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

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Subject: Narrative

Scope:
The following narrative provides a summary of our finding and structural design strategy of the Banda Aceh Stilt Building option:

Narrative:
Two stilt house alternates were presented to our design team. 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 that Banda Aceh natives are familiar with.

The two stilt house alternates included the following:

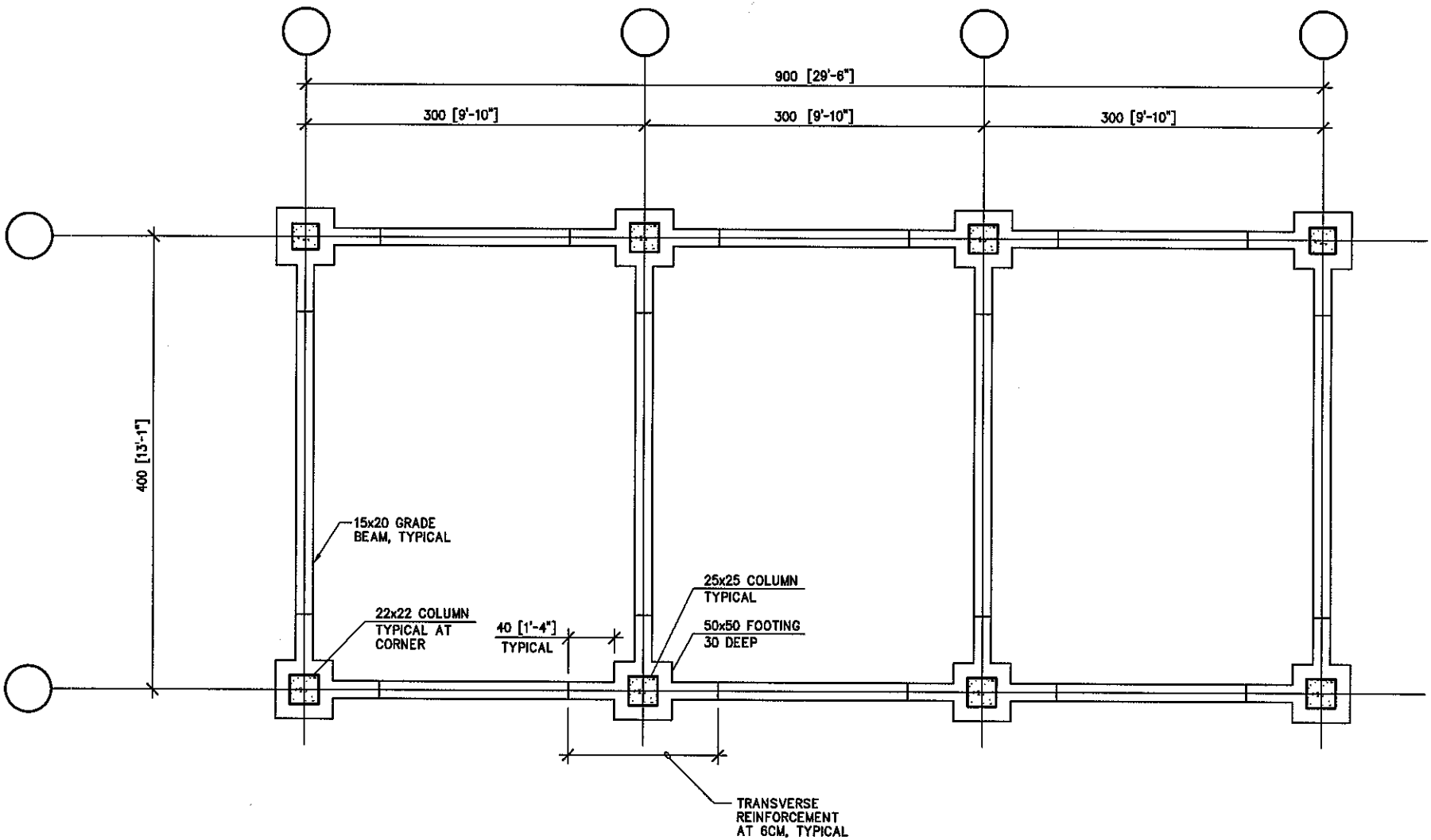
- Alternate 1: Timber superstructure with wood posts supported by concrete columns. Foundation assumed to be the same as Alternative 2 footings.
- Alternate 2: Timber superstructure supported on concrete beams, which are supported by concrete stilt columns, creating a concrete frame. Foundation consisted of bell shaped footings beneath each column.

Assessment of Alternatives:
With minor modifications, Alternates 1 and 2 could be considered life safe. Specifically, we would recommend the following modifications:

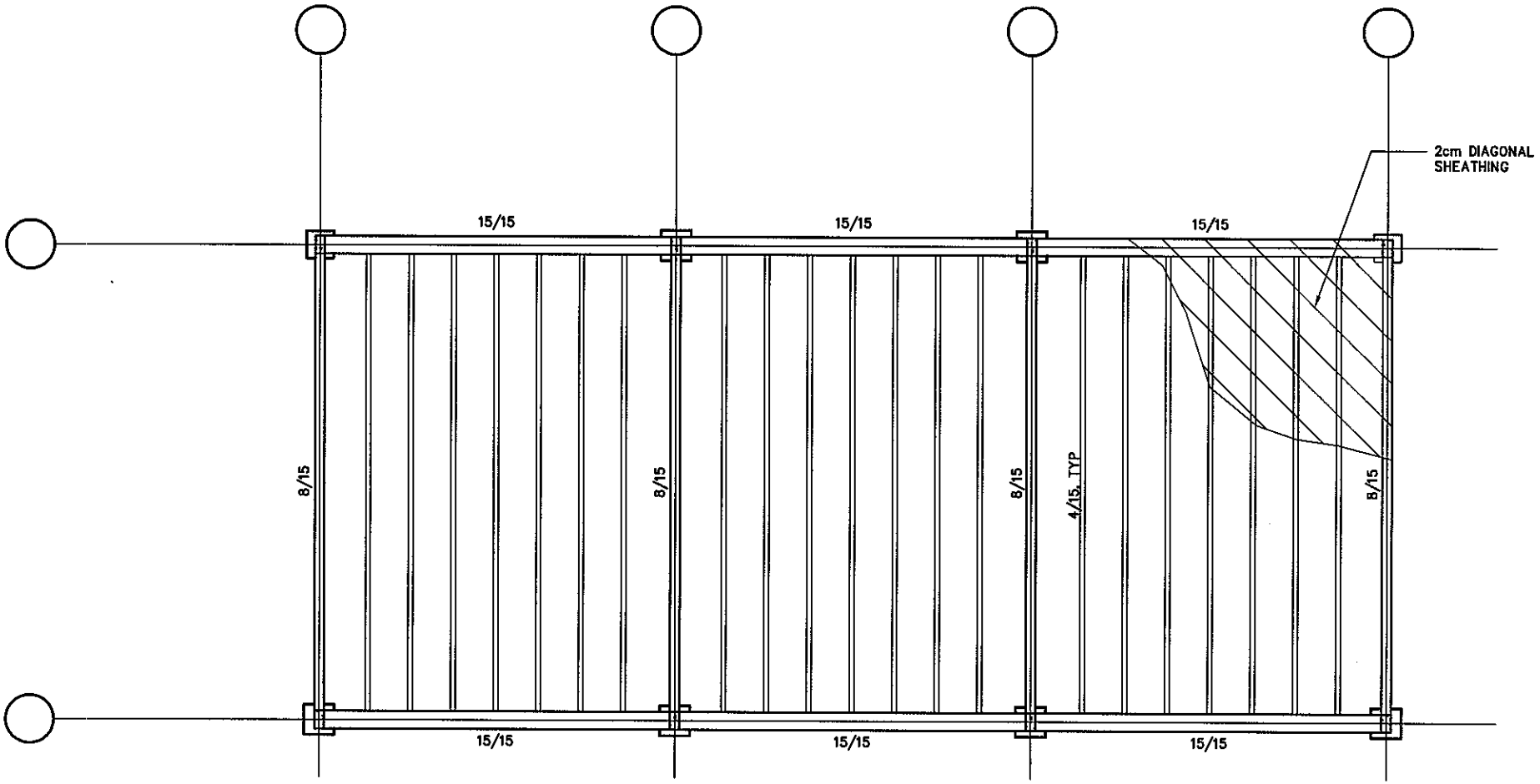
- Alternate 1: Embed the column posts into the concrete columns 1'-0" minimum. Also, limit the clear height of these posts to 1'-2" maximum.
- Alternate 2: Provide adequate reinforcement at the concrete beam and column intersections. Also, ensure proper soil compaction around the concrete footings.

Recommendations:
The design we chose consists of a concrete frame, similar to the Alternate 2 building. However, we substituted timber beams in lieu of concrete beams at the floor level. We relocated the concrete floor beams to the foundation, tying them to the base of the concrete columns, creating a footing grid system. This design solution is cost neutral and, we believe, results in a more seismically resistant system.

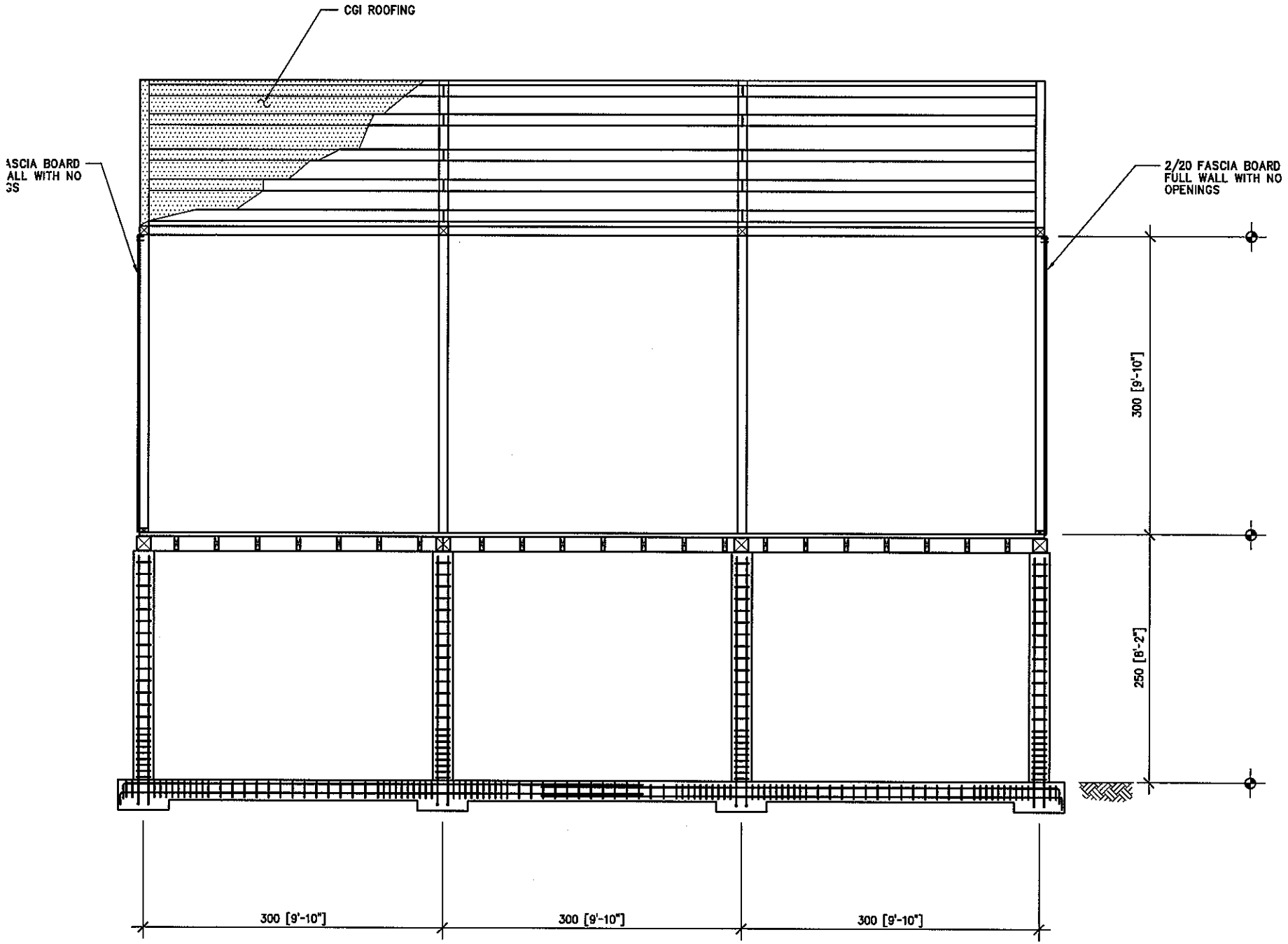
- Moving the concrete beams to the foundation reduces mass from the superstructure which will decrease the potential seismic force the house will be subjected to during an earthquake.
- Connecting the columns to the grid system of beams and the ground level, provides a more reliable fixed base condition.
- The beam and column reinforcement is such that, during a significant seismic event, the failure mechanism is designed to occur within the foundation beams which will increase the system's ductility and reduce the likelihood of sudden collapse.
- The foundation grid system will help mitigate differential settlement concerns.
- Eliminates concrete forming costs for the beams.



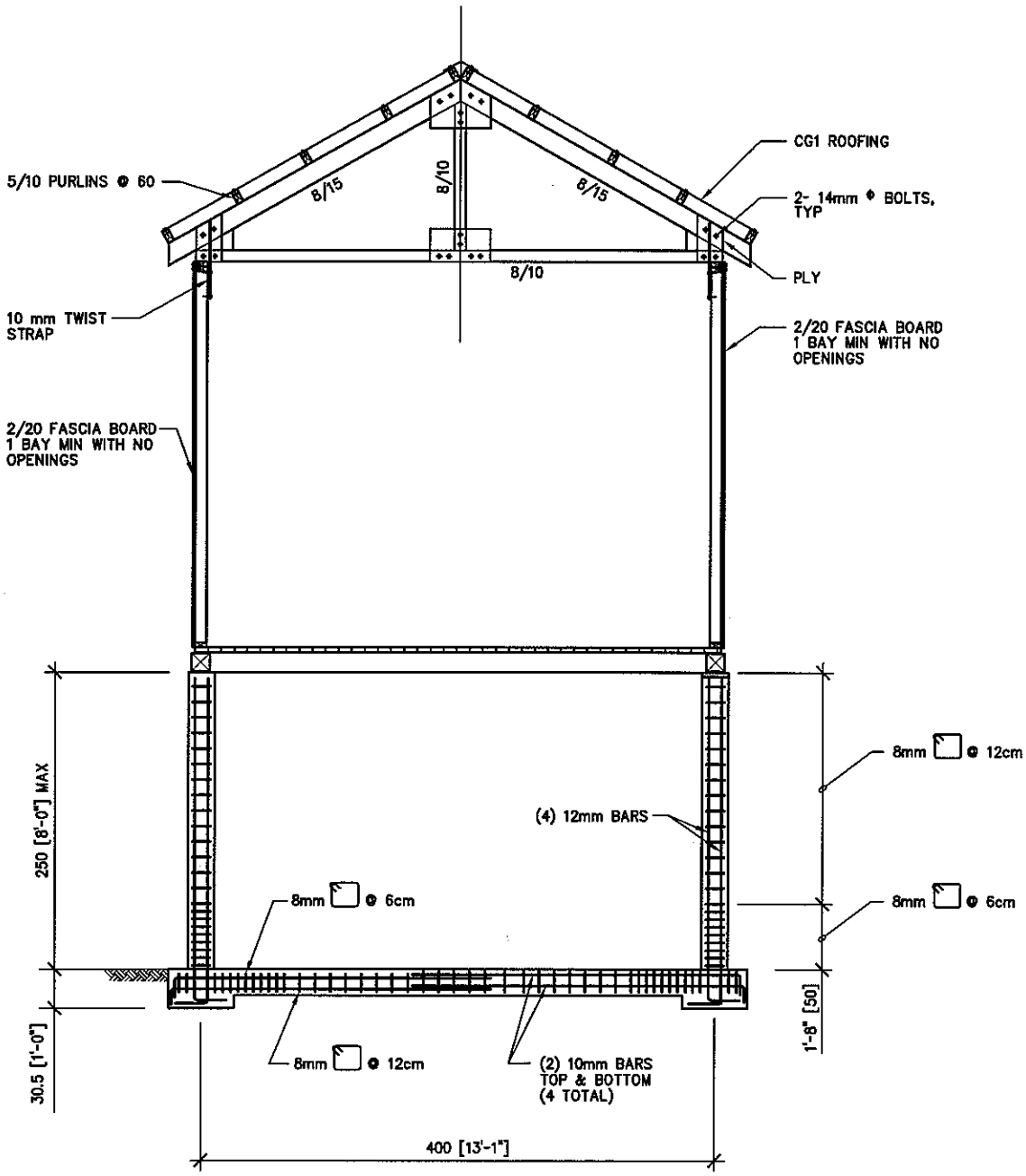
1 FOUNDATION PLAN



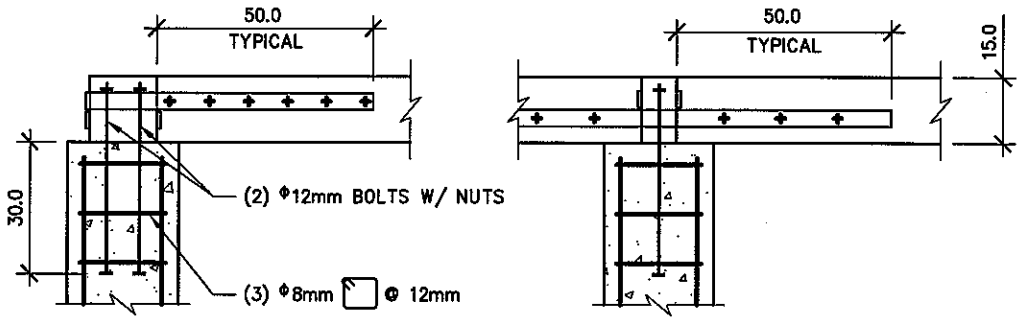
2 FLOOR FRAMING PLAN

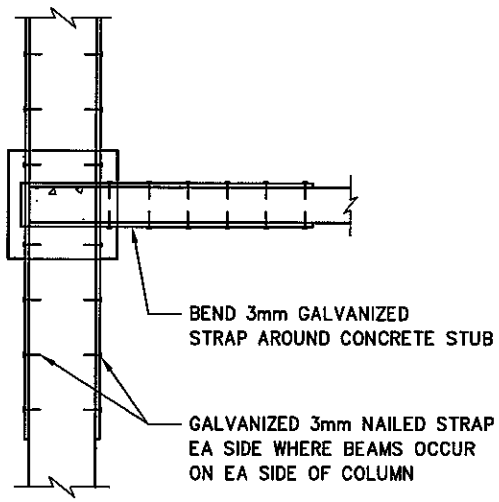


3 LONGITUDINAL SECTION



4 TRANSVERSE SECTION





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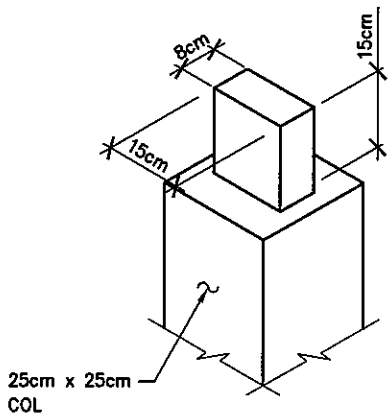

5 TOP OF COLUMN CONNECTION

UNIT PRICE LIST

Materials and Labor

FOUNDATION ONLY

Foundation Cost (+ general tools) =	**$**	6,249,390	**$**	**658**
Superstructure Cost =	**$**	-	**$**	-
Total Cost =	**$**	**6,249,390**	**$**	**658**

ALL DIMENSIONS IN cm unless otherwise indicated
9500 Rp. per US$

MATERIAL	Unit	Cost (Rp.)	Alt. Cost	Source	Qty / Volume	Unit	Cost (Rp.)
Foundation, Masonry, Reinforced Concrete							
Mountain Stone	m3	120,000		PU, OXFAM	0		-
Portland Cement	40 kg bag	29,000	32,000	Retailers, OXFAM	13.4	sacks	389,049
Mix Smooth Sand/Round Agg (Delivered)	4 cu m	220,000		Retailers	0.76	cu m	41,787
Sand (Delivered)	4 cu m	225,000		Retailers	0		-
Crushed Aggregate (Delivered)	4 cu m	300,000		Retailers	1.52	cu m	113,965
Fill soil	m3	50,000	55,000	PU, OXFAM	0		-
14.5mm dia ribbed steel	10m bar	96,000		Retailers	0		-
12.5mm dia ribbed steel	10m bar	71,000		Retailers	0		-
14mm dia (13.2mm actual) smooth steel	10m bar	64,000		Retailers	0		-
12mm dia (11.5mm actual) smooth steel	10m bar	47,000		Retailers	132	m	618,866
10mm dia (9.4mm actual) smooth steel	10m bar	32,000		Retailers	739	m	2,366,223
8mm dia (7.4mm actual) smooth steel	10m bar	20,000		Retailers	0		-
6mm dia (5.4mm actual) smooth steel	9m bar	11,000		Retailers	0		-
Steel Tie Wire	kg	7,000		Retailers	0		-
Solid Fired Brick (4 x 10 x 18)	ea	480		Retailers, Kiln Owners	0		-
Hollow Concrete Block (4" x 8" x 15 3/4")	ea	2,800		Block Manufacturer			-
						Σ =	3,529,890
						Σ =	*$ 371.57*

Timber Frame and Roof

Wood-Semantok/Ulin (very hard)	m3	2,700,000		PU
Wood-Kamper/Kruing	m3	2,300,000		PU
Wood-Borneo	m3	2,000,000		PU
Wood-Sengon	m3	1,500,000		PU
Timber Beam (15 cm x 15 cm)	linear m	42,600		PU
4" x 4"	4m plank	85,000		OXFAM
2" x 4"	4m plank	48,000		OXFAM
2" x 3"	4m plank	35,000		OXFAM
Fascia board (2cm x 20cm)	4m plank	44,000		OXFAM, PU
Plywood 4 mm thick	sheet	58,000		OXFAM
Plywood 3 mm thick	sheet	39,000		PU
Wood Nails	kg	8,000	9,000	PU, OXFAM
Iron Bolts	kg	4,500	8,000	PU, Retailers
Timber Primer	kg	14,000		PU
Paint (outer coat)	kg	28,000		PU
Steel Brackets	kg	30,000		rough estimate
CGI Sheets (240 x 80)	sheet	46,000		Retailers, OXFAM
Genteng Metal Sheets 133.5 x 85	sheet	52,000		Retailer
Genteng Metal Ridge Tiles	tile	5,000		total guess
Zeng Sheet Nails	kg	28,000		PU

	Unit	Cost (Rp.)	Alt. Cost	Source
Doors and Windows				
Door (with hinges and lock)	door	325,000		OXFAM
Window (with hinges and fittings)	window	250,000		OXFAM
Timber Door or Window Frame	m3	2,300,000		Lumber Yard
Timber Door	m3	2,300,000		Retailer, Lumber Yard
Door Hinge	Pair	15,700		PU
Door Latch	Unit	7,000		PU
Transparent Glass 3mm	m2	52,000		PU
Transparent Glass 5mm	m2	66,000		PU
Floor				
30 x 30 cm floor tile	m2	47,000		PU, Retailer
Side tile 20 x 20 cm	m2	50,000		PU, Retailer
Misc.				
Weld Mesh	m	11,000		
Mosquite Mesh	m	15,000		
Chicken Wire	m	6,000		

Reusable Construction Equipment					
Scaffolding poles (Dolken Wood)	bar	42,000	8		336,000
Formwork (2cm x 20cm)	4m plank	46,000	20		920,000
Fiber drum for water	drum	155,000	1		155,000
Wheelbarrow	barrow	180,000	1		180,000
Mortar mixer with gear	mixer	4,950,000	0		-
Mortar mixer without gear	mixer	3,700,000	0		-
Mixer rental	day	100,000	1		100,000
Assumptions					
5 houses under construction at the same time in pilot project					
Tools					
Mason's rule	ea	3,000	1		3,000
Level	ea	45,000	1		45,000
Trowel - 20 cm	ea	20,000	1		20,000
Plaster Trowel	ea	3,500	1		3,500
Plumb Bob	ea	8,000	1		8,000
Roll of String	ea	1,000	2		2,000
Small Mason's Hammer	ea	15,000	2		30,000
Carpenter's Hammer	ea	13,000	2		26,000
				Σ =	1,828,500
				Σ =	$ *192.47*

LABOR		Govt Est.	Likely Wage			
Foreman	person/day	41,000	61,500	4		246,000
Head Carpenter/Painter	person/day	52,000	78,000	3		234,000
Carpenter	person/day	43,000	64,500	3		193,500
Assistant Carpenter	person/day	23,000	35,000	3		105,000
Head Mason/Smith	person/day	52,000	78,000			-
Mason/Smith	person/day	43,000	64,500			-
Assistant Mason/Smith	person/day	28,000	42,000			-
Digger	person/day	25,000	37,500	3		112,500
					Σ =	891,000
					Σ =	$ *93.79*