

July 25, 2005

Project: **Banda Aceh Skirted House Design Options**

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Subject: Narrative

Scope:

The following narrative provides a summary of our findings and structural design strategy of the Banda Aceh Skirted House alternative:

Narrative:

Our design team investigated 4 options for the basic structure of the skirted house. Each option had a similar structural layout above the skirt. The largest deviation was in the design/material of the skirt itself. Our designated task was to examine the structural acceptability of these houses and if possible, design more efficient buildings with improved earthquake life safety performance, without increase in construction cost. Also, the design had to accommodate local construction capabilities and could not change the basic aesthetic familiar to Banda Aceh.

The four skirted house options included the following:

- Option 1: Reinforced concrete block skirt with wood sill plate.
- Option 2: Reinforced cast-in-place concrete skirt with wood sill plate.
- Option 3: Reinforced brick skirt with reinforced concrete beam on top.
- Option 4: Unreinforced brick skirt with interior walls acting as shear walls.

Assessment of Alternatives:

Each option could be designed to withstand earthquake loading but they differ greatly in terms of price and labor. All four options use a wood truss roof and horizontal braces in the ceiling to distribute the lateral loads.

The main difference between options 1-3 and option 4 is the lateral system. Options 1-3 use wood braces in the exterior walls to carry the lateral load to the skirt, which then transfers the load to the foundation. Option 4 uses the interior walls to take the lateral forces to the foundation and support posts under each truss to carry gravity loads. This allows the skirt to be purely cosmetic, such that if the unreinforced skirt failed the house would still be structurally sound. Since all the options were structurally acceptable, our decision came down to price and constructability.

- Option 1: Least expensive and labor intensive option.
- Option 2: More expensive and labor involved. Also requires a construction skill level that may be higher than what is normally available in Banda Aceh.
- Option 3: More expensive and very labor intensive. Reinforcing the bricks would involve drilling holes in every brick, running the bars through them, and then filling the holes up with grout. Material costs alone are more expensive than the concrete block option.
- Option 4: More expensive due to extra sheathing required and lots of nailing involved for the interior walls. Interior shear walls would also require interior footings and would prohibit the homeowner from moving or altering the walls sometime in the future. There is also no way to prevent the unreinforced skirt from falling on someone.

Recommendations:

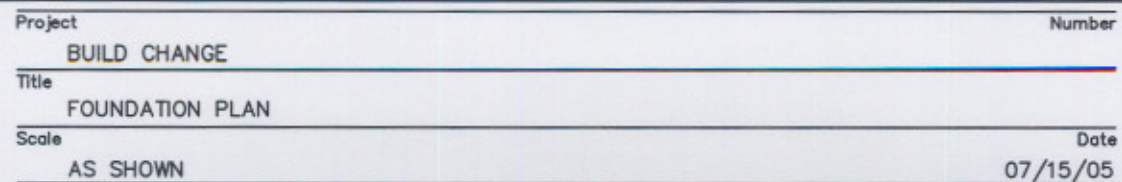
After our assessment of the options, we designed our house to have a reinforced concrete block skirt, with vertical reinforcement in the skirt to resist out-of-plane forces. One advantage of this option was that it allowed us to not use reinforced concrete plinth beams and columns within the skirt itself, which resulted in significant cost savings. Another major change we made from the Indonesian examples was using a poured

Banda Aceh

Narrative

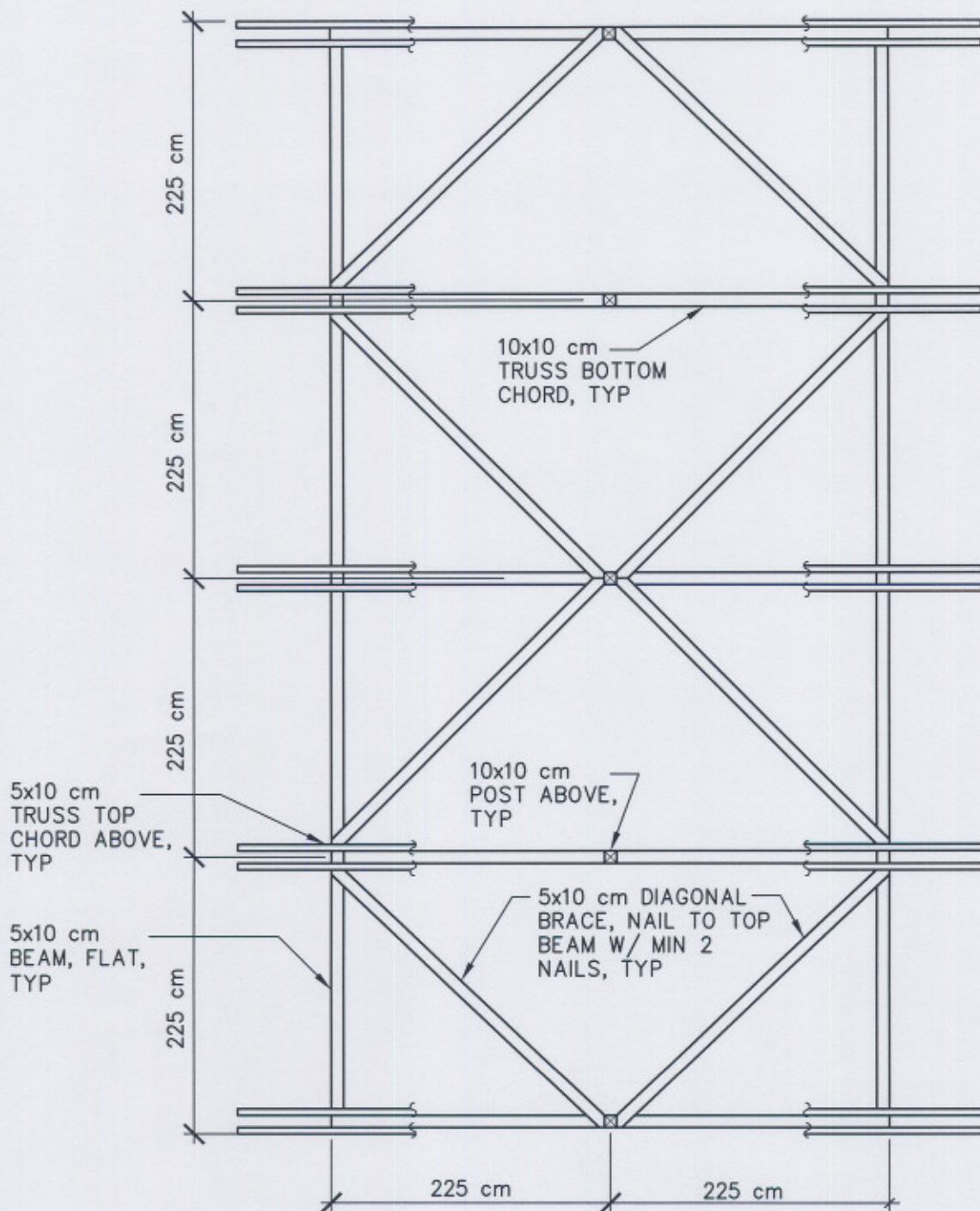
July 25, 2005

concrete foundation as opposed to river stone. This will help transfer the lateral forces to the soil and resist uplift due to overturning and since we had saved money elsewhere, we could afford this slightly more expensive option. Another change is the addition of horizontal bracing to act as a diaphragm. Finally, we adjusted the connections to make them more secure.



S-1

07/15/05



CEILING FRAMING PLAN

1:50 cm



Project

BUILD CHANGE

Title

CEILING FRAMING PLAN

Scale

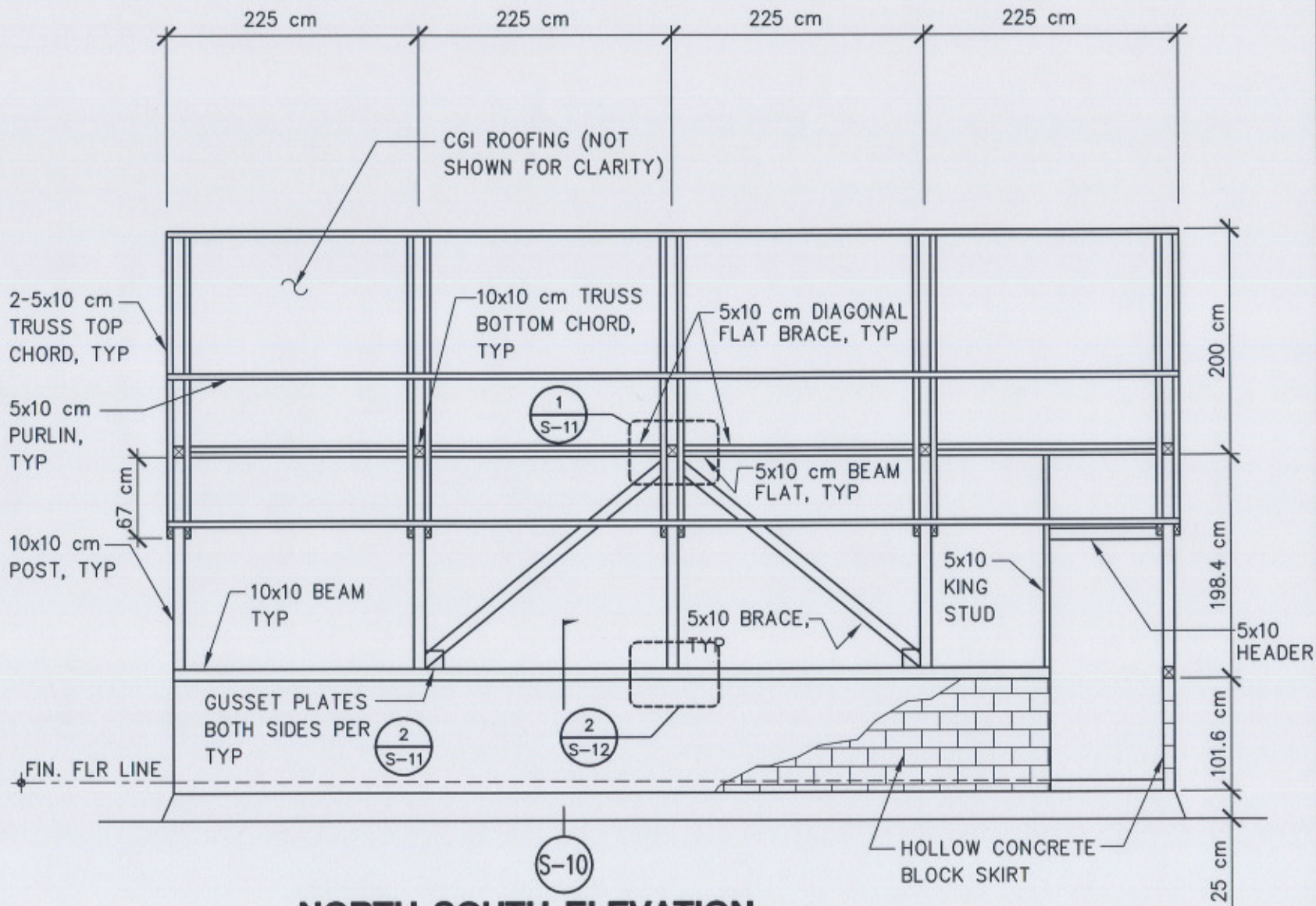
AS SHOWN

Date

07/15/05

Drawing

S-2



NORTH SOUTH ELEVATION

1:50 cm

Project

BUILD CHANGE

Title

NORTH-SOUTH ELEVATION

Scale

AS SHOWN

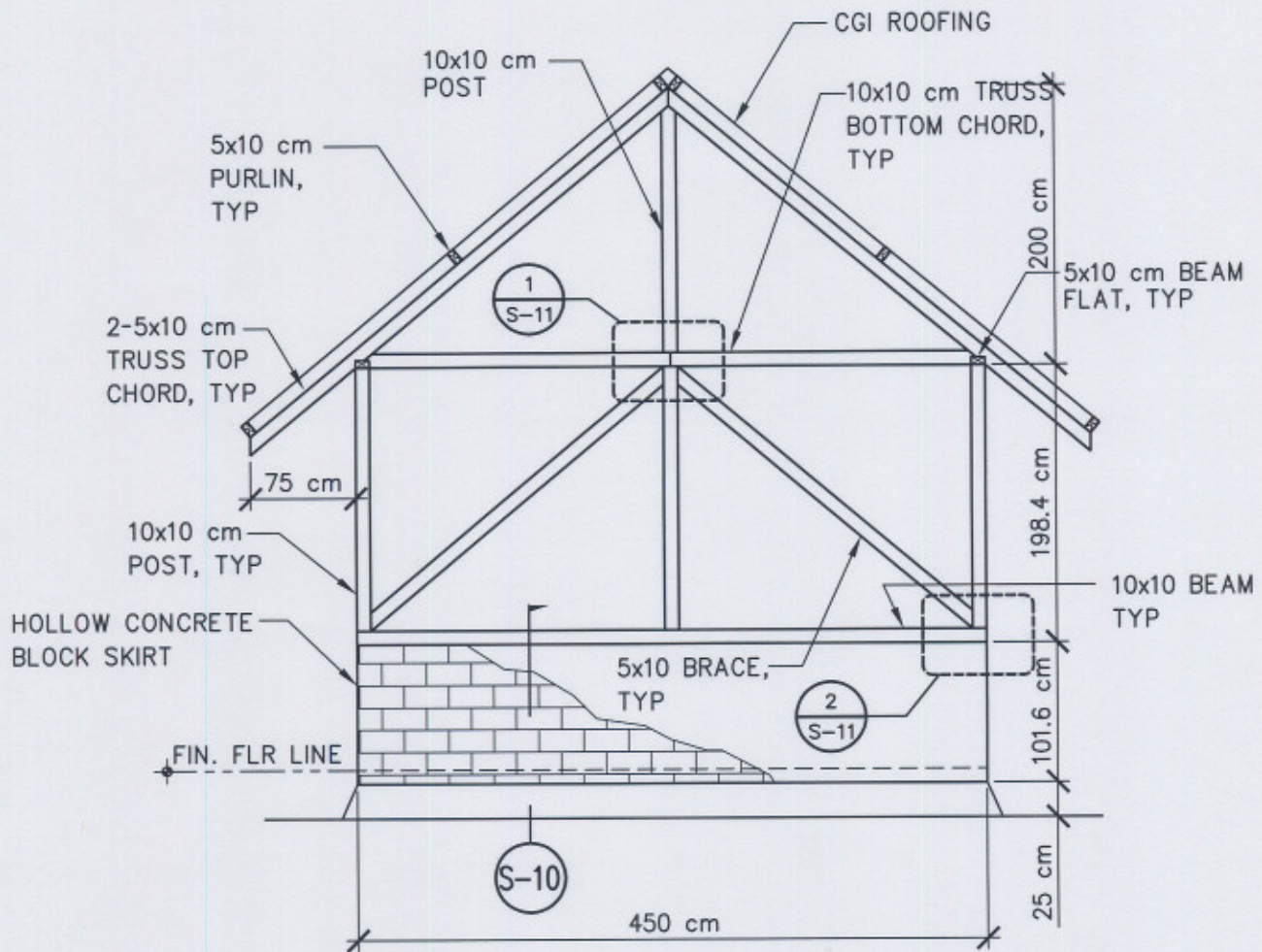
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Date

07/15/05

Drawing

S-3



EAST-WEST ELEVATION

1:50 cm

Project
BUILD CHANGE

Title
EAST-WEST ELEVATION

Scale
AS SHOWN

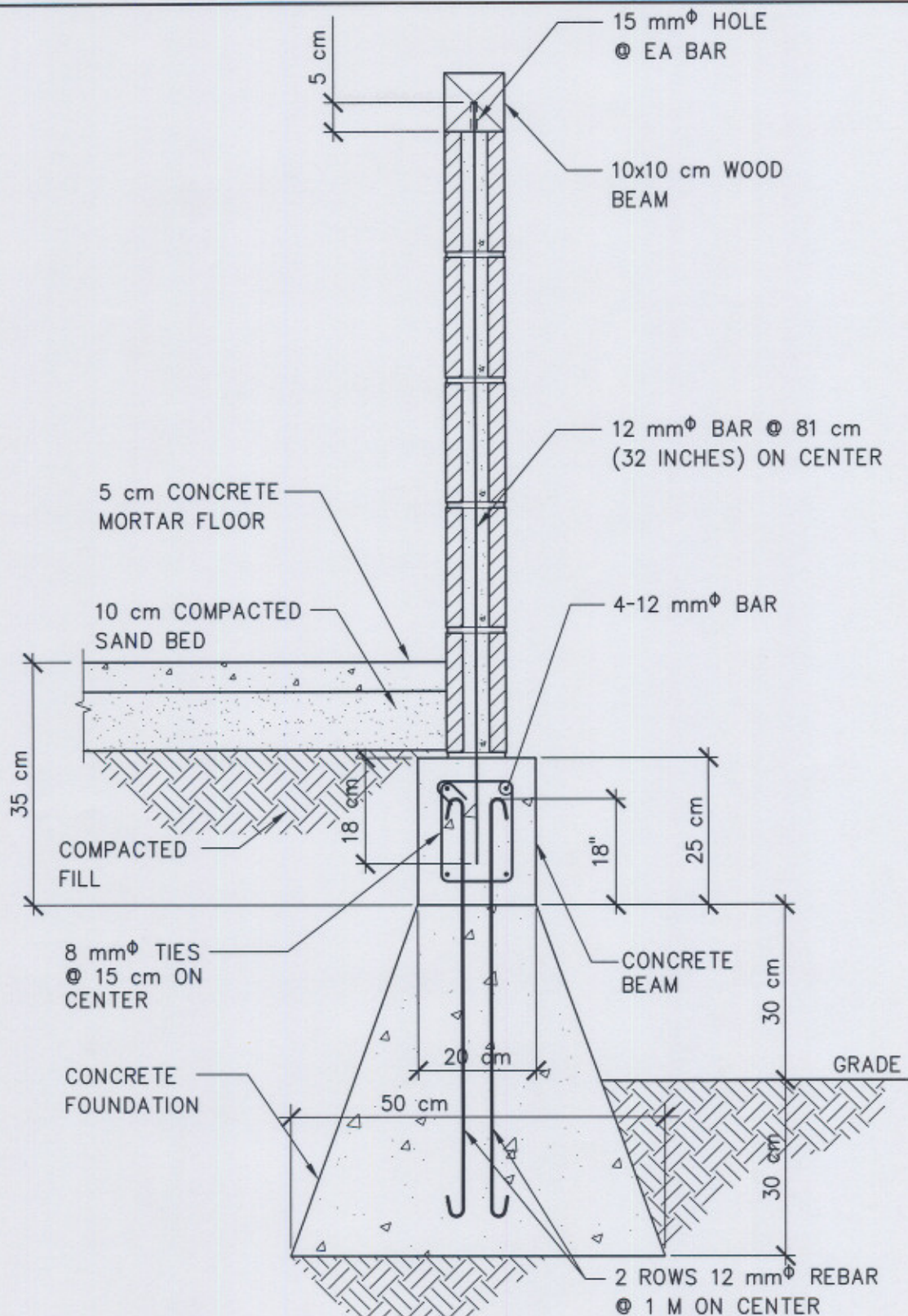
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S-4

Date

07/15/05



TYPICAL WALL SECTION

1:10 cm

Project

BUILD CHANGE

Number

Drawing

Title

TYPICAL WALL SECTION

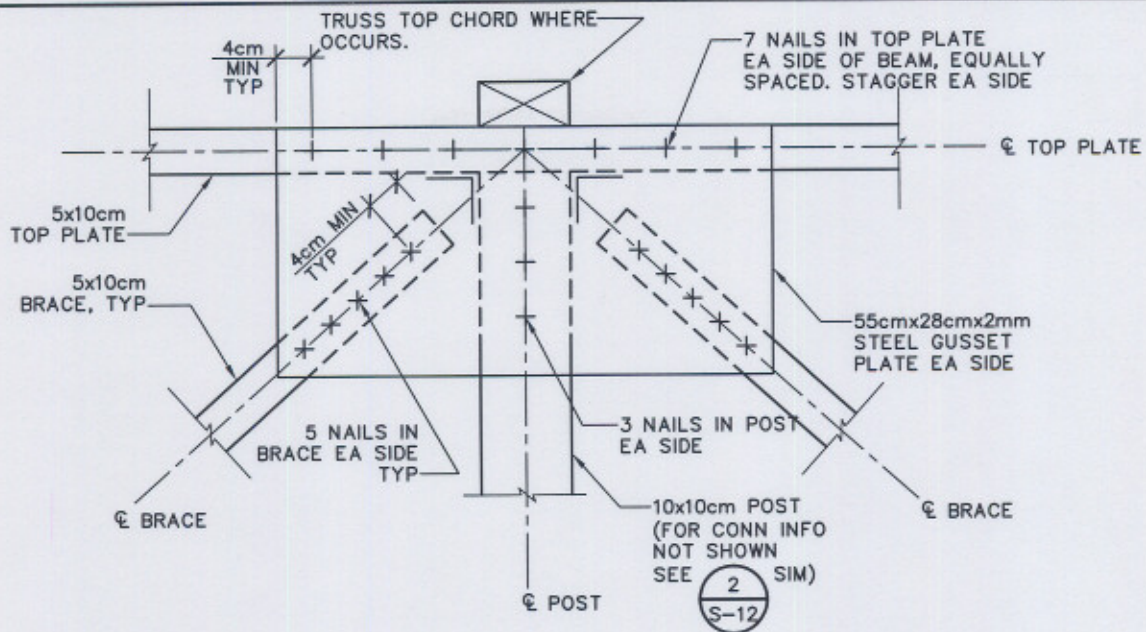
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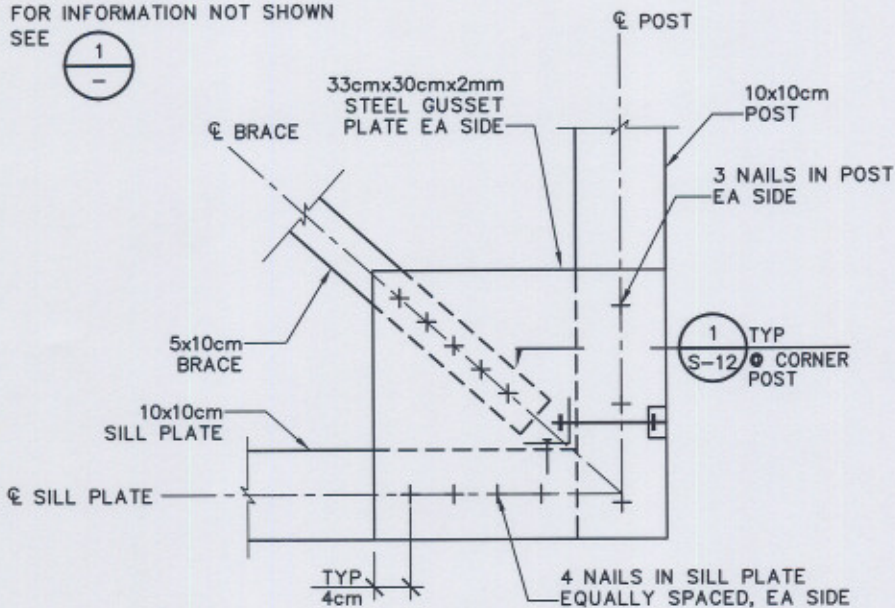
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S-10



1 BRACE CONNECTION • TOP PLATE

FOR INFORMATION NOT SHOWN
SEE



2 TYPICAL CONNECTION • CORNER

GENERAL NOTES

1. THE FOLLOWING APPLIES TO ALL NAILING
UNLESS OTHERWISE NOTED:
MIN NAIL END DIST = 4cm
MIN NAIL SPACING = 4cm

Project

BUILD CHANGE

Number

Drawing

Title

TYPICAL DETAILS I

Scale

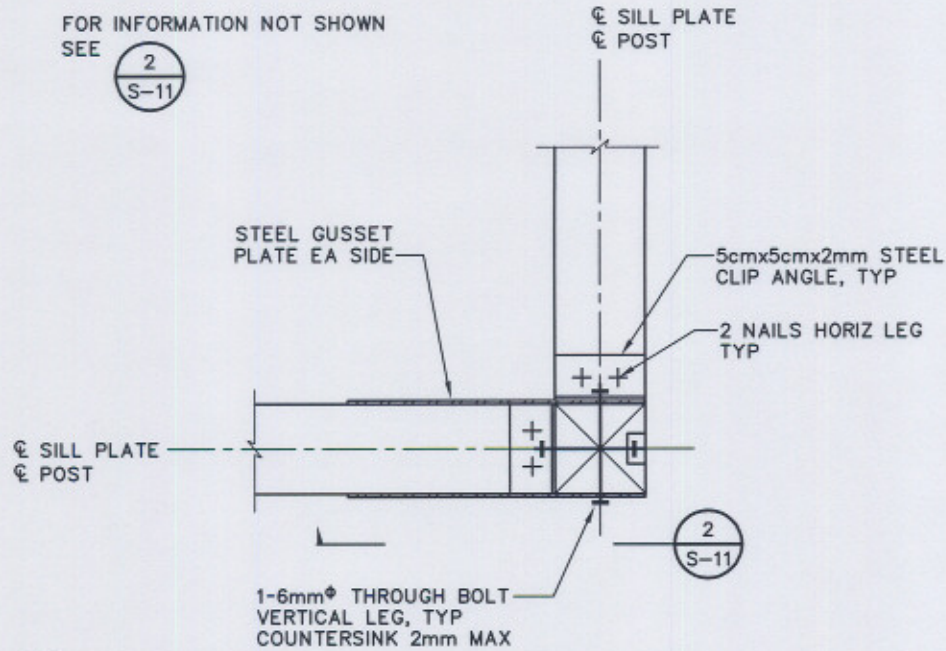
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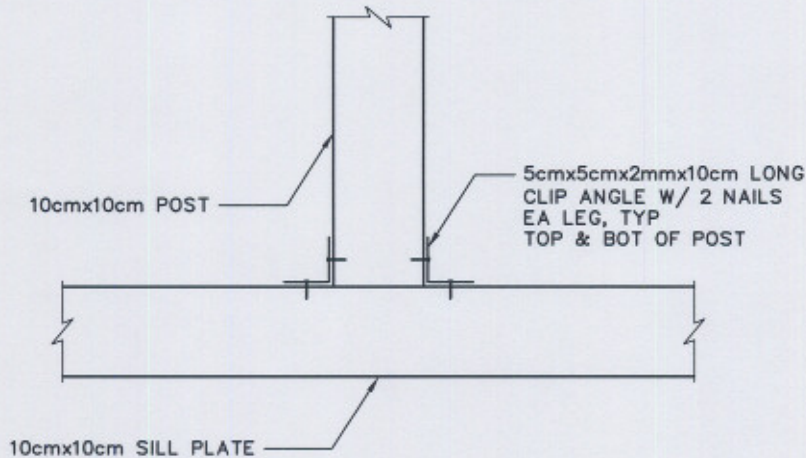
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1

PLAN DETAIL AT CORNER POST



2

TYPICAL POST CONNECTION

Project

BUILD CHANGE

Number

Drawing

Title

TYPICAL DETAILS II

Scale

N.T.S.

Date

07/15/05

S-12

Skirted House Cost Estimate

	Dimension	Unit	(Rupies) Cost per unit	Quantity Required	(Rupies) Total Price	(Dollars) Total Price
Foundation and Slab:						
5 cm concrete mortar floor		cu m	334,335	2.025	677,028	\$71
10 cm compacted sand bed		4 cu m	225,000	1.0125	227,813	\$24
20 cm compacted fill		cu m	50,000	8.1	405,000	\$43
Wood for formwork	2cm x 20cm	4 m	46,000	24	1,104,000	\$116
Concrete in foundation	1:2:4 mix ratio	cu m	197,500	5.67	1,119,825	\$118
Concrete in grade beam	1:2:4 mix ratio	cu m	197,500	1.35	266,625	\$28
12 mm rods in beam		10 m bar	47,000	11	517,000	\$54
8 mm stirrups @ 15 cm o.c.		10 m bar	20,000	12	240,000	\$25
12 mm rods from grade beam into foundation		10 m bar	47,000	5	235,000	\$25
Concrete workers labor		person/day	60,000	24	1,440,000	\$152
Diggers labor		person/day	37,500	4	150,000	\$16
Total =					6,382,291	\$672

Skirt:

Concrete blocks	4"x8"x15.75"	block	2,800	340	952,000	\$100
12 mm rod up skirt		10 m bar	47,000	5	235,000	\$25
Mortar in skirt and between blocks		cu m	379,313	0.193	73,207	\$8
Mortar finish		cu m	379,313	0.54	204,829	\$22
Concrete workers labor		person/day	50,000	8	400,000	\$42
Total =					1,865,036	\$196

Walls:

10x10 beam on top of skirt		4 m	85,000	7	595,000	\$63
5x10 braces		4 m	48,000	8	384,000	\$40
10x10 columns		4 m	85,000	6	510,000	\$54
Fascia board	2cm x 20cm	4 m	44,000	70	3,080,000	\$324
Plywood	3 mm thick	sheet	39,000	20	780,000	\$82
Doors (w/ hinges and locks)		ea	325,000	3	975,000	\$103
Windows (w/ hinges and fittings)		ea	250,000	4	1,000,000	\$105
5x10 studs in partition		4 m	48,000	9	432,000	\$45
Plywood on partitions	3 mm thick	sheet	39,000	10	390,000	\$41
Bolts		kg	4,500	4	18,000	\$2
Steel brackets		kg	30,000	5	150,000	\$16
Nails		kg	8,000	10	80,000	\$8
Carpenters Labor		person/day	60,000	40	2,400,000	\$253
Total =					10,794,000	\$1,136

Ceiling:

10x10 cross beams (bottom chord of truss)		4 m	85,000	10	850,000	\$89
5x10 braces		4 m	48,000	8	384,000	\$40
5x10 top plate		4 m	48,000	7	336,000	\$35
Connections			30,000	5	150,000	\$16
Carpenters labor		person/day	60,000	4	240,000	\$25
Total =					1,960,000	\$206

Roof:

CGI Sheets	240cm x 80 cm	sheet	46,000	50	2,300,000	\$242
Metal ridge tiles		tile	5,000	8	40,000	\$4
5x10 purlins		4 m	48,000	18	864,000	\$91
5x10 roof joists		4 m	48,000	20	960,000	\$101
10x10 truss posts		4 m	85,000	3	255,000	\$27
Sheet metal nails		kg	28,000	8	224,000	\$24
Connections			30,000	5	150,000	\$16
Carpenters labor		person/day	60,000	24	1,440,000	\$152
Foreman labor		person/day	61,500	6	369,000	\$39
Total =					6,602,000	\$695

TOTAL HOUSE COST = 22,661,036 \$2,385