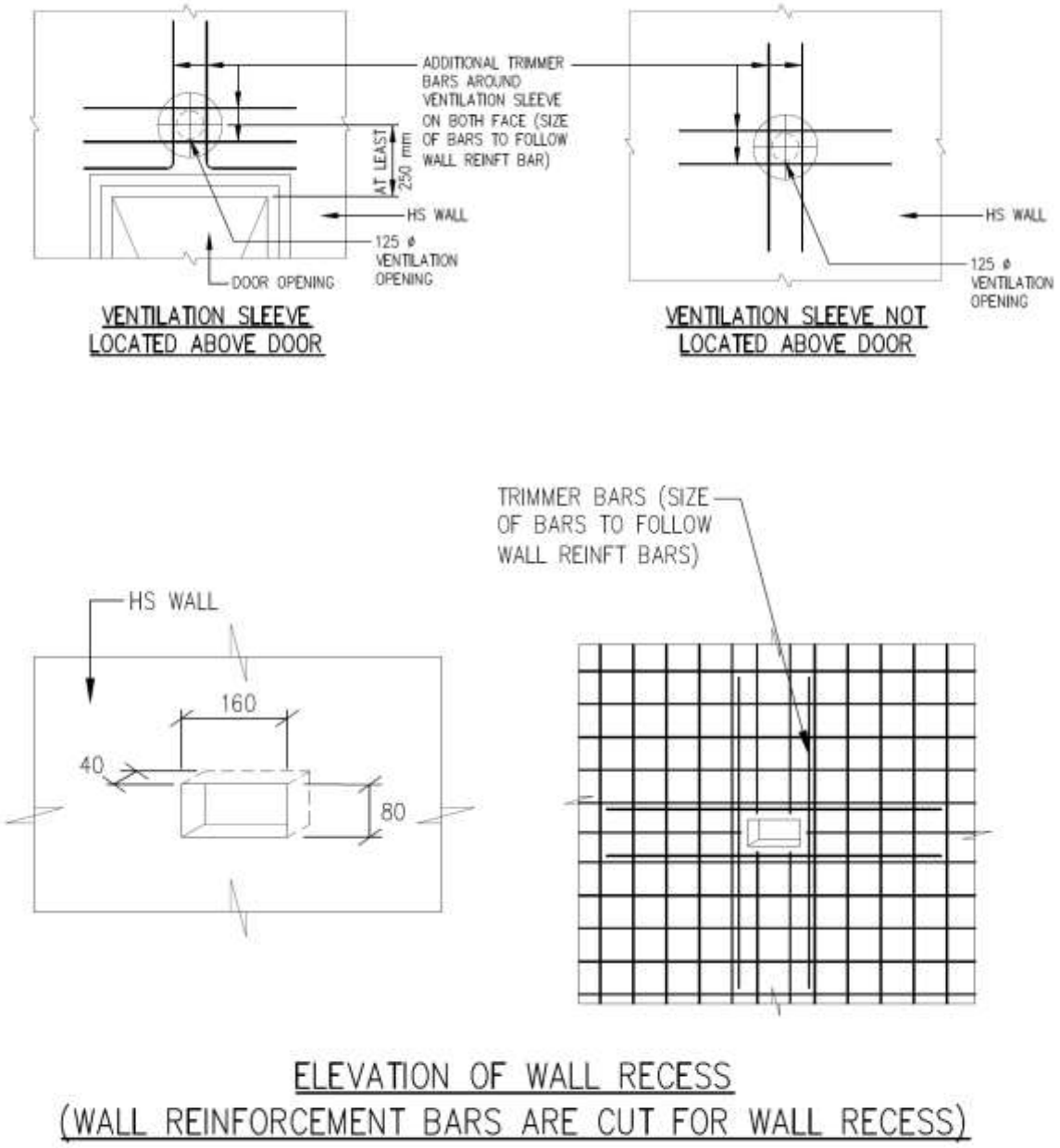


FIGURE 9. STEEL REINFORCEMENT BAR DETAILS AROUND VENTILATION SLEEVE AND WALL RECESSES

LIST OF TABLES

LIST OF FIGURES

Fig. 22 - Layout of a typical public shelter showing reinforcement spacing

CODE OF PRACTICE FOR BIM E-SUBMISSION SERIES

This section is part of the Code for Practice for BIM e-Submission series:

Code of Practice for BIM e-Submission	
	A. General Requirements
	B. Architectural Requirements
	C. Civil & Structural (C&S) Requirements
	D. Mechanical, Electrical & Plumbing (MEP) Requirements

All documents related to BIM e-Submission can be downloaded from the CORENET website:

- Code of Practice for BIM e-Submission
- BIM e-Submission Templates
- BIM e-Submission Template Guides

https://www.corenet.gov.sg/general/building-information-modeling-(bim)-e-submission.aspx

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www.bca.gov.sg

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www.corenet.gov.sg

