Evaluating Premium Incentives for the California Earthquake Authority

APPENDICES

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A. INDEX BUILDING DESIGN DOCUMENTS

A.1 INDEX BUILDING 1

Index buildings 1 and 2 are taken from Porter et al. (2002a), and were designed by Reitherman and Cobeen (2003). See those references for additional details.

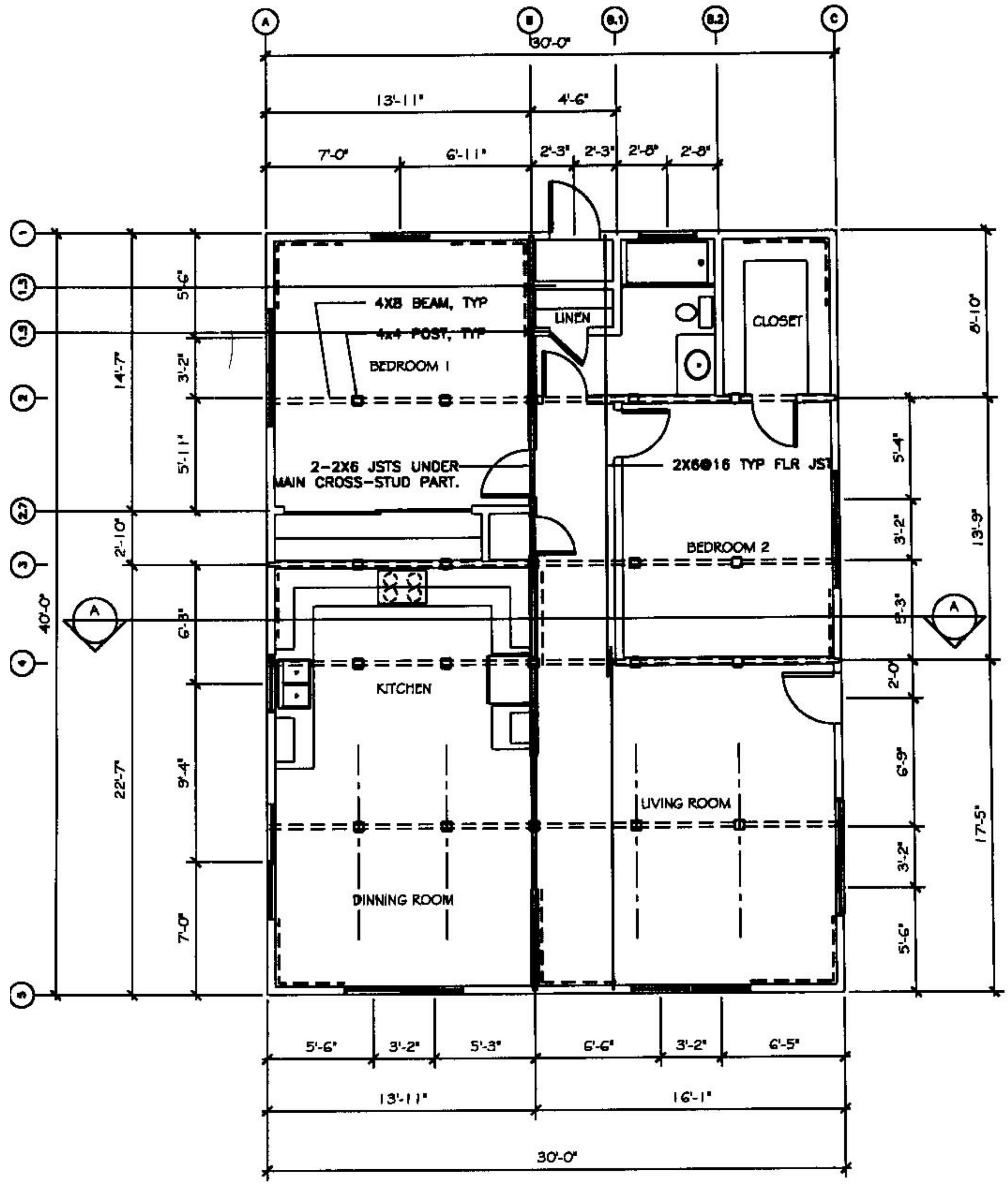
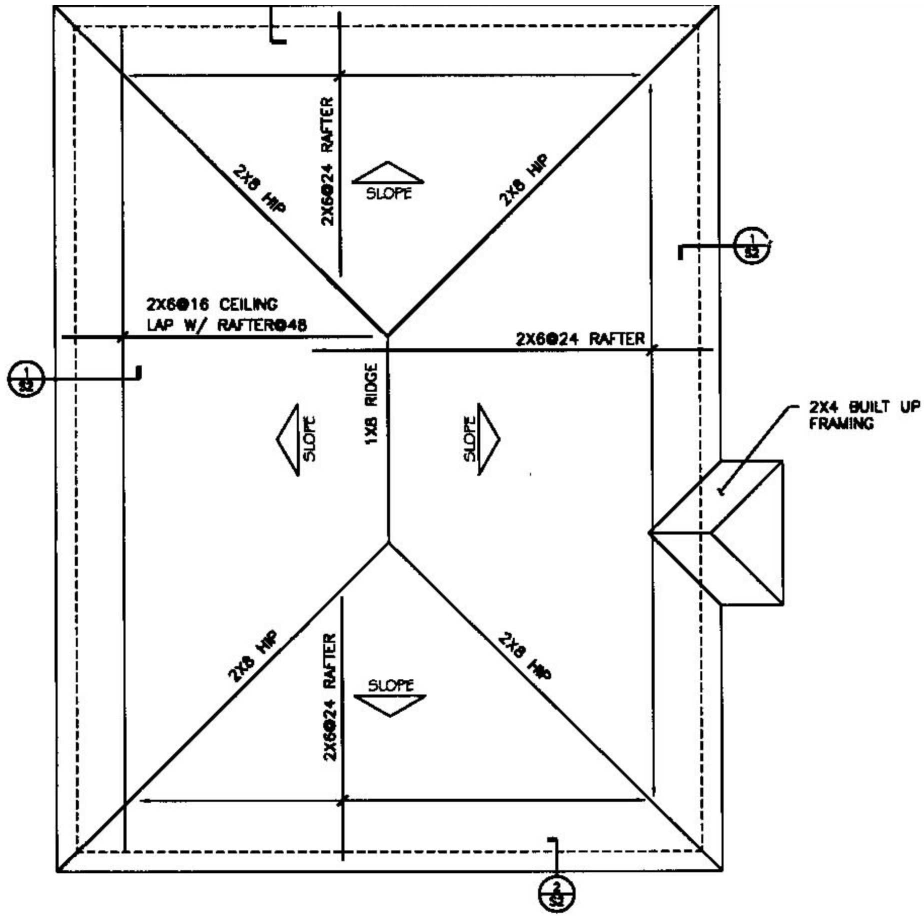
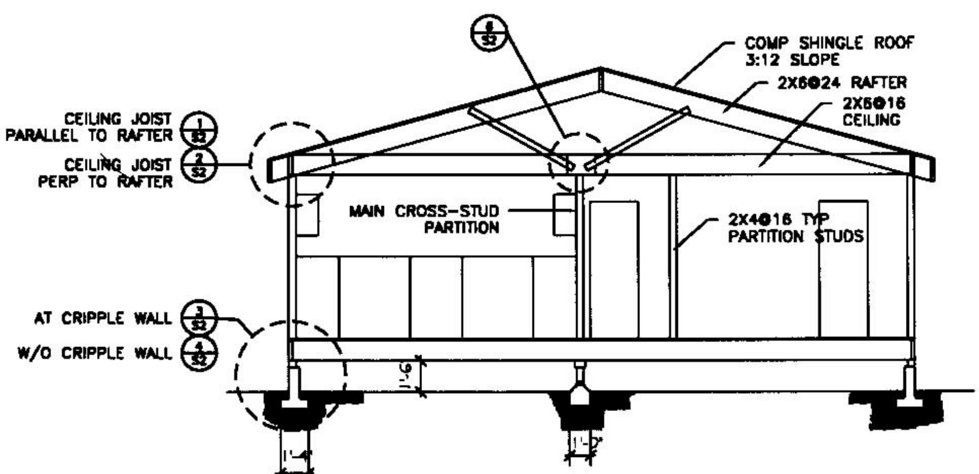


Figure A-1. Index building 1 floor plan (sheet A1, right)

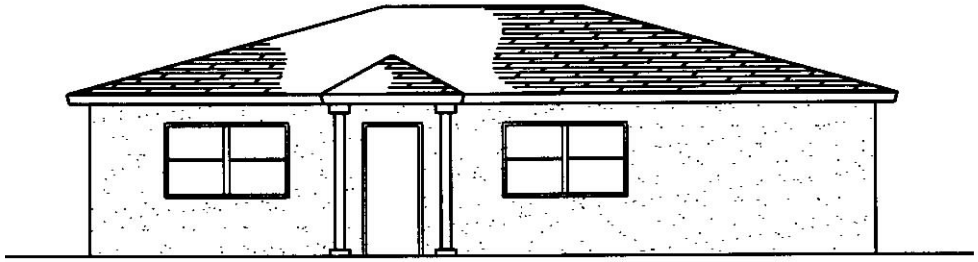


ROOF PLAN

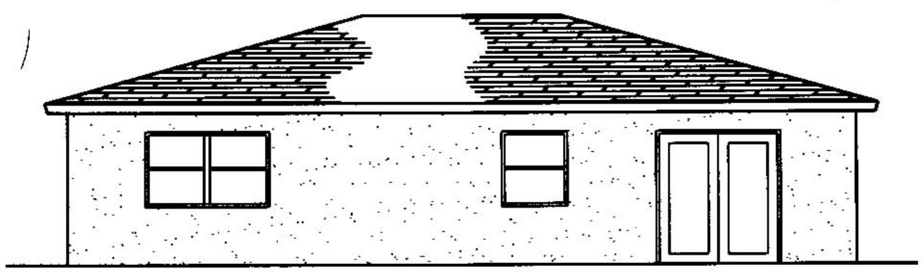


SECTION A-A

Figure A-2. Index building 1 roof plan and section A-A (sheet A1, left)

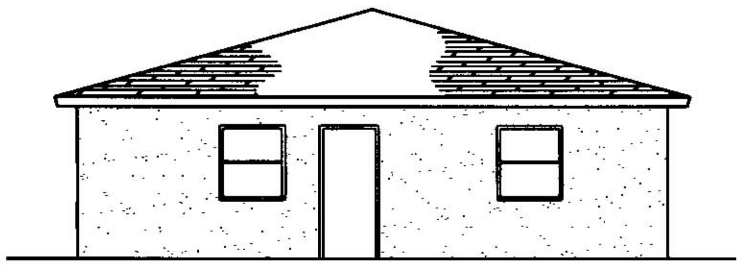


FRONT ELEVATION

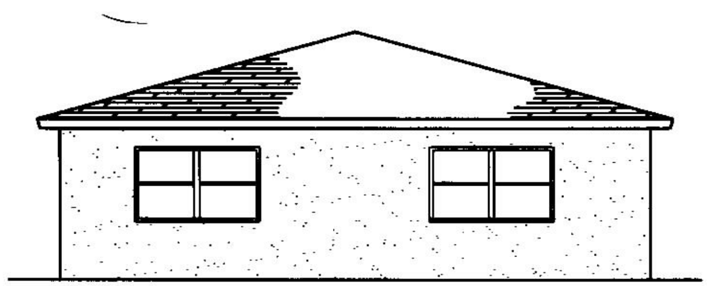


REAR ELEVATION

Figure A-3. Index building 1 exterior elevations (sheet A2, right)



RIGHT ELEVATION



LEFT ELEVATION

Figure A-4. Index building 1 exterior elevations (sheet A2, left)

NOTES FOR SMALL HOUSE INDEX BUILDING

The Small House Index Building is one of four index buildings prepared for Element 4 – Economic Aspects, as part of the CUREe-Caltech Woodframe Project. This house is being used as part of structural analysis studies conducted under Task 1.5.4, which will be used for component-based fragility analyses conducted under Task 4.1.

Drawing sheets A1, A2, S1 and S2 contain information describing the small house. Sheets A1 and A2 contain the architectural plans, drafted by Roy Young and Associates, based on a description developed by the Woodframe Project. Descriptions of framing have been added to Sheet A1 by Element 3. Sheets S1 and S2 contain typical details, notes, assembly and weight information, provided by Element 3.

The small house is a one story single family dwelling of 1200 square feet. It is intended to have been built as a housing development "production house" in the early 1950's, located in either Northern or Southern California. The design is based on prescriptive construction. To the extend possible, characteristic materials and fastening have been identified.

SPECIES
Typical species for framing – Douglas-fir.
Foundation sill plates – heart redwood.

SHEATHING
Roof sheathing 1x6 straight sheathing boards
2-8d common nails per crossing
8d common dimensions from Bethlehem Steel match ASTM F1667:
Flat head, diamond point, L=2.5", D=.131"

Floor sheathing – same as roof sheathing, applied diagonally. Note that the diagonal application leads to edge nailing and approximately 3" on center for all edges for the floor diaphragm.

Gypsum wallboard sheathing – $\frac{3}{8}$" sheathing – probably applied vertically (by the late 50's horizontal placement was being encouraged).
1958 UBC describes two nails:
1. Smooth shank--Flat-head diamond point 5d – 13-1/2 gage, 1-5/8 long
2. Deformed shank –slightly countersunk head –.098" x 1-1/4" long x $\frac{1}{4}$ dia. Head.
Nail 1 is slightly longer and larger diameter than described for F1667 NLGWS-05. The second nail matches fairly closely F1667 NLGWM-02.
Bethlehem steel describes a nail to match number 1. It was provided cement coated and was a non-stock size.
For gypsum board wall sheathing one of these fasteners would have been used at 6-8 inches on center (say 7) over the height of each stud. We understanding is that they would not have been edge-nailed at this spacing to the top or bottom plates. The spacing at top and bottom plates would likely have been 16 inches on center as part of the vertical line of fasteners at each stud.

Gypsum board ceiling sheathing. The fasteners above would have been spaced at 5 to 7 inches along the ceiling joists. The perimeter edges parallel to the joists would have been nailed in order to provide proper vertical support. The edges perpendicular would not have been nailed.

Note that there was some discussion as the whether interior wall and ceiling finish would have been button board with a plaster finish coat. It was decided that while this construction was still common in custom homes in this period, production homes would more typically have been built with gypsum wall board.

STUCCO
UBC Sec. 4710. 18 ga woven wire, furred out from backing $\frac{3}{8}$" nailed with galvanized nails, ?" minimum penetration, spaced 6" maximum vertically, 16" horizontally.

FASTENING

Anchor bolts – $\frac{1}{2}$ inch diameter at 6'-0" maximum on center.

Framing nailing is thought to have been mostly done with common nails, although box nails were allowed by code. The following is the schedule of minimum fastening from the 1958 UBC

Joist to sill or girder – toe nail 2-16d
Bridging to joist – toe nail 2-8d
1x6 subfloor to joist – face nail 2-8d
2-inch subfloor to joist or girder 2-16d
Plate to joist or blocking 16d – 16"oc
Stud to plate – end nail 2-16d
Stud to plate – toe nail 3-16d or 4-8d
Top plates –spike together 16d – 24"oc
–laps and intersections 2-16d
Ceiling joists –to plate – toe nail 2-16d
–laps over partitions 3-16d
–to parallel alternate
rafters 3-16d
Rafter to plate 3-16d
Continuous 1-inch brace to stud 2-8d
2-inch cut-in brace to stud 2-16d
1-inch sheathing to bearing 2-8d
Corner studs and angles 16d – 30"oc*
(Built-up corners)

*Reference c is more specific in showing corner configurations and calls for 16d-16"oc between studs or 3-10d into each spacer block.

Additional Fastening From Reference c, Figure 7

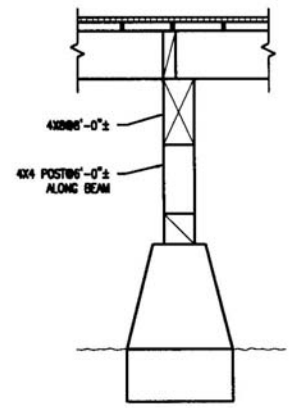
Rim joist (called header) to joists – end nails 2-20dRim joist to sill – toe nails 10d – 12"oc

LET-IN-BRACES
The floor plan of the small house shows likely locations of 2x4 let-in braces. Because the finish materials are thought to have a much larger effect on the building behavior, the let in braces may of may not be included in computer modeling of the house.

REFERENCES
a. Uniform Building Code, 1958 Edition
b. Bethlehem Wire Nails and Other Wire Products, Bethlehem Steel, 1950.
c. Technique of House Nailing, Housing and Home Finance Industry, Washington D. C., November 1947.
d. ASTM F-1667-95 Standard Specification for Driven Fasteners: Nails, Spikes, Staples

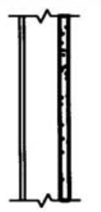
Figure A-5. Index building 1 structural notes (sheet S1, right)

FLOOR



	PSF
FLOORING	1.0
1X SHEATHING (ACTUAL 3/4")	2.2
2X6@16" (1-5/8X5-1/2)	1.6
BLOCKING	0.3
4X8@8'-0" AVG (3-5/8X5-1/2)	0.8
TOTAL	5.9

EXTERIOR WALL



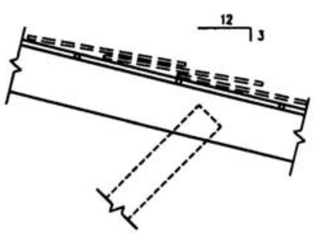
	PSF
7/8" 3 COAT STUCCO	8.8
2X4 STUDS@16" (1-5/8X3-1/2)	1.1
TOP PLATES	0.3
INT FINISH MIN 1/2" GYP	1.8
TOTAL	12.0

1/4" GLAZING + FRAME ~ 4.0 PSF

INTERIOR WALL

	PSF
2X4 STUDS@16"	1.1
TOP PLATES	0.3
FINISH - 2 X 1/2" GYPBD	3.6
TOTAL	5.0

3:12 SLOPED ROOF



	PSF
COMP SHINGLE	3.5
RE-ROOF	3.5
BUILDING PAPER	
1X SHEATHING (ACTUAL 3/4)	2.2
2X6@24" (1-5/8X5-1/2)	1.1
2X4@24" TO 1/4 POINTS	0.7
MISC	0.0
TOTAL	11.0
ADJUST FOR SLOPE X1.0308	11.3

CEILING

	PSF
2X6@16" (1-5/8X5-1/2)	1.6
INSULATION 0.3 #/inX3-1/2	1.1
FINISH MIN 5/8" GYP	2.3
MISC	0.0
TOTAL	5.0

Small House Index Building

Building Weights

Item	Location		Length (ft)	Width or Height (ft)	Area (sq ft)	Unit Weight (psf)	Weight #	Total Weight #
Roof			32	42	1344	11	14,784	14,784
Ceiling			30	40	1200	5	6,000	6,000
Wall	Line A-Rear	Total	40	8	320			3,344
		window/door			62	4	248	
		typ exterior			258	12	3,096	
	Line B-Int	Total	40	8	320			1,360
		open & door			80	2	160	
		typ interior			240	5	1,200	
	Line B.1-Int	Total	19	8	152			710
		open & door			16.7	2	33	
		typ interior			135.3	5	677	
	Line B.2-Int	Total	8	8	64			320
		open & door			0	2	0	
		typ interior			64	5	320	
	Line C-front	Total	40	8	320			3,256
		window/door			73	4	292	
		typ exterior			247	12	2,964	
	Line 1-Right	Total	30	8	240			2,544
		window/door			42	4	168	
		typ ext			198	12	2,376	
	Line 1.3-Int	Total	5	8	40			200
		open & door			0	2	0	
		typ interior			40	5	200	
	Line 1.6-Int	Total	5	8	40			150
		open & door			16.7	2	33	
		typ interior			23.3	5	117	
	Line 2-Int	Total	18	8	144			620
		open & door			33.4	2	67	
		typ interior			110.6	5	553	
	Line 2-Int	Total	18	8	144			467
		closet door			63.3	1	63	
		typ interior			80.7	5	404	
	Line 3-Int	Total	14	8	112			560
		open & door			0	2	0	
		typ interior			112	5	560	
	Line 4-Int	Total	12	8	96			480
		open & door			0	2	0	
		typ interior			96	5	480	
	Line 5-Left	Total	30	8	240			2,544
		window/door			42	4	168	
		typ ext			198	12	2,376	
Floor			30	40	1200	5.9	7080	7080
Cripple Walls	Line A	ext	40	2	80	9.9	792	792
	Line C	ext	40	2	80	9.9	792	792
	Line 1	ext	30	2	60	9.9	594	594
	Line 5	ext	30	2	60	9.9	594	594
Total Building Weight								47,190

Figure A-6. Index building 1 structural notes (sheet S1, left)

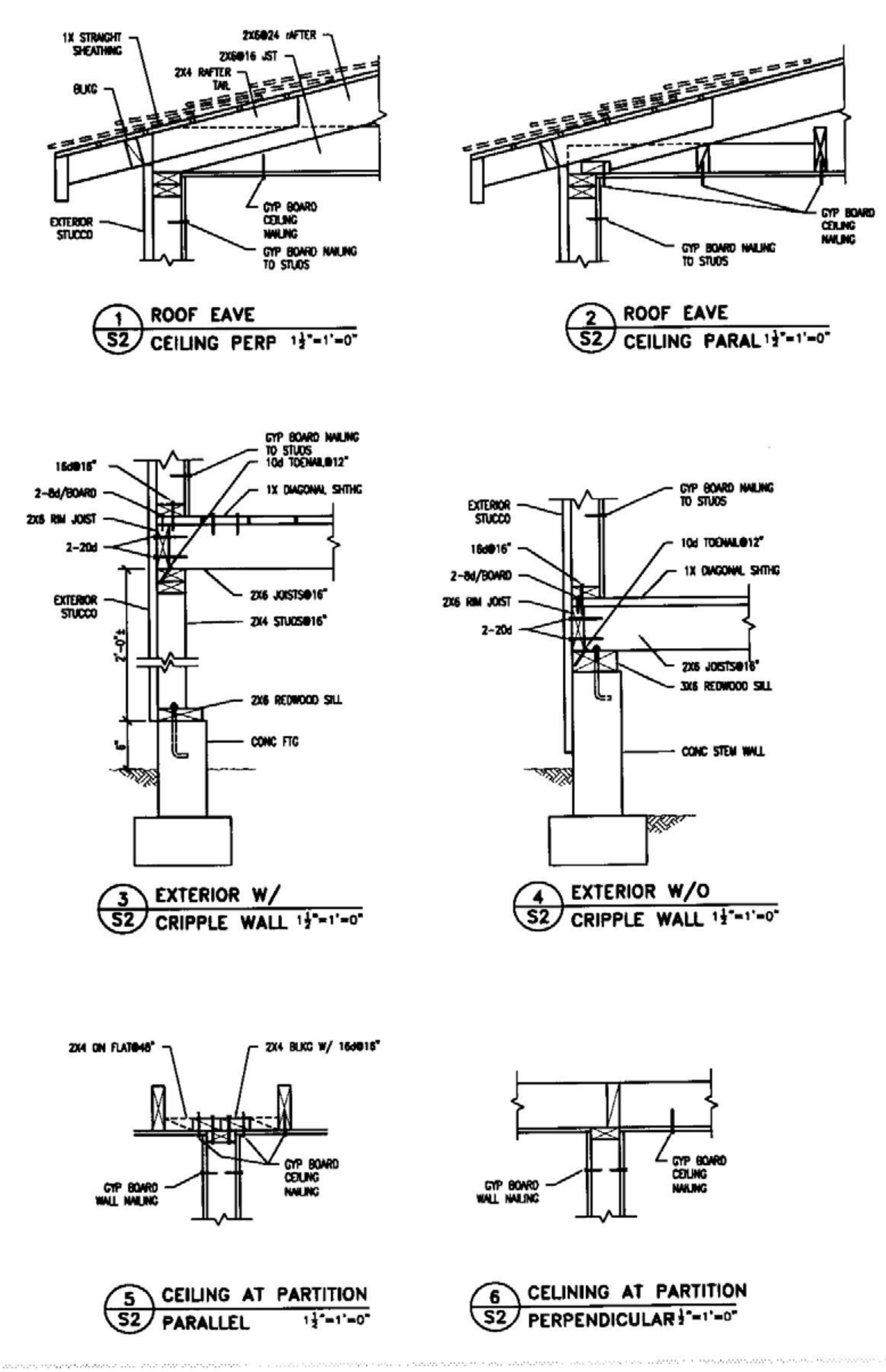


Figure A-7. Index building 1 structural details (sheet S2)

A.2 INDEX BUILDING 2

Index building 2 is identical to IB1, except for the addition of cripple wall bracing, as shown in Figure A-8.

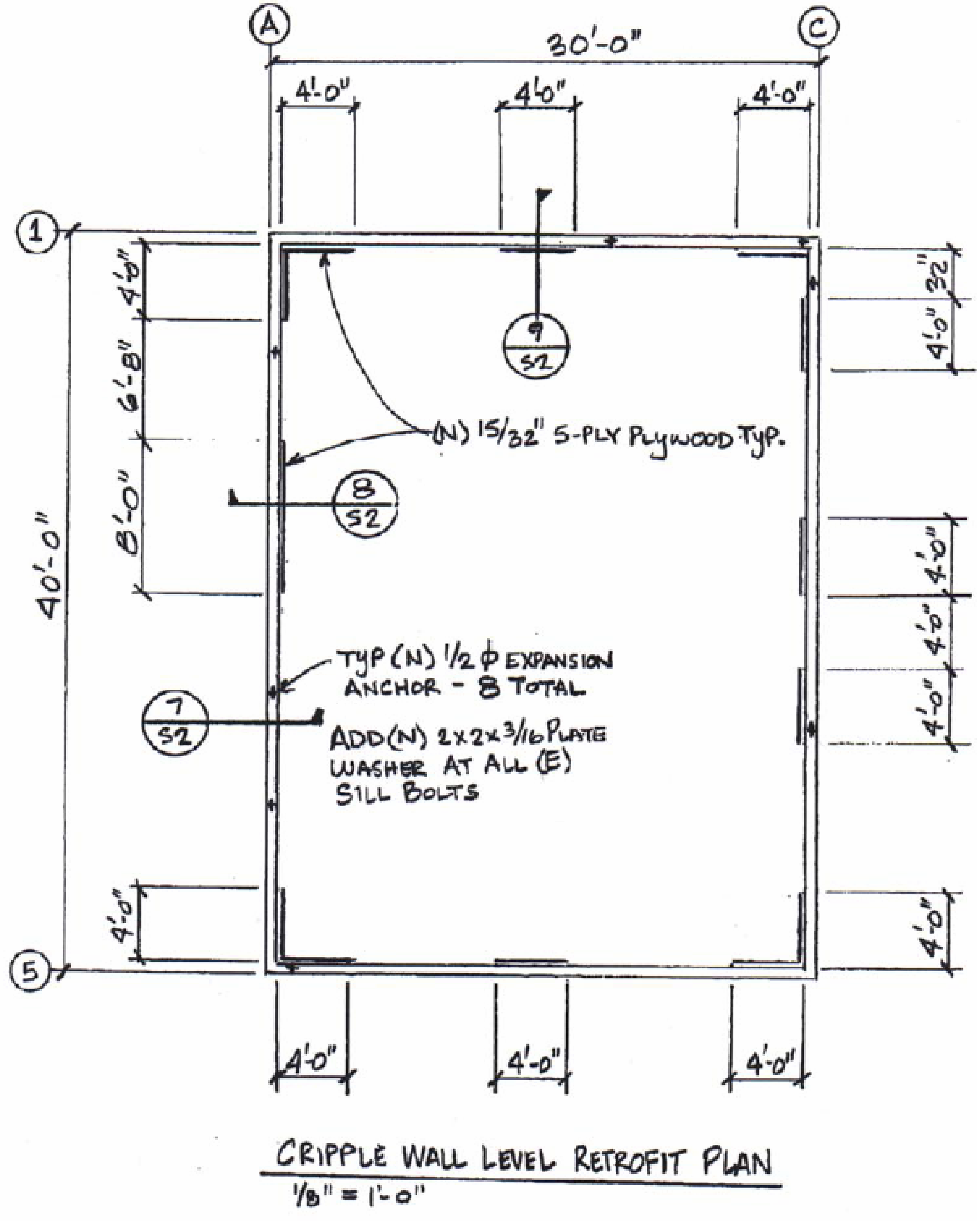


Figure A-8. Retrofit scheme for index building 2

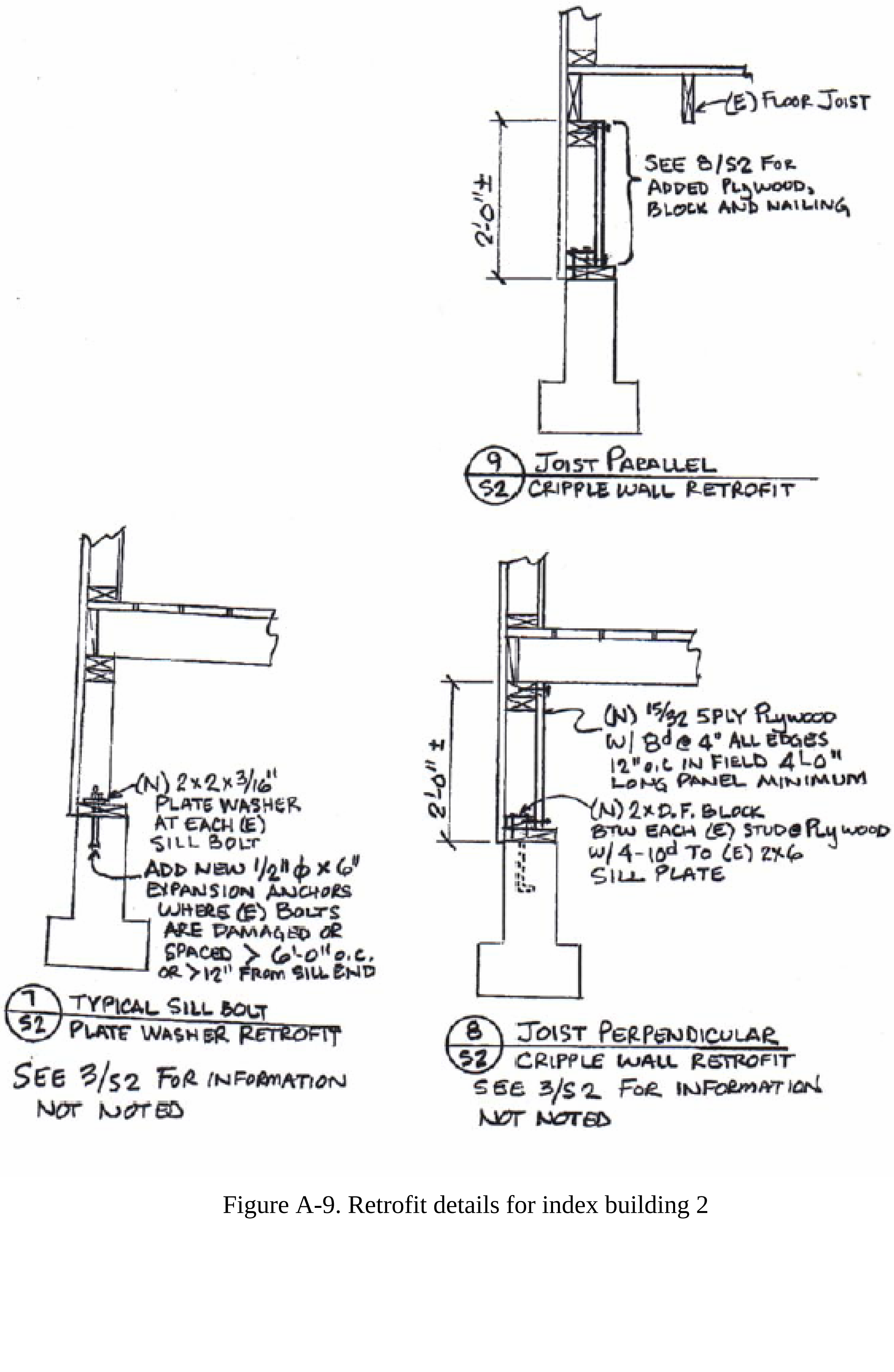


Figure A-9. Retrofit details for index building 2

A.3 INDEX BUILDING 3

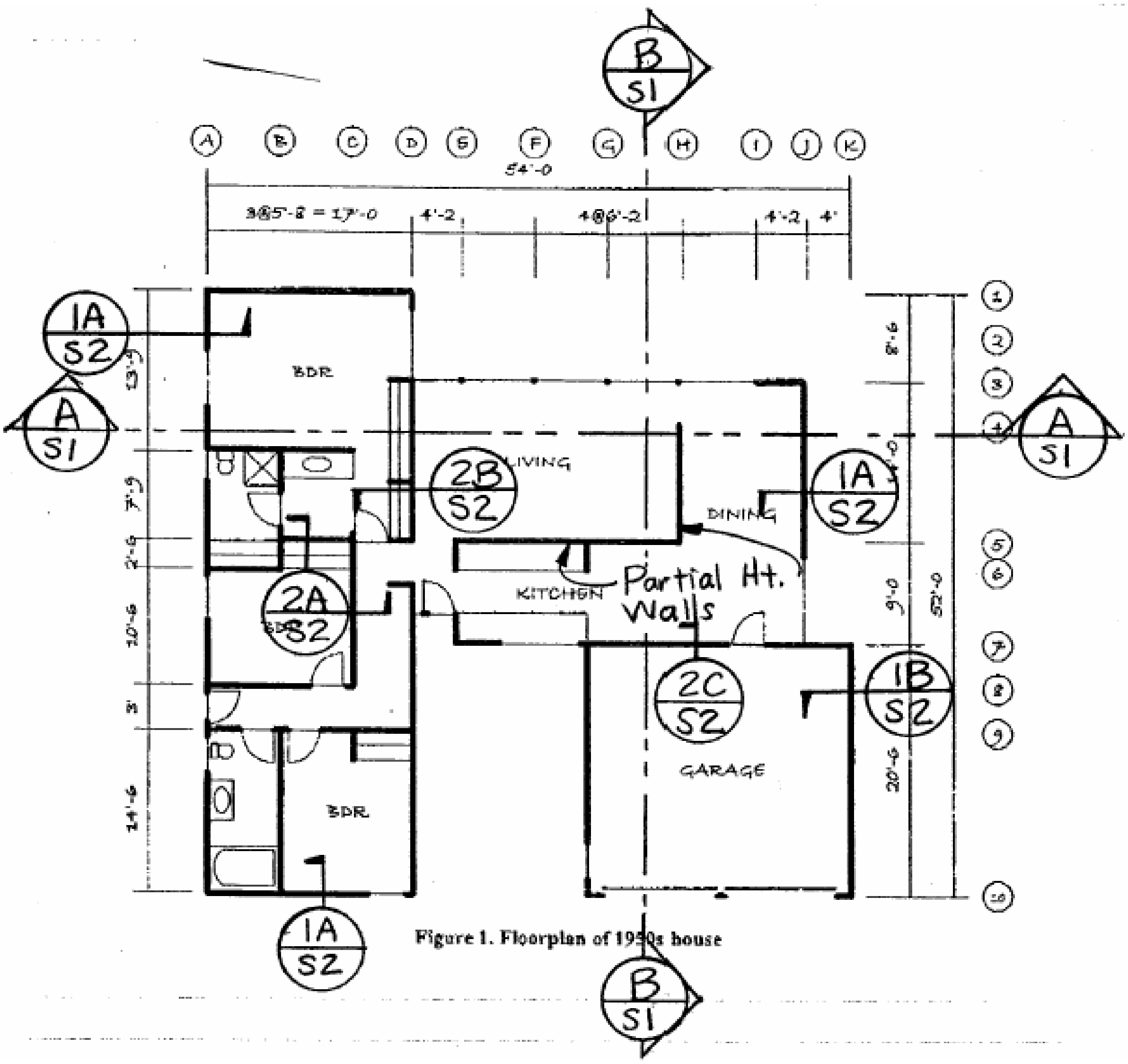


Figure A-10. Index building 3 floorplan (detail 1-S1)

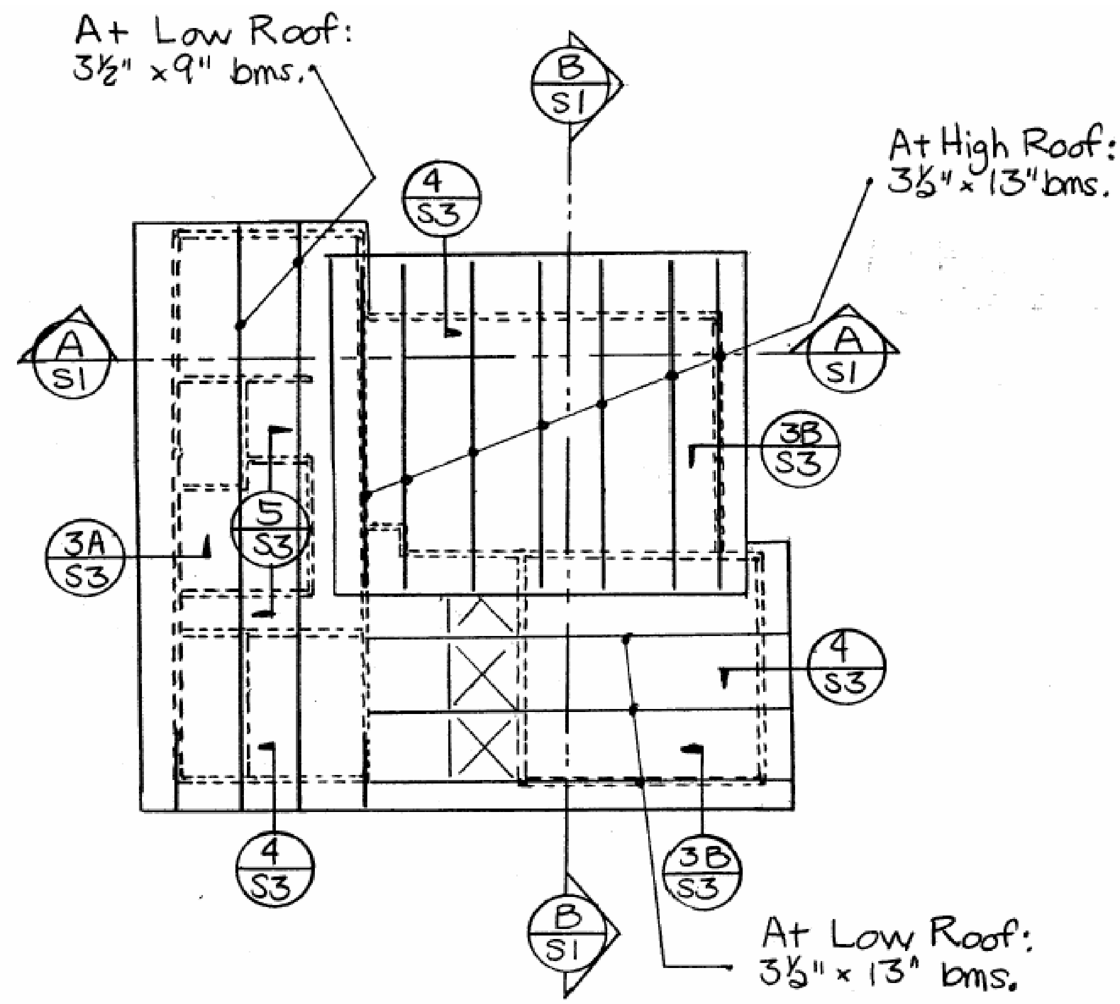


Figure A-11. Roof framing (detail 3-S1)

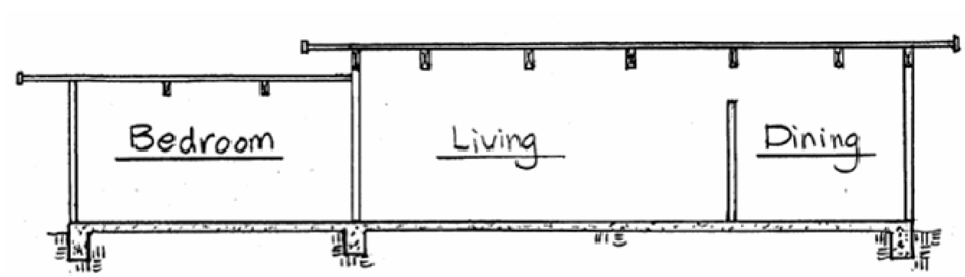


Figure A-12. Index building 3 section A-A (detail A-S1)

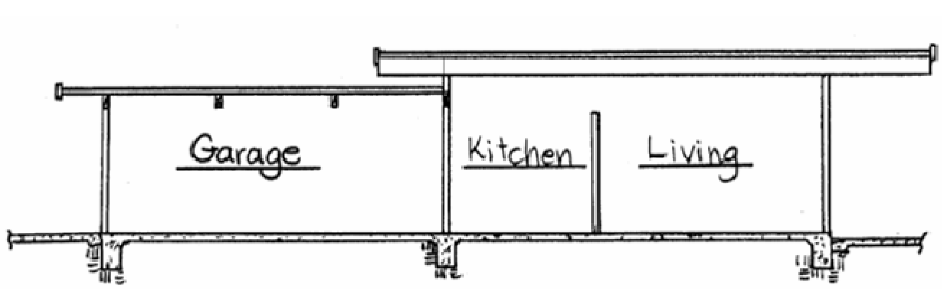


Figure A-13. Index building 3 section B-B (detail B-S1)

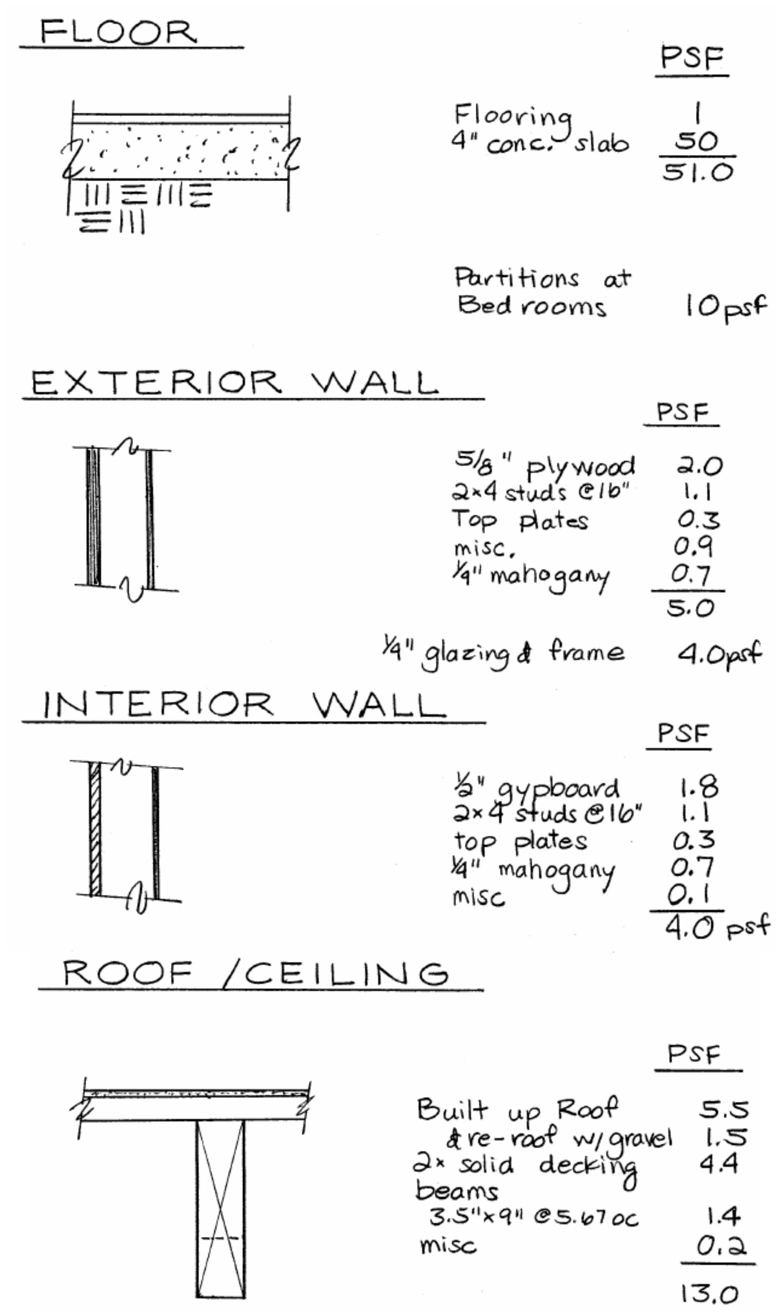


Figure A-14. Index building 3 details (detail B-S1)

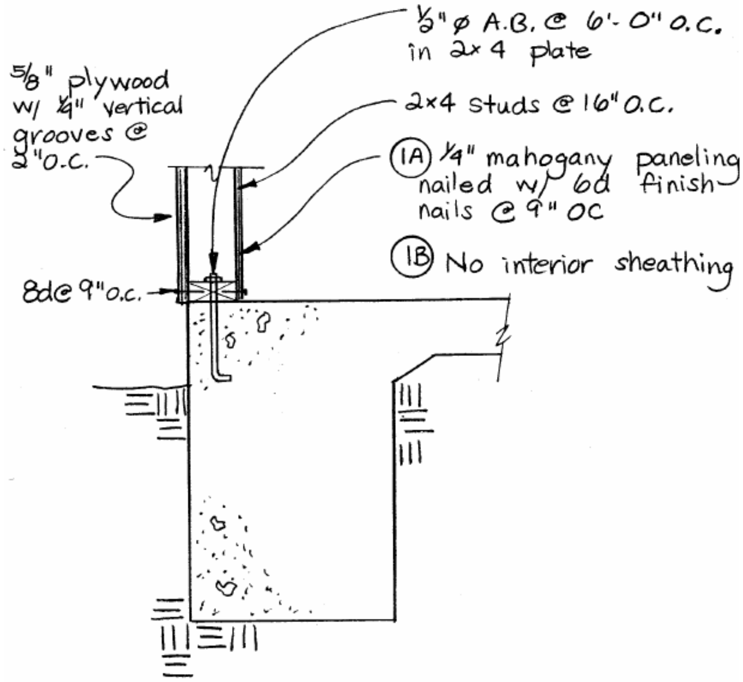


Figure A-15. Index building 3 exterior wall footing (detail 1-S2)

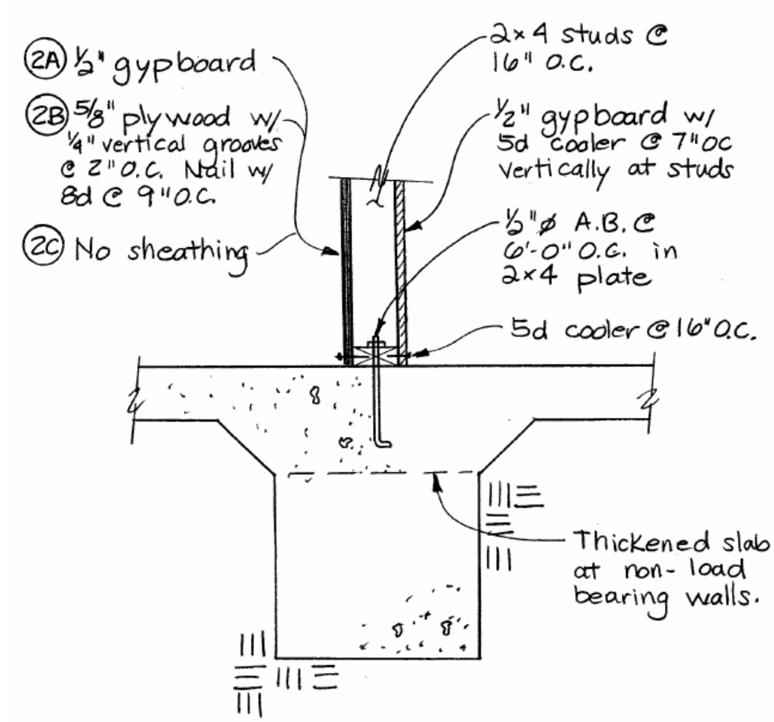


Figure A-16. Index building 3 interior wall footing (detail 2-S2)

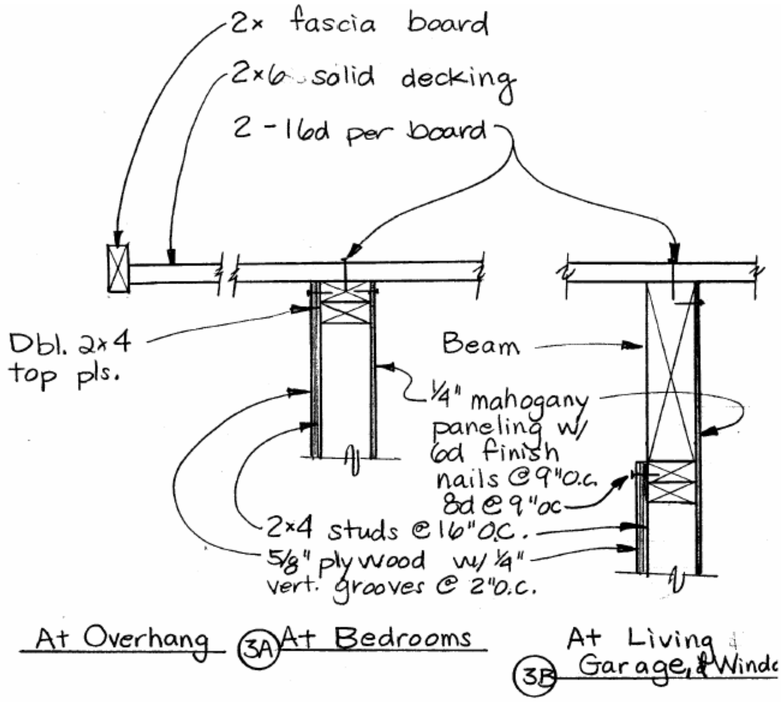


Figure A-17. Index building 3 top of exterior wall perpendicular to deck (detail 3-S3)

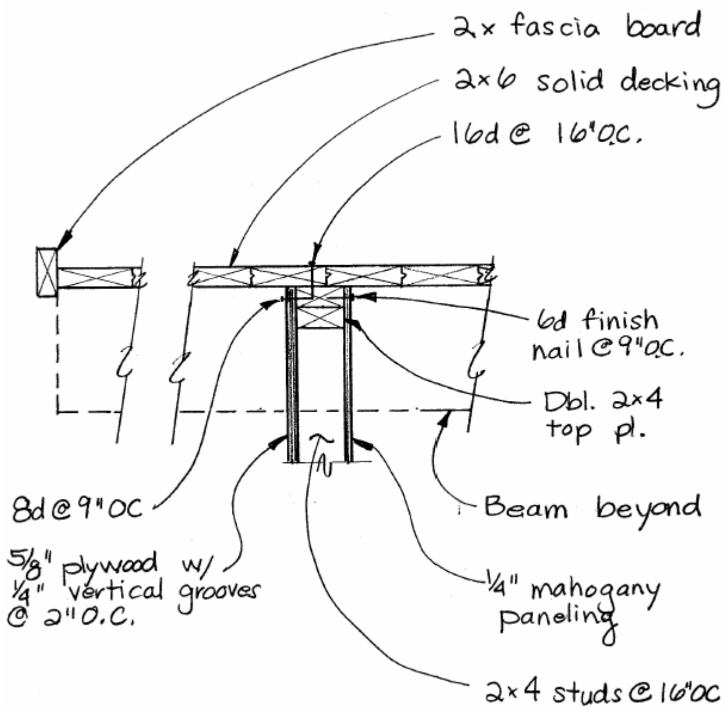


Figure A-18. Index building 3 top of exterior wall parallel to deck (detail 4-S3)

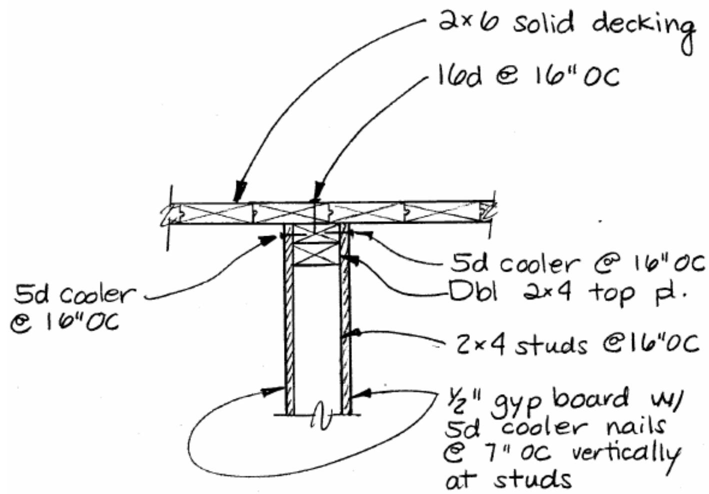


Figure A-19. Index building 3 top of interior wall parallel to deck (detail 5-S3)

Index building 3 general information. This is a real house, surveyed in June, 2002, and built in a San Rafael development in 1955-1956, in the Eichler style. The floorplan has been reduced by 1 bedroom to meet the square-footage requirement, but is otherwise identical to the actual house. The foundation is slab on grade throughout, with radiant heating (no longer operational). Wall framing is redwood 2x4 @16 OC, 1 sill plate, 2 hdr plates, blocked at mid-height with 2x4 toe-nailed to the studs. Ceilings in the bedroom wing and garage are 8'-0. The ceiling in the LR, DR, and K is 10’-0. The roof is flat. Roof girders in the bedroom wing run N-S along column lines A-D, with members whose measured dimensions are 9x3-1/2. Over the LR/DR/K, the roof is framed with girders running N-S along column lines D-J, with measured dimensions 13x3-1/2. All ceilings are painted 2x6s running E-W at all spaces except the garage and atrium, where they run N-S (i.e., always spanning between girders). The roof is tar and gravel over solid 2x6 wood decking. The girders at the garage and atrium have measured dimensions 13x3-1/2, and are spaced at 6’-10 OC running E-W. The exterior walls are painted, 5/8-in plywood with 1/4-in square vertical grooves at 2-in on center, nailed ext & int at 9 in OC. The wall between the LR, DR, and K is partial height, 7'-0 high. The portion of it from G5 to H5 and along H is 7x7x7 concrete block. There is a fireplace with metal flue at H5. Finishes are listed in Table A-1.

Table A-1. Index building 3 finishes

	Wall	Floor	Ceiling
Kitchen	¼-in Philippine Mahogany, small-headed nails @ 9-in OC int & ext, except 5G-H, which is painted CB	Vinyl tile	Painted 1x6 wood
Dining	Ditto	Carpet	Ditto
Living	5/8-in grooved plywood on line D, grass cloth wallpaper over GWB on 5E-G, painted CB on 5G-H, H4-5	Ditto	Ditto
Entry	grass cloth wallpaper over GWB on line E, 5/8-in grooved plywood on line D	Vinyl tile	Ditto
Hall	¼-in Philippine Mahogany	Ditto	Ditto
Master BR (N end)	¼-in Philippine Mahogany on lines 1 and A, wallpaper over GWB elsewhere	Carpet	Ditto
Baths	Wallpaper over GWB	Vinyl tile	Ditto
BRs	¼-in Philippine Mahogany at exterior walls, wallpaper over GWB elsewhere		Ditto
Garage	None	None	Unpainted

A.4 INDEX BUILDING 4

Index building 4 is based on the large house analyzed in Porter et al. (2002a) and designed by Reitherman and Cobeen (2003), with two modifications: no structural sheathing (wood shearwall) is included, and the foundation is changed from slab on grade to raised foundation, bolted, with unbraced cripple walls.

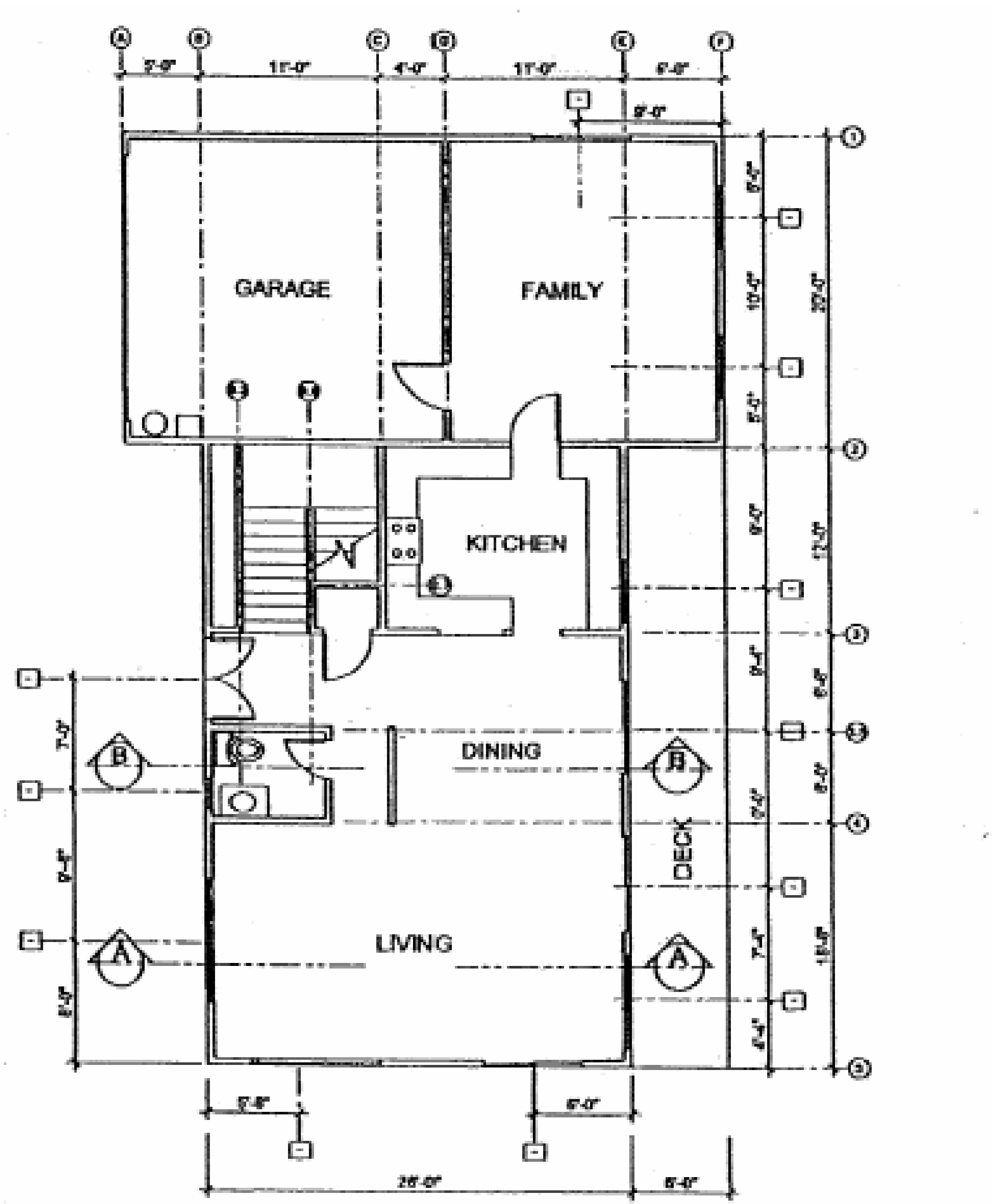


Figure A-20. Index building 4 first-floor plan (sheet A1, left)

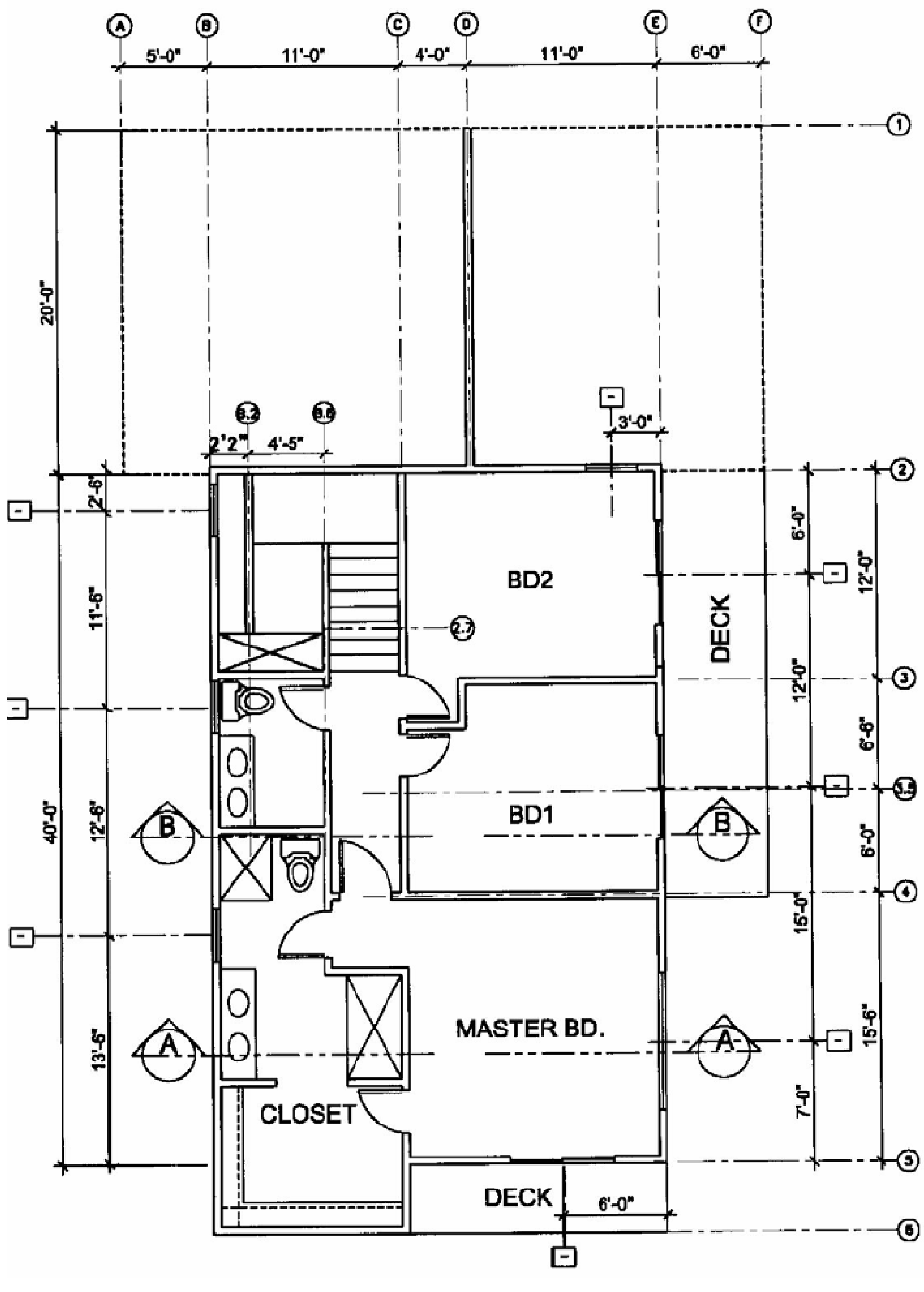


Figure A-21. Index building 4 second-floor plan (sheet A1, right)

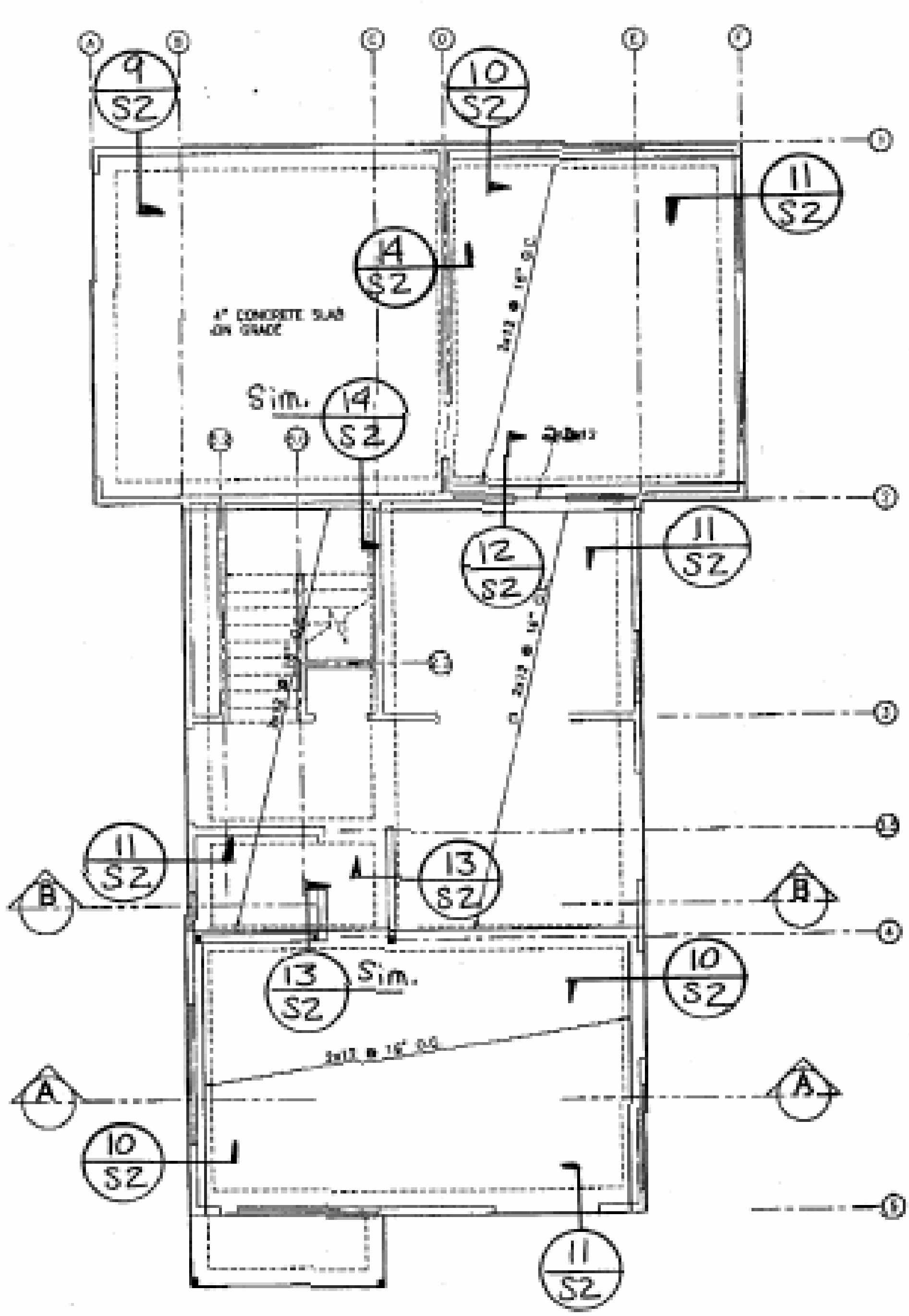


Figure A-22. Index building 4 foundation plan

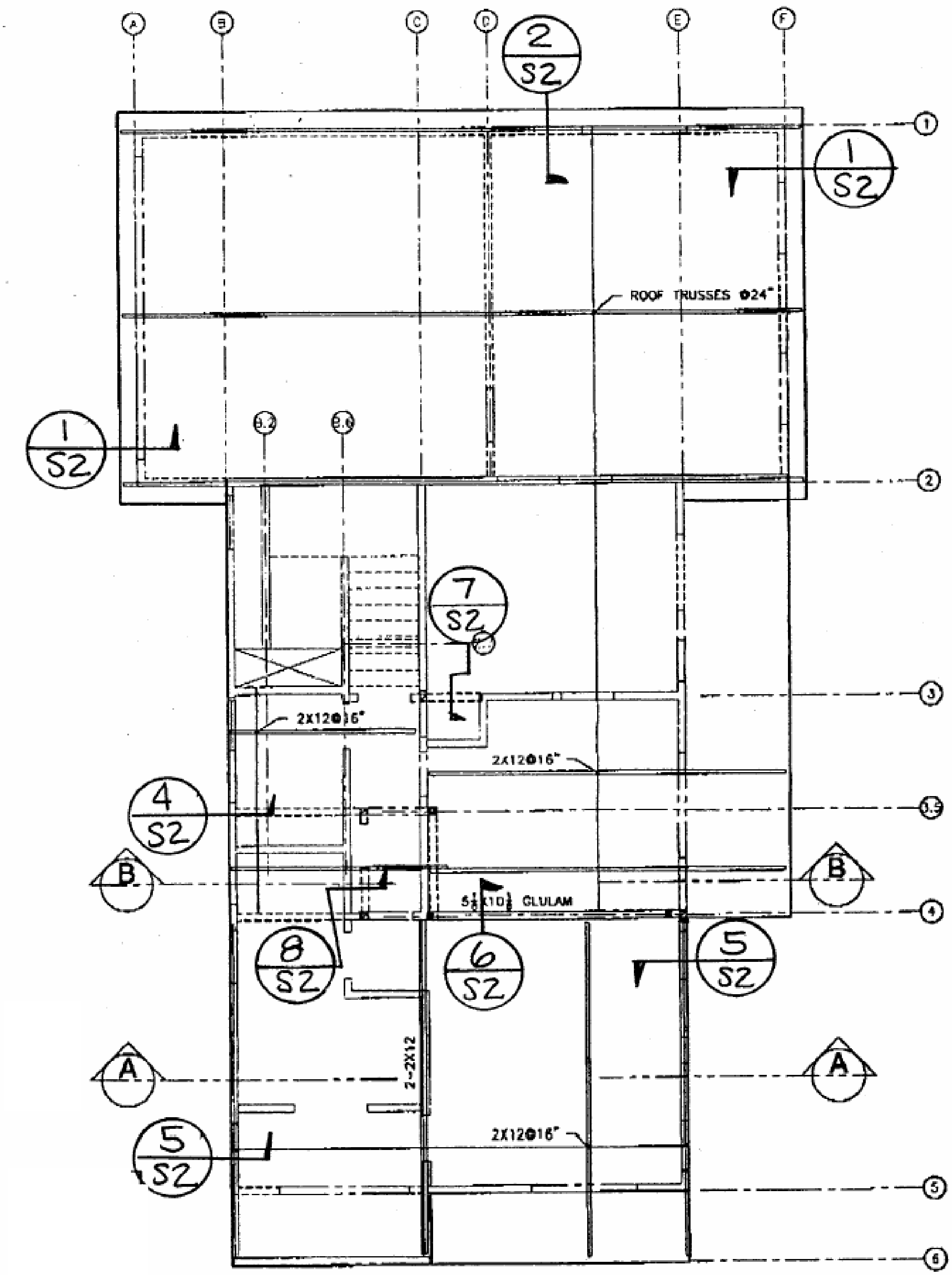


Figure A-23. Index building 4 second floor framing plan and low roof plan

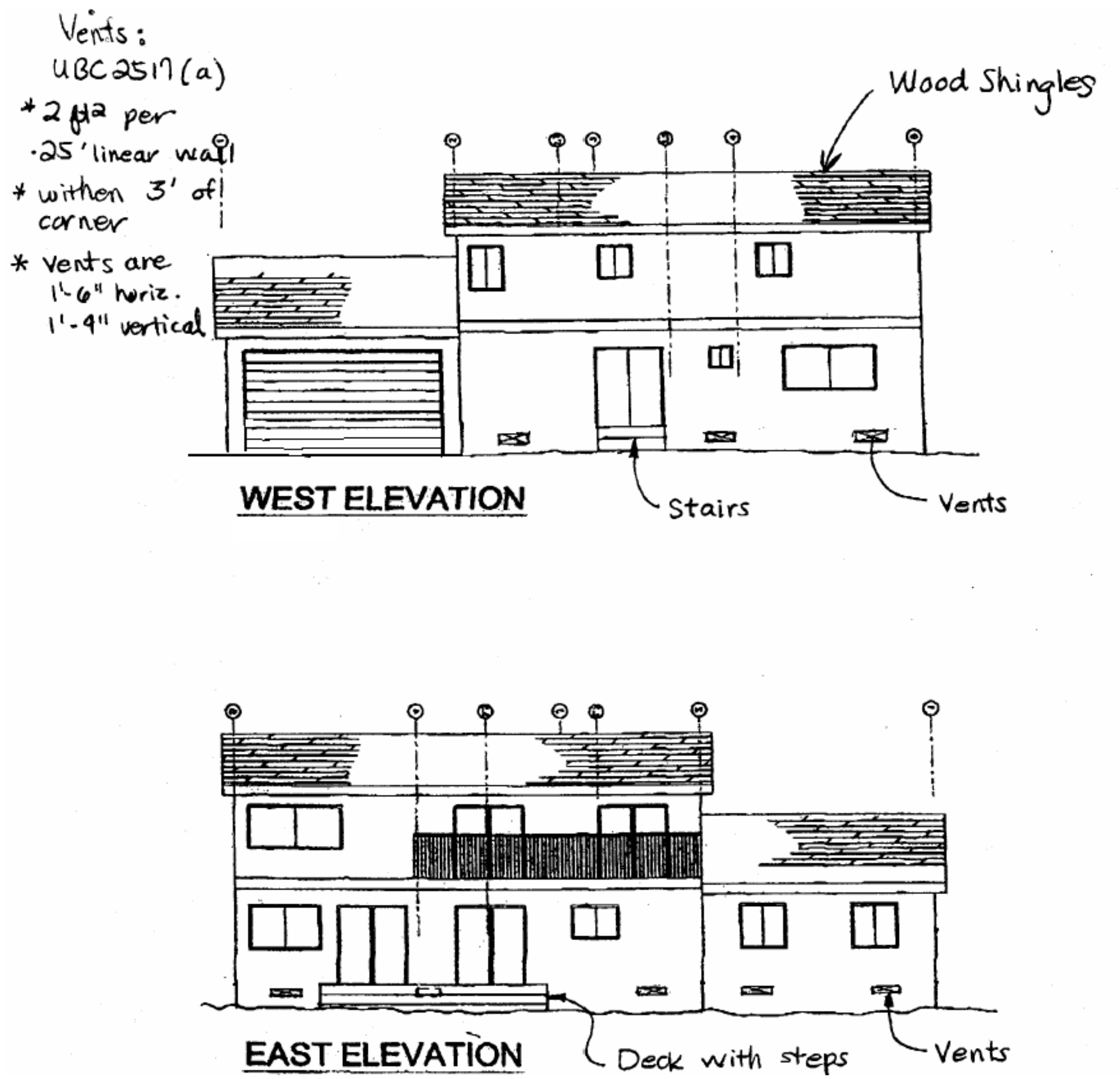
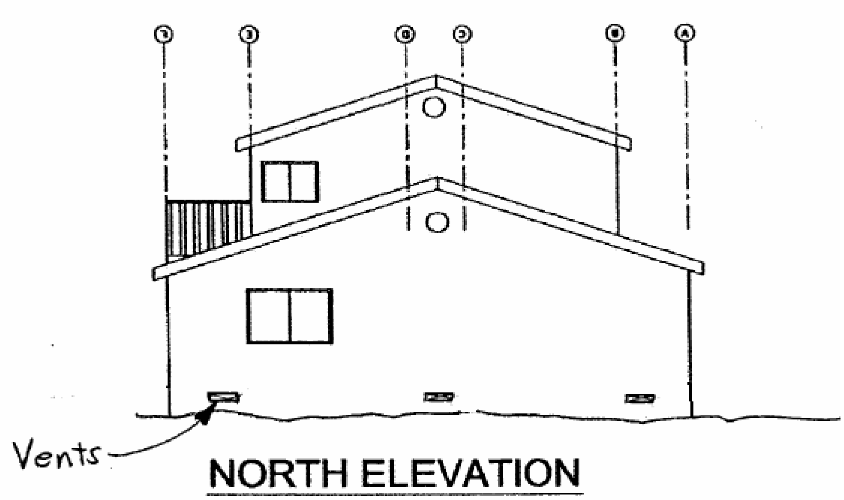


Figure A-24. Index building 4 exterior elevations (sheet A2, right)



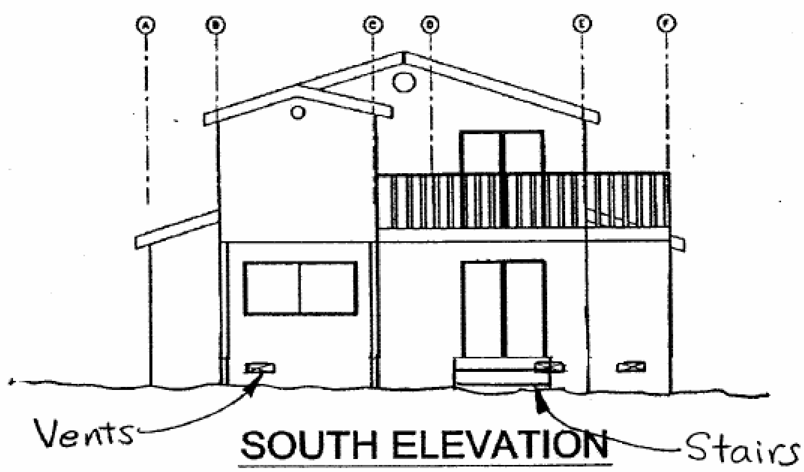


Figure A-25. Index building 4 exterior elevations (sheet A2, left)

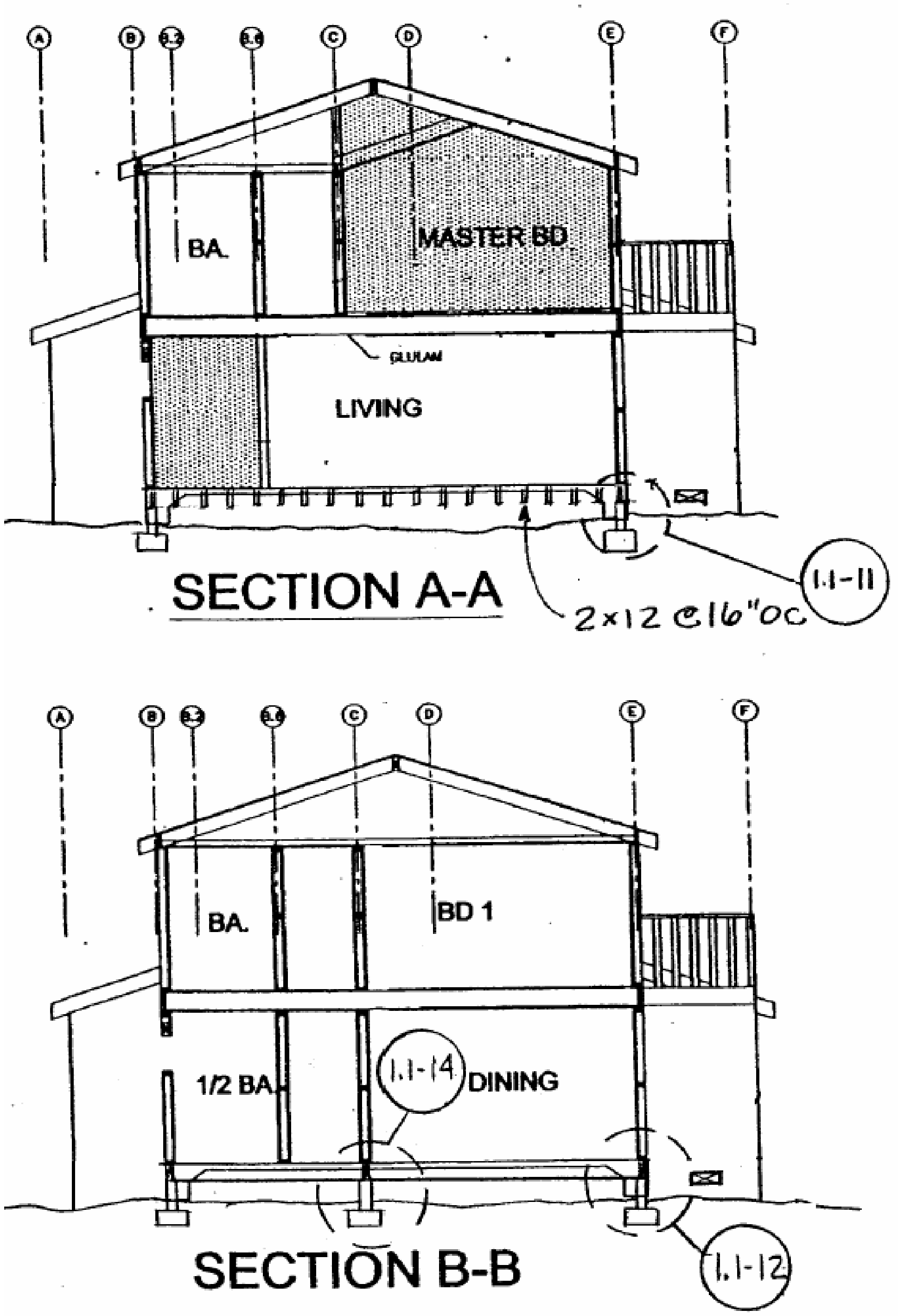


Figure A-26. Index building 4 sections (sheet A3, right)

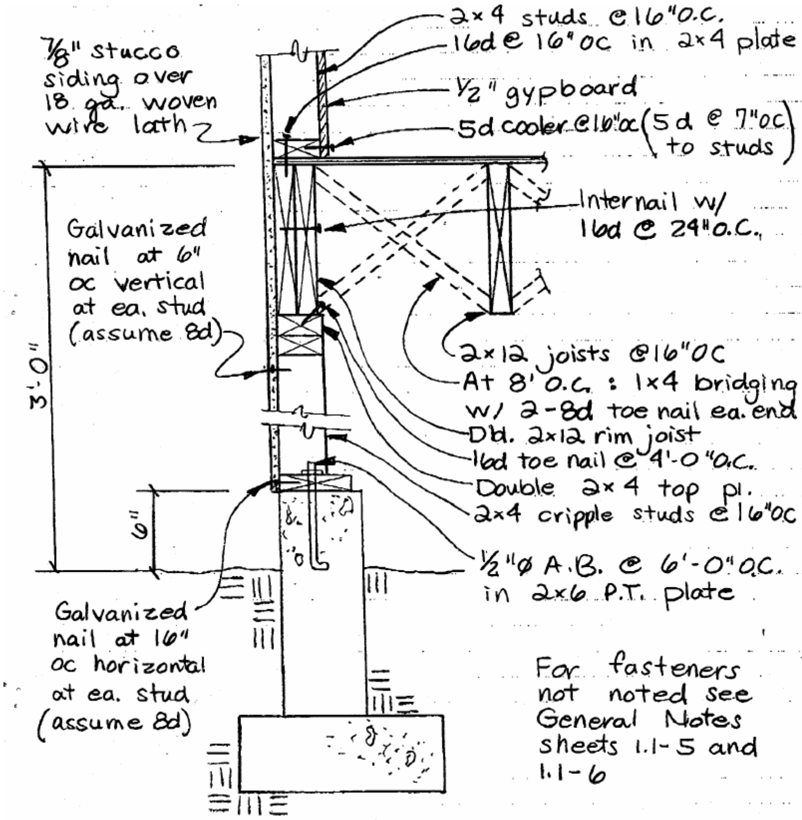


Figure A-27. Exterior cripple wall parallel to joists (detail 10-S2)

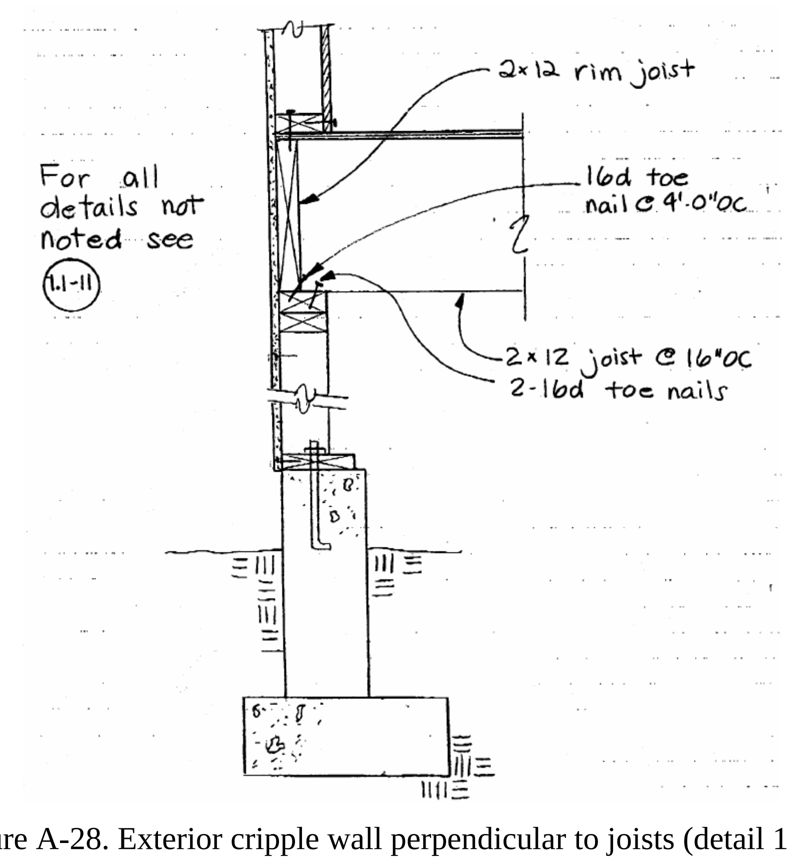


Figure A-28. Exterior cripple wall perpendicular to joists (detail 11-S2)

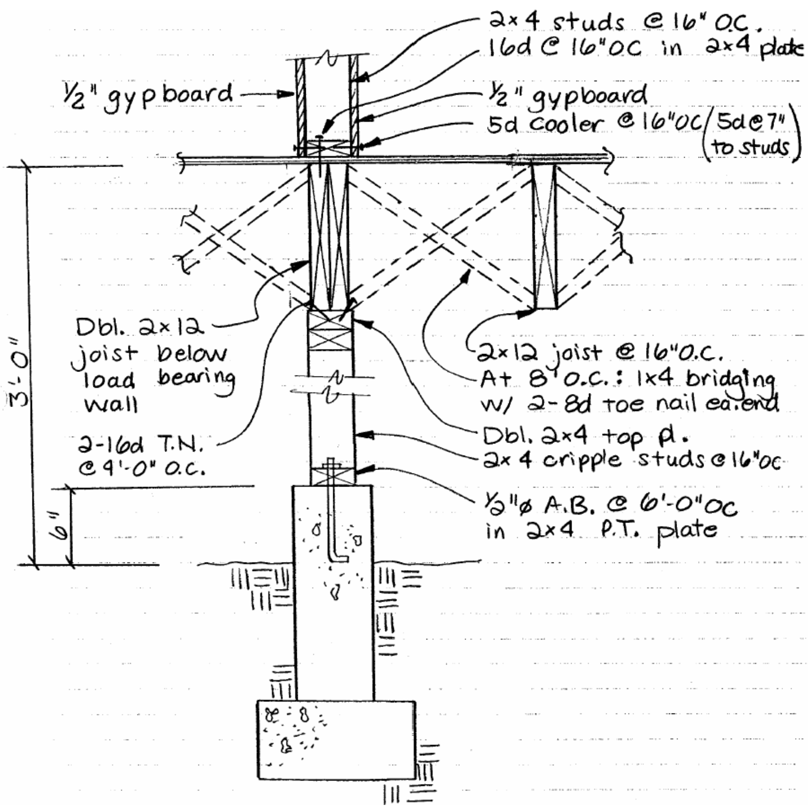


Figure A-29. Interior cripple wall parallel to joists (detail 12-S2)

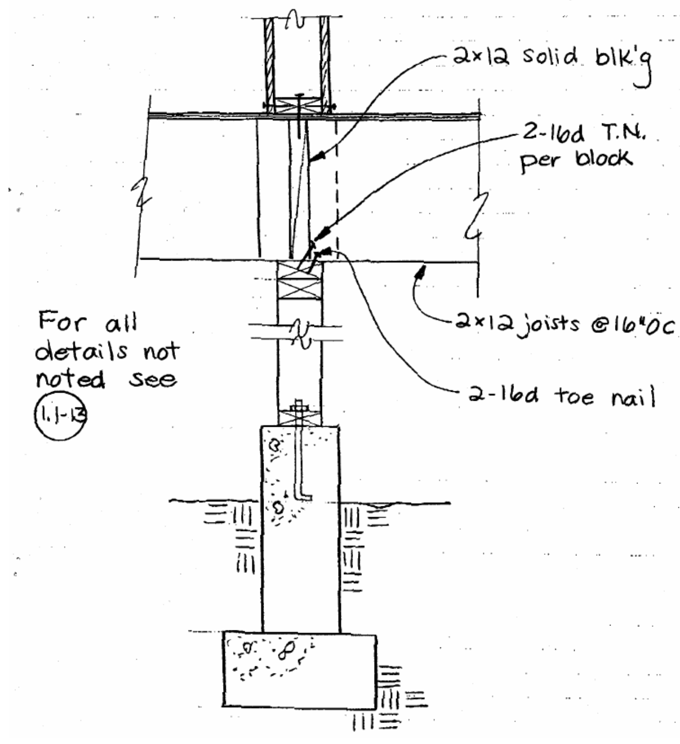


Figure A-30. Interior cripple wall perpendicular to joists (detail 13-S2)

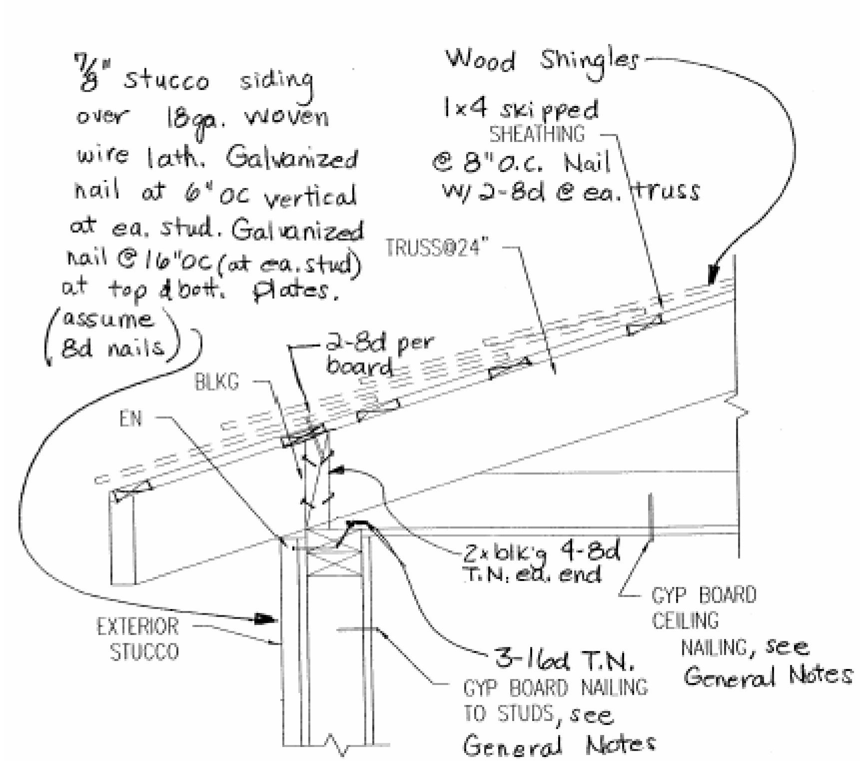


Figure A-31. Index building 4 roof eave (detail 1-S2)

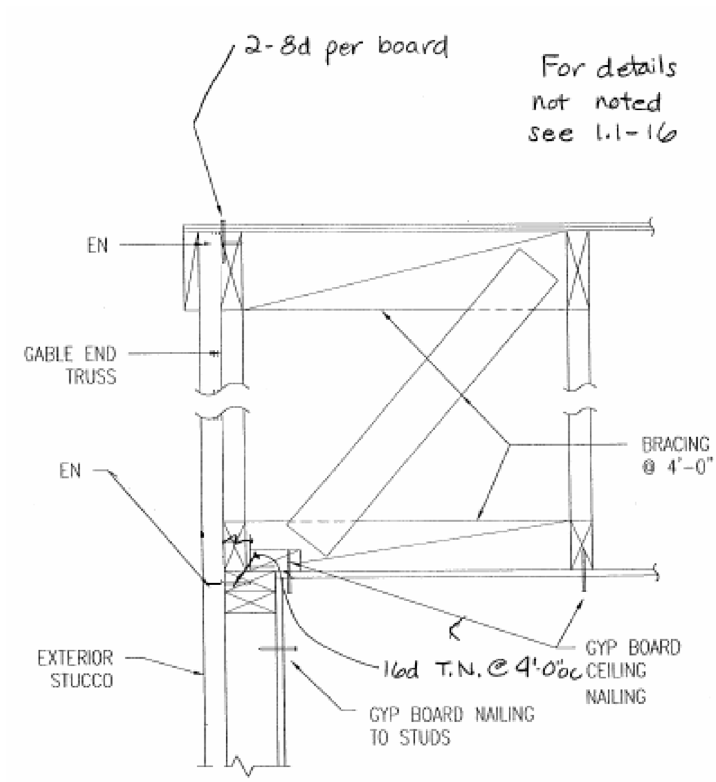


Figure A-32. Index building 4 gable end roof typical ceiling (detail 2-S2)

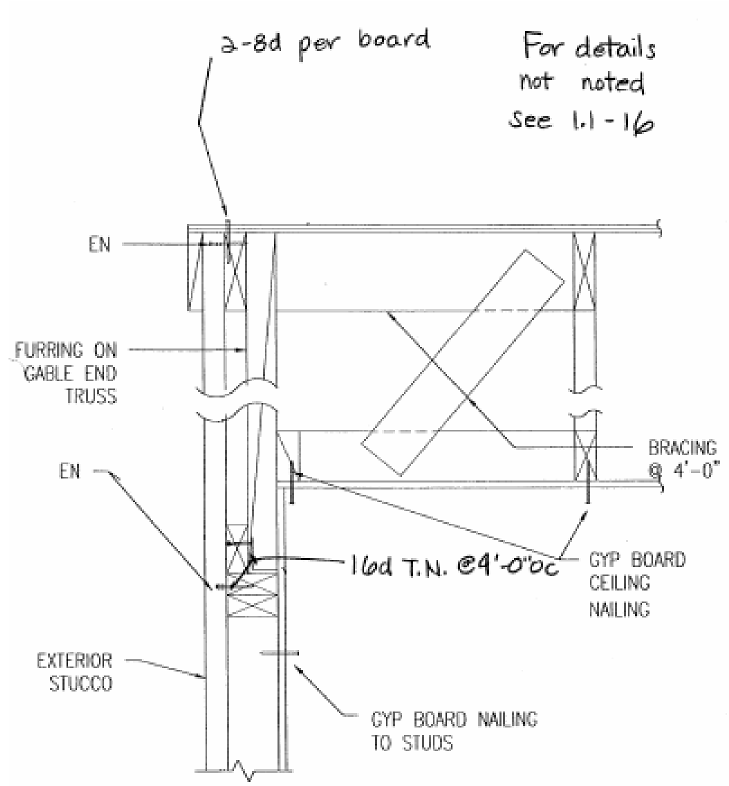


Figure A-33. Index building 4 gable end roof high ceiling (detail 2A-S2)

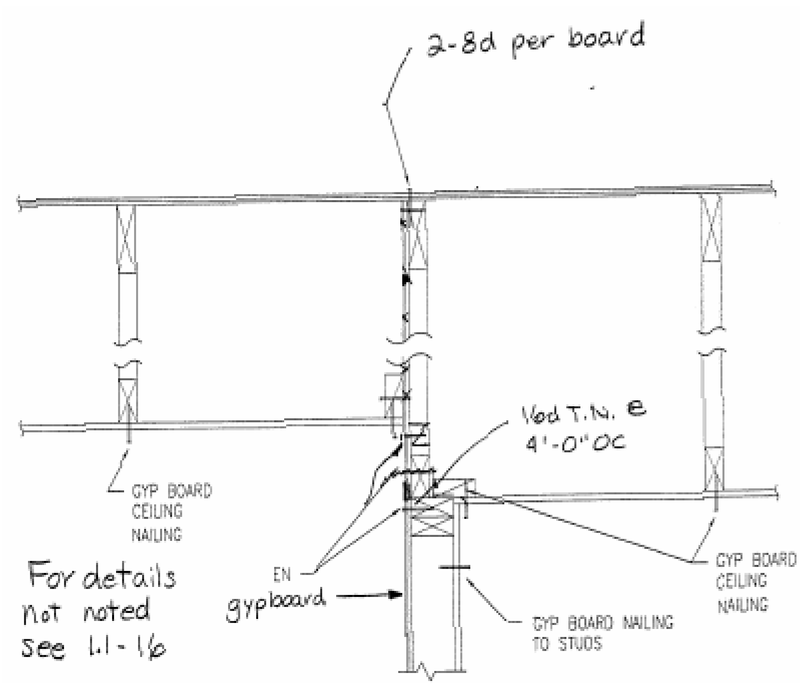


Figure A-34. Index building 4 master bedroom roof high ceiling (detail 3-S2)

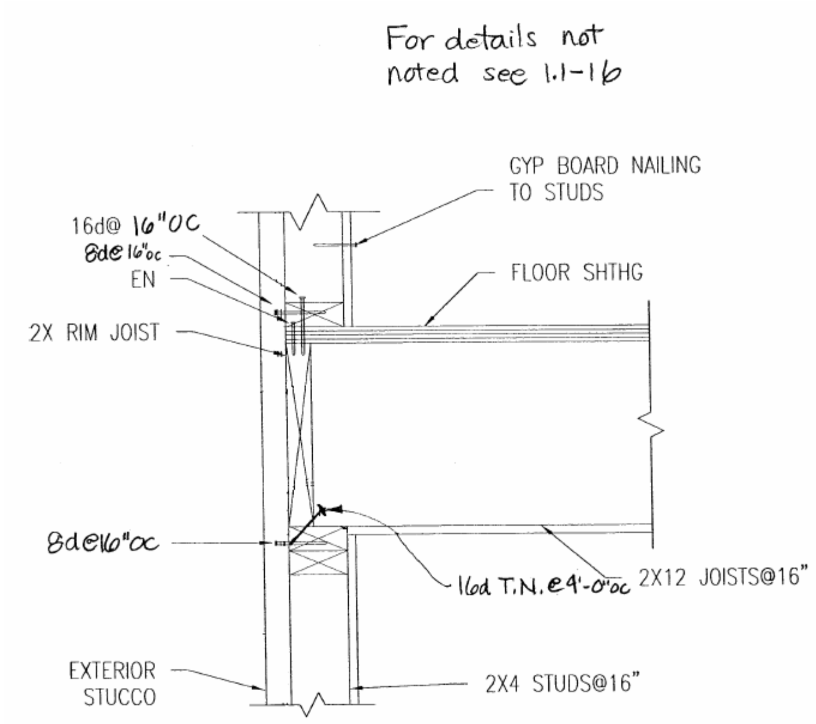


Figure A-35. Index building 4 floor edge joists perpendicular (detail 4-S2)

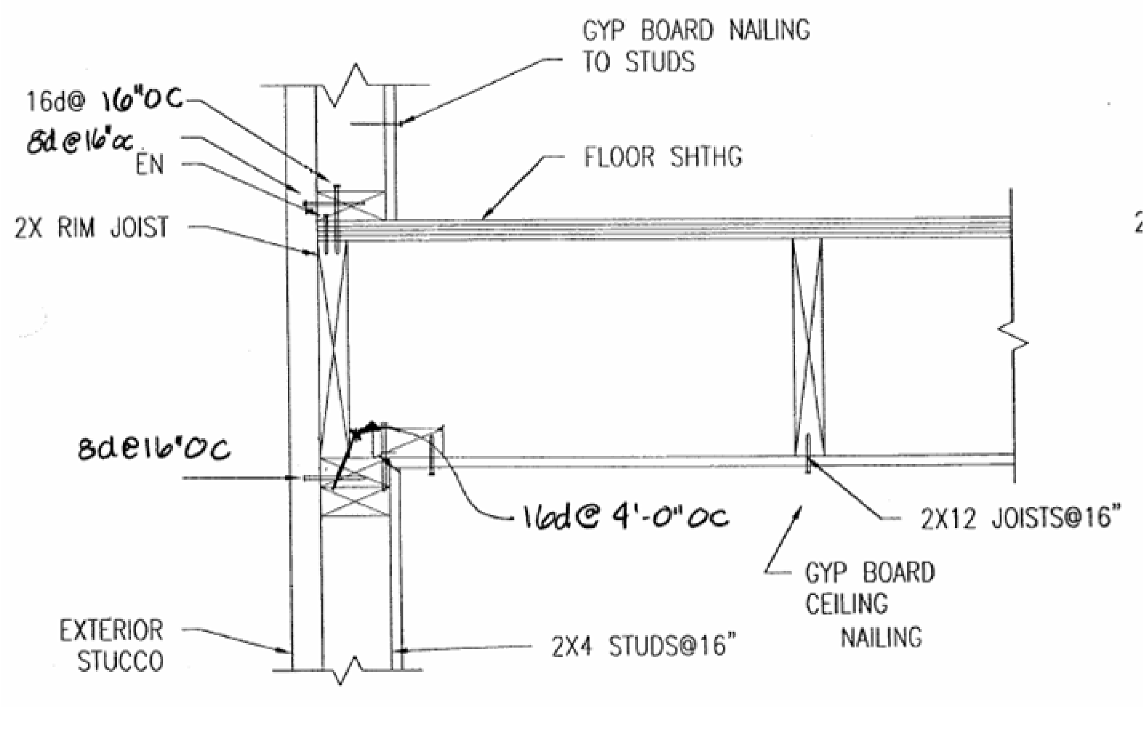


Figure A-36. Index building 4 floor edge joists parallel (detail 5-S2)

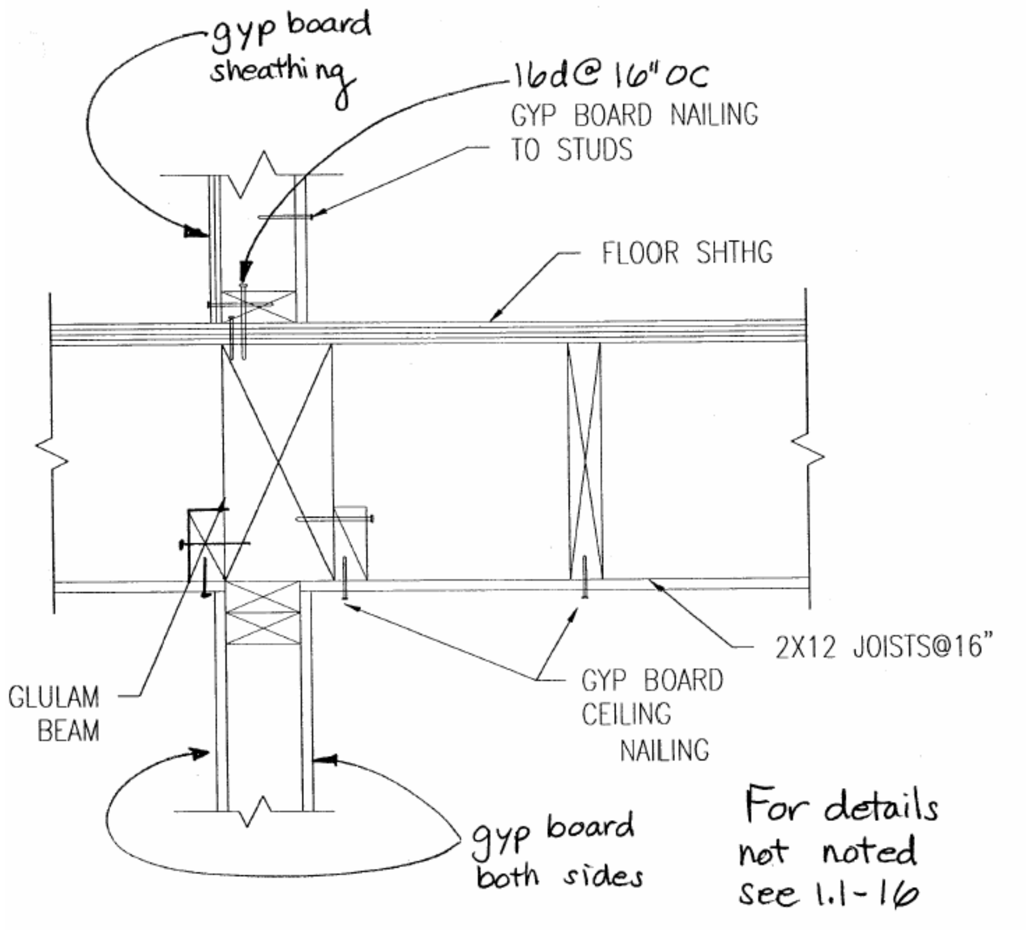


Figure A-37. Index building 4 floor at line-4 glulam (detail 6-S2)

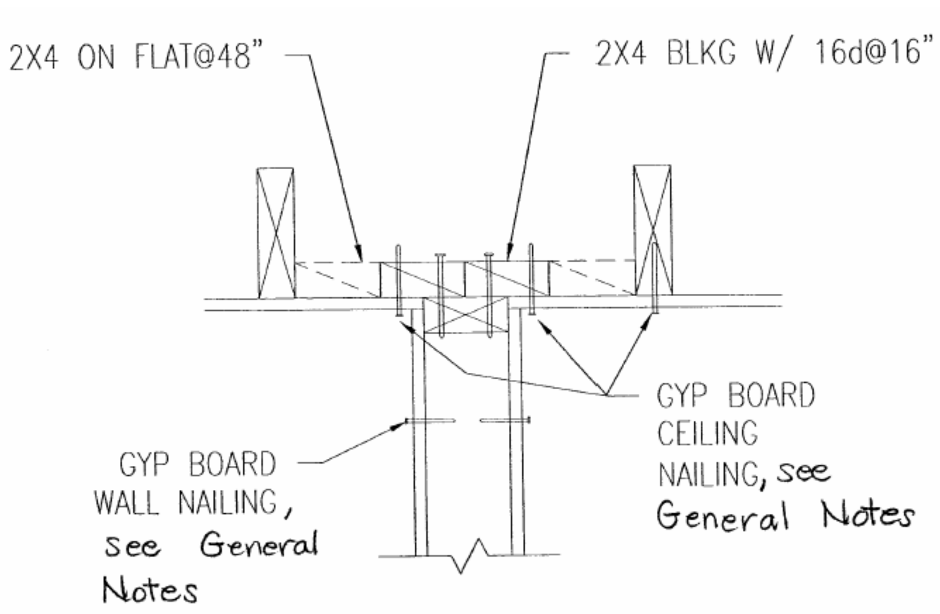


Figure A-38. Index building 4 ceiling at partition parallel (detail 7-S2)

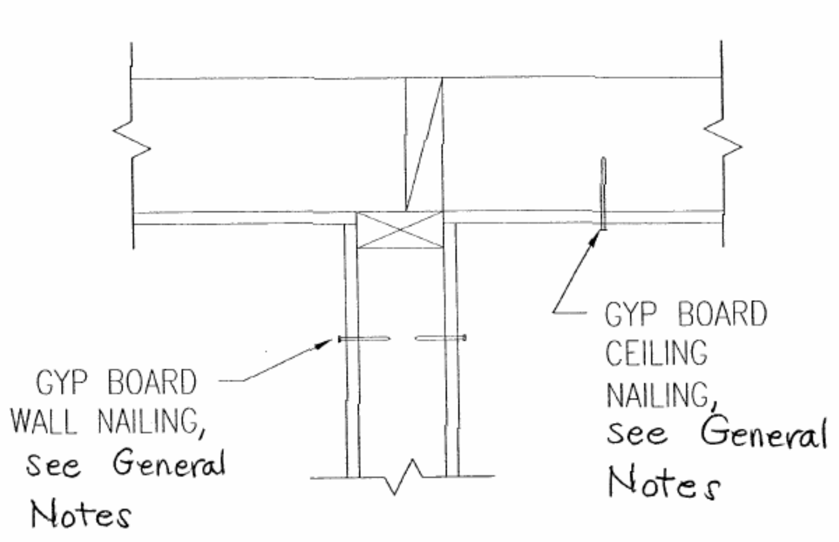


Figure A-39. Index building 4 ceiling at partition perpendicular (detail 8-S2)

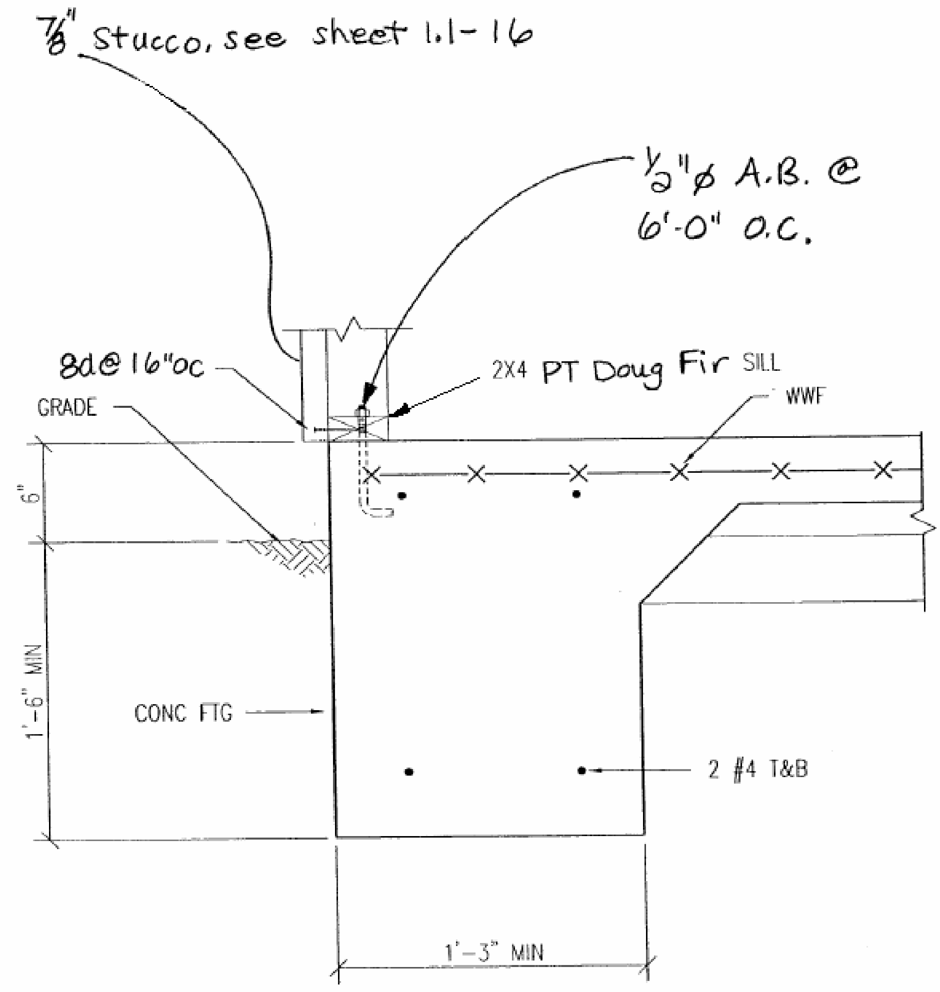


Figure A-40. Index building 4 typical exterior footing at garage (detail 9-S2)

General notes for index building 4. This index building is a two-story single family dwelling of approximately 2400 square feet. It has cripple walls and a framed first floor throughout the living area. A concrete slab on grade is shown at the garage. It is intended to have been built as a housing development “production house” in the 1960s, located in either Northern or Southern California. The design is based on light frame construction described in the UBC. To the extent possible, characteristic materials and fastening have been identified.

SPECIES

Typical species for framing - Douglas-fir.
Foundation sill plates - pressure treated Douglas-Fir.
Roof trusses - could vary - assume Southern Pine

SHEATHING

Roof sheathing: 1x4 skipped sheathing at 8 in. on center
2-8d common at supports
8d common dimensions: ASTM F1667, flat head, diamond point, L=2.5”, D=0.131”
Floor sheathing: 3/4" T&G PLWD or OSB
10d common at 6" supported edges, 12" other supports
Wall sheathing: stucco at exterior, gypsum wallboard at interior

Gypsum wallboard sheathing: 1/2" sheathing, 1964 UBC, table 47-J, specifies 5d nail at 6 to 8 inches on center at walls and 5d nails at 5 to 7 inches on center at ceilings.
Per the table, nails are 13.5 ga. 1 -5/V long, 15/64" flat head, diamond pointed nail
The gypsum board wall sheathing is typically nailed at 7 inches on center over the height of each stud. It is most likely that the gypsum sheets would not have been edge-nailed at this spacing to the top or bottom plates. The spacing at top and bottom plates would likely have been 16 inches on center as part of the vertical line of fasteners at each stud.

Gypsum board ceiling sheathing: ½-in sheathing. 1964 UBC, table 47-J, specifies 5d nails at 5 to 7 inches on center to ceiling joist supports. The perimeter edges parallel to the joists would have been nailed in order to provide proper vertical support. The edges perpendicular to the ceiling joists would not have been nailed.

STUCCO

UBC Tables 47G & I specify 18 ga. woven wire lath, furred out from backing 1/4", nailed with galvanized nails spaced 6" O.C. maximum vertically and 16" O.C. horizontally.

FASTENING

Anchor bolts: 1/2 inch diameter, 7" embedment, at 6-0" maximum on center.
Framing nailing was done with box or common nails. The following is the schedule of minimum fastening from the 1964 UBC:
Joist to sill or girder: toe nail 2-16d
Bridging to joist: toe nail each end 2-8d
1x6 subfloor to joist: face nail 2-8d
2 inch subfloor to joist or girder: 2-16d
Plate to joist or blocking: face nail 16d @ 16”
Stud to top plate: end nail 2-16d

Stud to plate: toe nail 3-16d or 4-8d
Top plates: spike together 16d @ 24"
Top plates: laps and intersections face nail 2-16d
Ceiling joists - to plate: toe nail 2-16d
Ceiling joists - laps over partitions: 3-16d
Ceiling Joists to parallel alternate rafters: 3-1 6d
Rafter to plate: 3-16d
2-inch cut-in bracing to stud: 2-16d
1 inch sheathing to bearing: 2-8d
Corner studs and angles (built up corners) 16d @ 30"

REFERENCES

a. Uniform Building Code, 1964 Edition
b. ASTM F-I 667-95 Standard Specification for Driven Fasteners: Nails, Spikes, Staples

A.5 INDEX BUILDING 5

This building is identical to index building 4, except that the cripple walls are braced with new structural sheathing, as shown in Figure A-43 and Figure A-44.

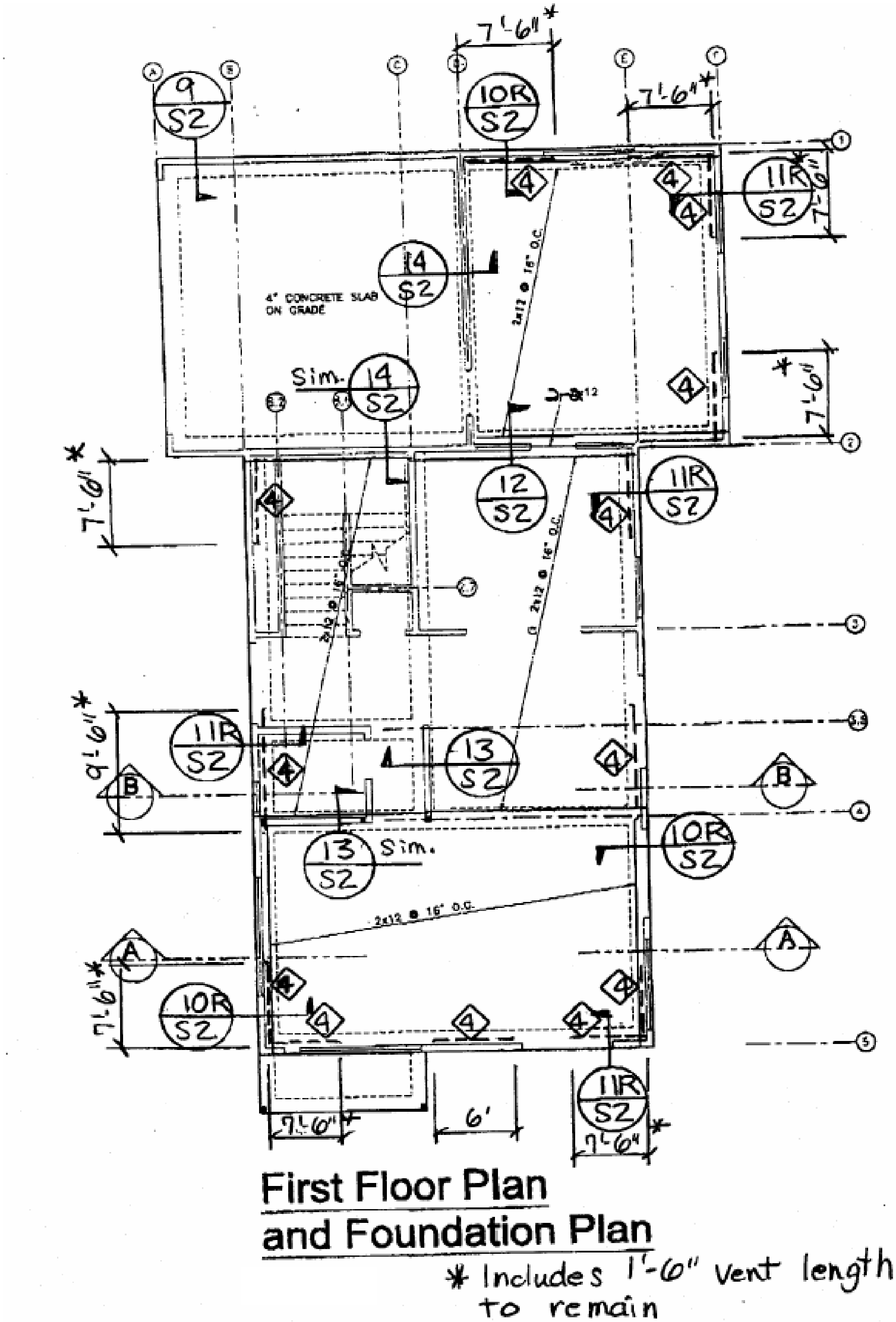


Figure A-41. Index building 5 first floor and foundation plan

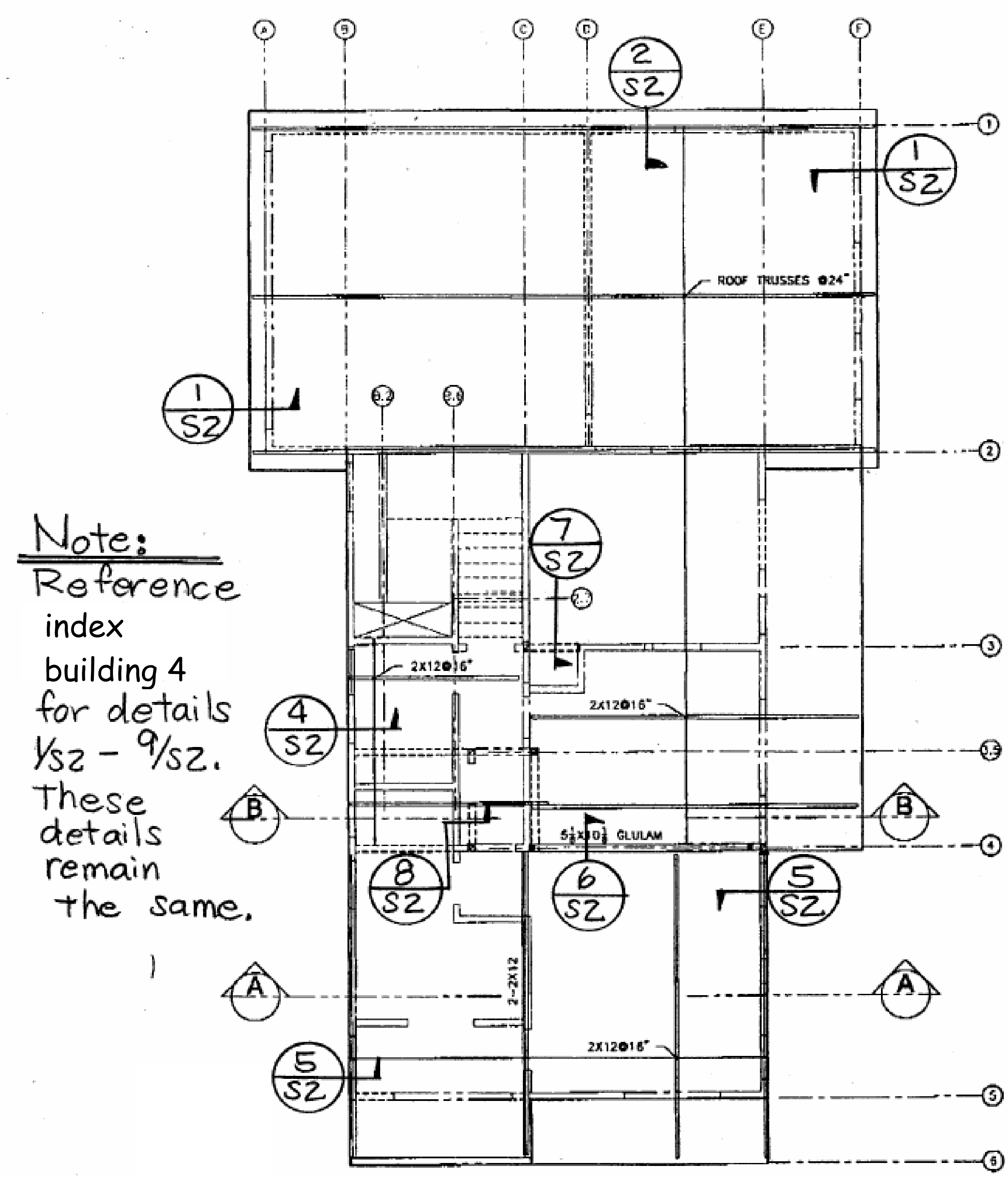


Figure A-42. Index building 5 second-floor framing plan and roof plan

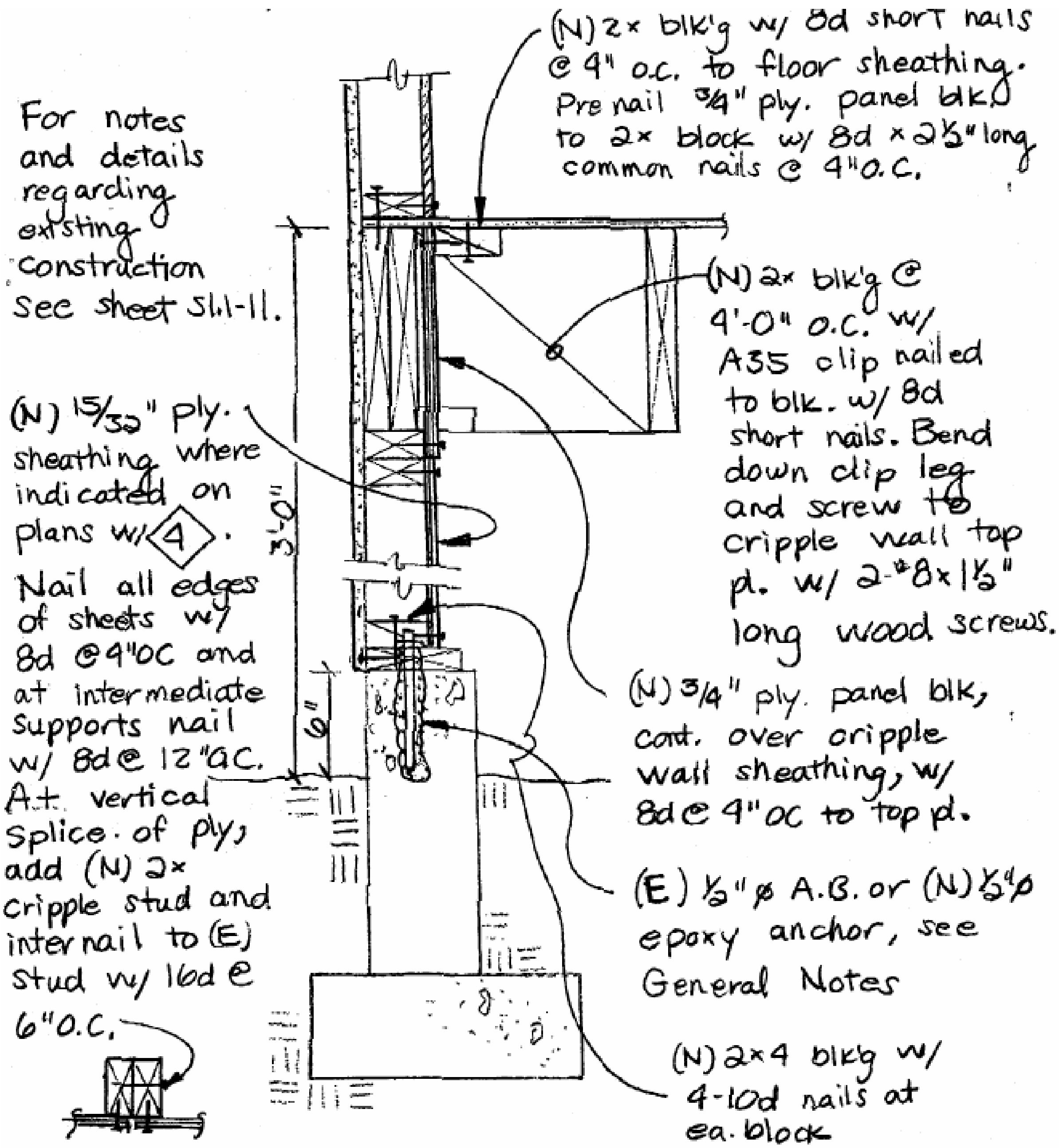


Figure A-43. Index building 5 exterior cripple wall joists parallel (detail 10R-S2)

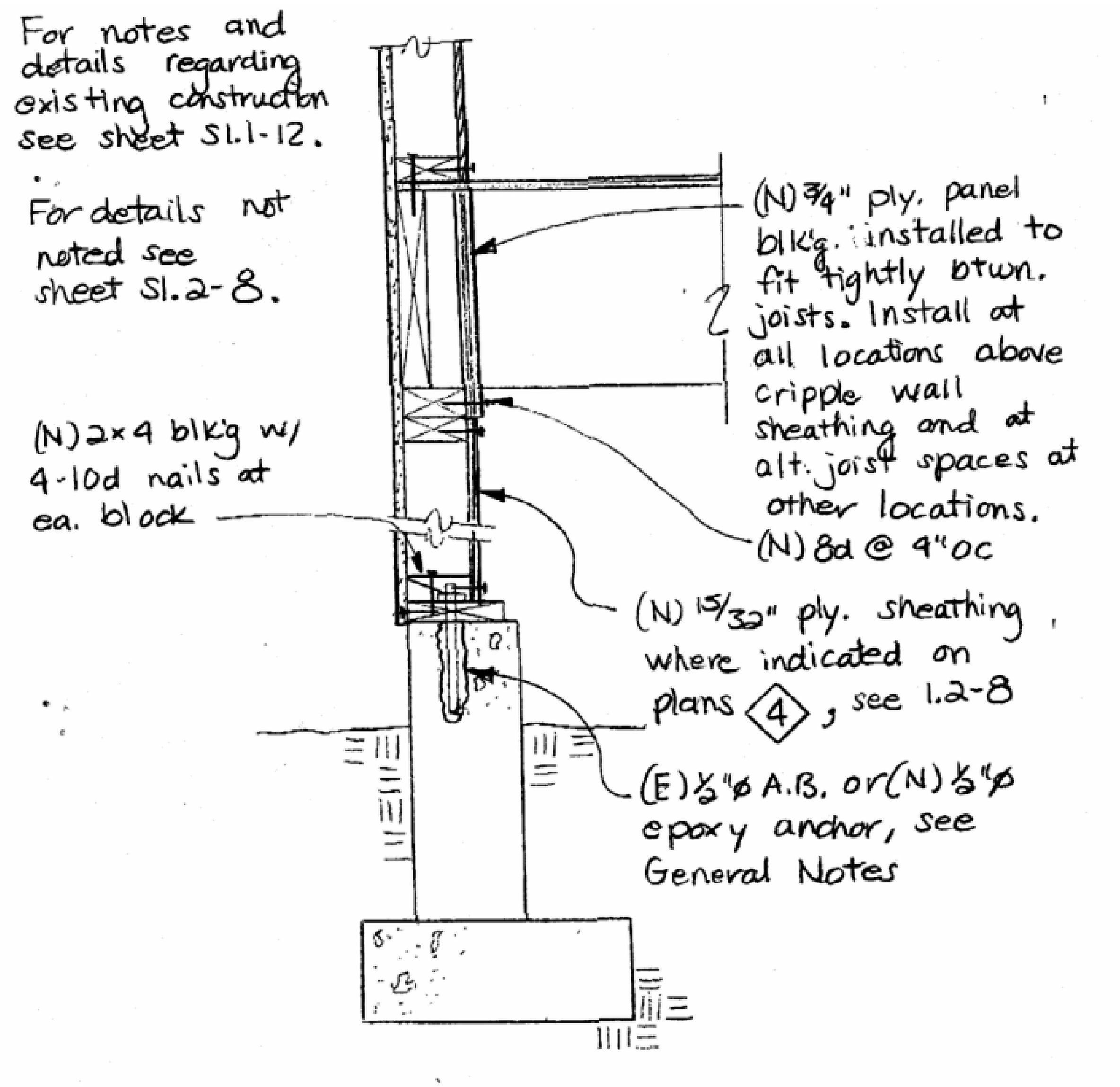


Figure A-44. Index building 5 exterior cripple wall joists perpendicular (detail 11R-S2)

General notes for index building 5. The seismic upgrade of the cripple walls follows the Guidelines for the Seismic Retrofit of Existing Buildings, Chapter 3, Prescriptive Provisions for Seismic Strengthening of cripple Walls and Sill Plate Anchorage of Light, Wood-Frame Residential Buildings. Notes on the plans and details reference existing construction unless otherwise noted as new (N). Cripple walls are 15/32 inch plywood nailed with 8d common nails spaced at 4"o.c. at all edges and 12"o.c. at each intermediate support with not less than two nails at each stud. Blocking panels: ¾-inch plywood nailed with 8d common nails per the details

A.6 INDEX BUILDING 6

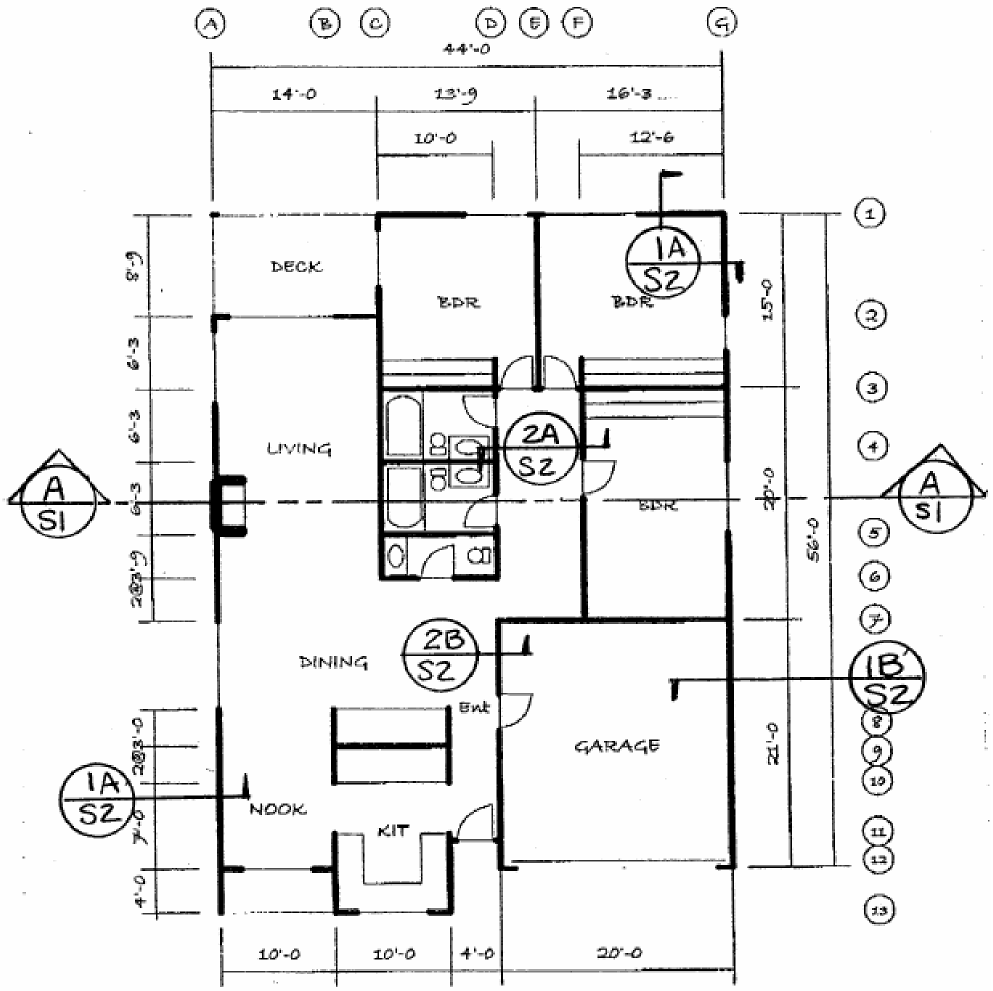


Figure A-45. Index building 6 floor plan (detail 1-S1)

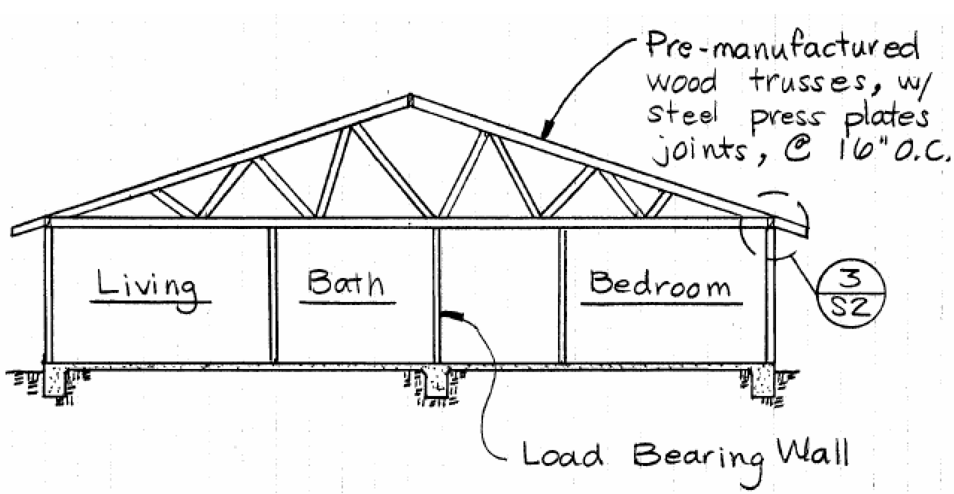


Figure A-46. Index building 6 section A-A (detail A-S1)

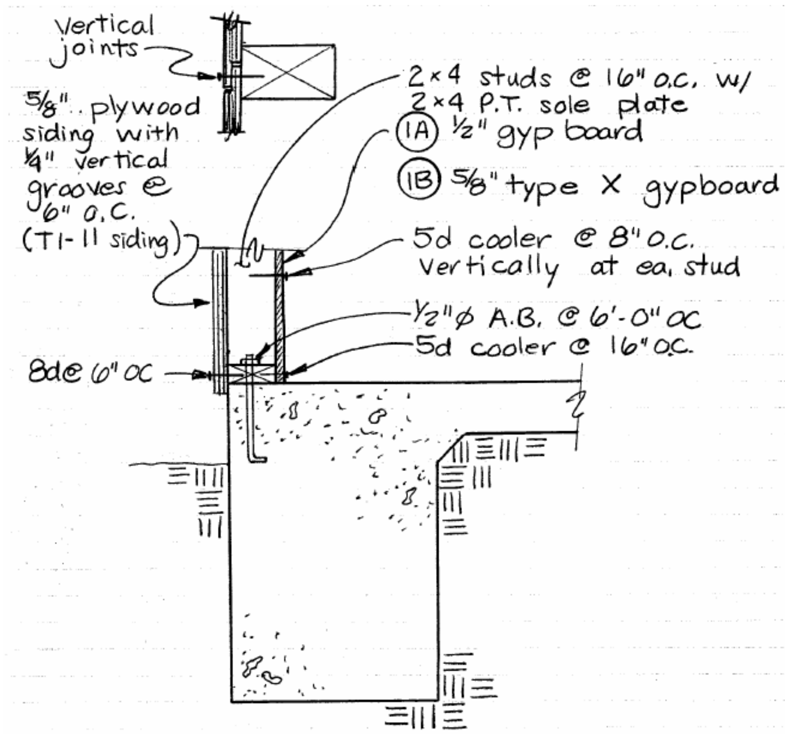


Figure A-47. Index building 6 exterior wall section (detail 1-S2)

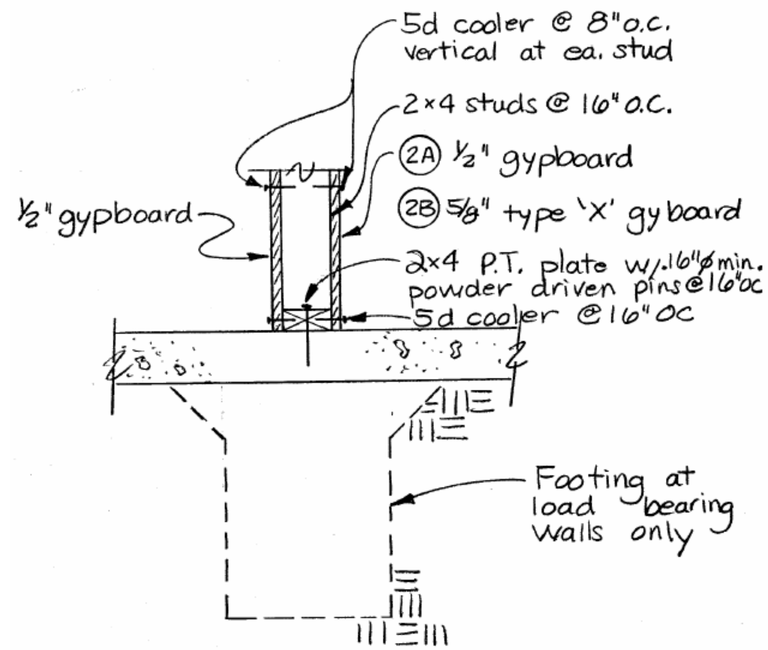


Figure A-48. Index building 6 interior footing section (detail 2-S2)

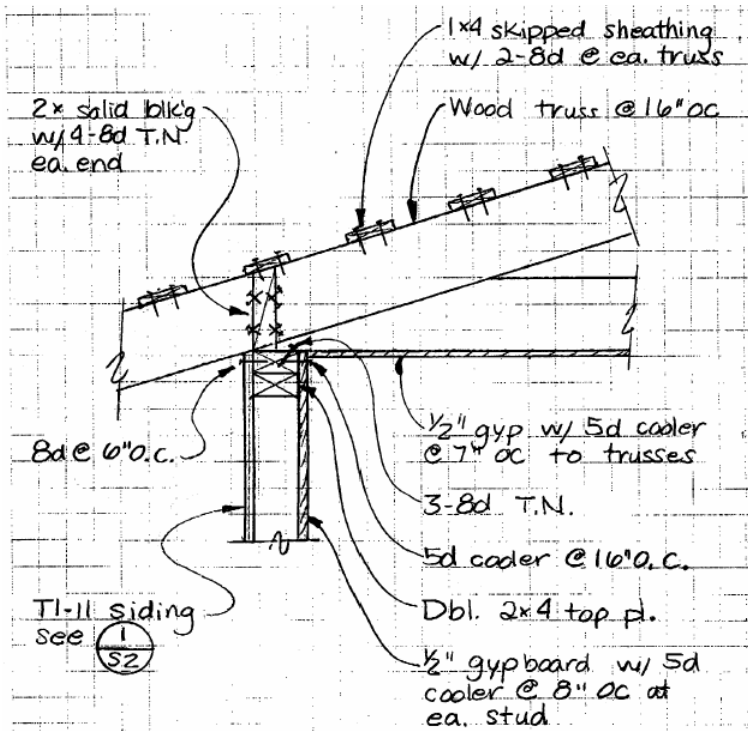


Figure A-49. Index building 6 top of exterior wall (detail 3-S2)

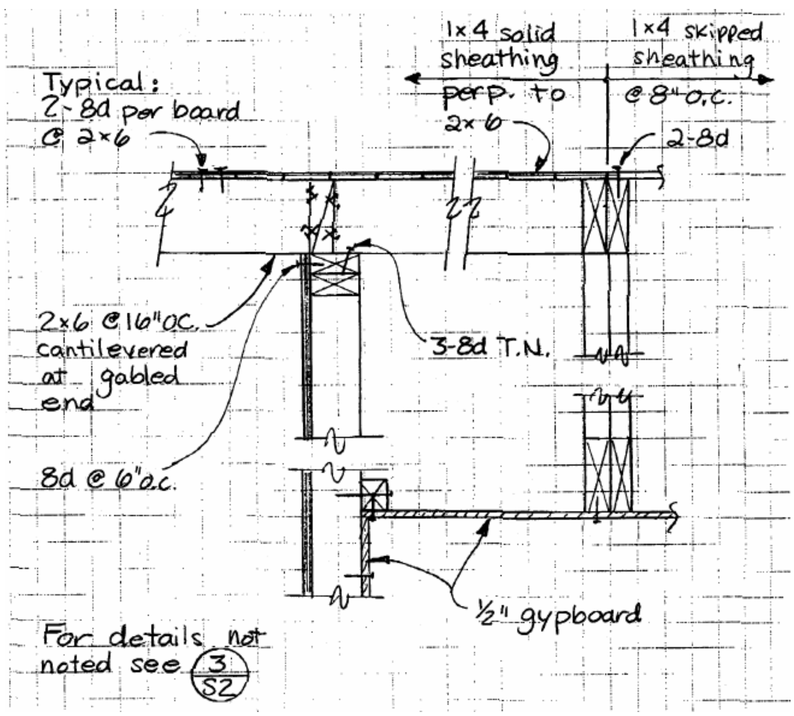


Figure A-50. Index building 6 top of wall at gabled end (detail 4-S2)

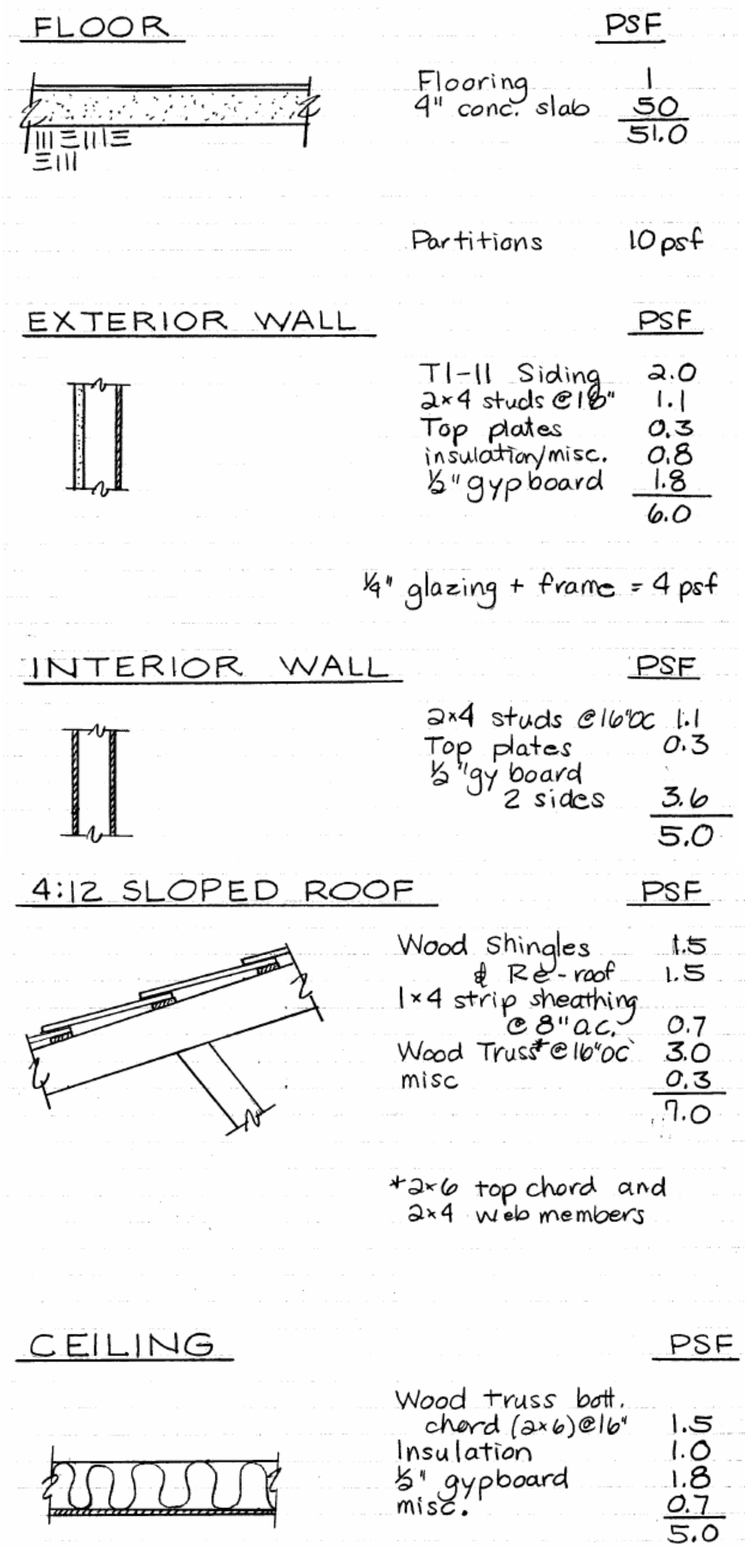


Figure A-51. Index building 6 wall, floor, roof, and ceiling sections

General notes for index building 6.

SPECIES

Typical species for framing - Douglas-fir
Foundation sill plates - pressure treated Douglas-Fir
Roof trusses - could vary - assume Southern Pine

SHEATHING

Roof sheathing: 1x4 skipped sheathing at 8 in. on center
2-8d common at supports
8d common dimensions - ASTM F1667:
Flat head, diamond point, L-2.5”, D-.131”
Wall sheathing: 5/8” plywood siding with l/q)l vertical grooves at 6”o.c. (T1-11 siding)
Gypsum wallboard sheathing: 1/2” sheathing

1973 UBC, table 47-G, specifies 5d cooler nail at 8 inches on center at walls and 5d cooler nails at 7 inches on center at ceilings. Per the table, nails are 13 ga. 1 -3/8” long,l9/64” flat head, with annular rings.

The gypsum board wall sheathing is typically nailed at 8 inches on center over the height of each stud. It is most likely that the gypsum sheets would not have been edge-nailed at this spacing to the top or bottom plates. The spacing at top and bottom plates would likely have been 16 inches on center as part of the vertical line of fasteners at each stud. The 4’x8’ or 4’x10’ gypboard panels are typically installed with their length in the vertical direction. For walls taller than 10’, the horizontal panel joint is unblocked.

Gypsum board ceiling sheathing: ½-in sheathing.

1973 UBC, table 47-G, specifies 5d cooler nails at 7 inches on center to ceiling joist supports. The perimeter edges parallel to the joists would have been nailed in order to provide proper vertical support. The edges perpendicular to the ceiling joists would not have been nailed.

FASTENING

Anchor bolts: ½-inch diameter, 7" embedment, at 6'-0" maximum on center.
Framing nailing was done with box or common nails. The following is the schedule of minimum fastening from the 1973 UBC:
Joist to sill or girder: toe nail 3-8d
Bridging to joist: toe nail each end 2-8d
1x6 subfloor to joist: face nail 2-8d
2 inch subfloor to joist or girder: blind and face nail 2-16d
Sole plate to joist or blocking: face nail 16d @ 16"
Stud to top plate: end nail 2-16d
Stud to sole plate: toe nail 4-8d
Doubled top plates: face nail 16d @ 24"
Top plates: laps and intersections face nail 2-16d
Ceiling joists - to plate: toe nail 3-8d
Ceiling joists - laps over partitions: face nail 3-16d
Ceiling Joists to parallel rafters: face nail 3-16d
Rafter to plate: toe nail 3-8d
1-inch brace to each stud and plate: face nail 2-8d

B. INDEX BUILDING STRUCTURAL MODELS

This appendix presents analytical details required to create the structural models. The CEA has explicitly asked for a brief report. Therefore, for brevity, full details of the structural models are omitted here: otherwise, diagrams showing node and element numbering and geometry, and CASHEW and Ruaumoko input and output files, would probably run to hundreds of pages. Instead, this appendix includes only a few details necessary to model the force-deformation characteristics of shearwall elements not previously documented, and consideration of drifts associated with cripple-wall collapse.

B.1 VARIOUS SHEARWALL TYPES

Where applicable, hysteresis parameters employed by Isoda et al. (2001) are used as mean values, with the modification that strengths are treated as uncertain, with coefficient of variation equal to 0.36, per Porter et al. (2002a). Two shearwall types are new to this study: the plywood shearwalls (8-ft and 10-ft height) on index building 3, and the T1-11 plywood sheathing on index building 6. Furthermore, the CEA recently sponsored research of walls with stucco exterior finish and gypsum wallboard interior finish, and it was desirable to compare these with prior test data.

An important source for prior test data is Pardoen et al. (2000), who report on a series of cyclic racking tests of a variety of woodframe wall specimens. The testing regimen includes 35 groups of three identical specimens each. Each specimen is an 8-ft x 8-ft (2.44m x 2.44m) wall subjected to the test protocol recommended by Shepherd (1996) for the Structural Engineers Association of Southern California (SEAOSC). Two sets of three specimens were tested, producing the mean and standard-deviation (μ and σ) values of initial stiffness (K), Ramberg-Osgood bi-linear factor (r), yield strength (F_y), and ultimate strength (F_u) shown in Table B-1. Units of stiffness are lb/in; units of strength are lb; r is unitless.

B.2 STUCCO EXTERIOR WALLS

Several of the index buildings examined in the present are sheathed with a 7/8-in stucco exterior finish. Stucco on woodframe construction is a relatively rigid material that acts as a structural element, that is, it contributes substantially to the lateral strength and stiffness of a woodframe house during an earthquake. In a study such as the present one, where structural analyses are performed as part of the loss-estimation process, it is therefore necessary to include the stucco in the mathematical model of the force and deformation behavior of the house, and therefore to understand its mechanical characteristics, i.e., how it deforms when subjected to lateral forces, and how it becomes damaged when subjected to those forces.

Three studies provide useful laboratory data on the mechanical characteristics of stucco-wall test specimens. First consider Pardoen et al. (2000). Recalling that the specimens were 8 ft in length, these results indicate that 7/8-in stucco sheathing with 1-in crown staples at 6-in centers provides approximately 108 lb/lf and 320 lb/lf of yield and ultimate strength, respectively, under the boundary conditions in these tests. In the stucco-sheathed walls, F_y was reached at 0.06-in (0.06%) drift; F_u at 0.6-in (0.6%) drift. Initial stiffness was 3400 lb/in/lf and the Ramberg-Osgood factor was 0.125.

Table B-1. Mechanical properties of 8-lf segments of woodframe walls (after Pardoen et al., 2000)

Sheathing	**Connectors**	**Application**	μ_K	σ_K	μ_r	σ_r	μ_{Fy}	σ_{Fy}	μ_{Fu}	σ_{Fu}
7/8 Stucco	1" crown staples	one side	27302	5480	0.125	0.027	863	206	2558	73
7/8 Stucco	Furring nail 3/8 head	one side	20069	7817	0.162	0.043	1342	349	2947	153
1/2 GWB	1-7/8" drywall nails	both sides	23004	3499	0.211	0.065	1885	130	3104	248
15/32 OSB/STR I	10d hand driven common	one side	22040	4171	0.151	0.038	5778	2940	9271	4427
15/32 STR I	#8 bugle head screws	one side	19122	3442	0.274	0.077	4553	2660	10691	3590
15/32 STR I	10d hand driven common	both sides	27270	4135	0.278	0.038	8403	1768	16075	2045
15/32 STR I	10d hand driven common	one side	15148	3074	0.238	0.134	5553	1996	9699	2171
15/32 STR I	8d hand driven common	one side	14240	1226	0.229	0.023	4840	654	7672	348
3/8 STR I	8d hand driven common	one side	16633	5559	0.199	0.040	5461	2066	8572	2501
5/8 GWB	1-7/8" drywall nails	both sides	29599	9250	0.203	0.044	2945	646	5554	408
7/16 OSB/RS	#8 bugle head screws	one side	22915	7055	0.205	0.032	3268	1060	10123	4467
7/16 OSB/RS	8d hand driven common	one side	19367	1742	0.138	0.016	4002	692	6082	647

μ: mean value
σ: standard deviation
K: initial stiffness (lb/in)
F_y: yield strength (lb)
F_u: ultimate strength (lb)
r: Ramberg-Osgood bi-linear factor

Chai et al. (2002) report on lateral tests of 2-ft and 4-ft level and stepped cripple walls 12 ft in length, structurally sheathed with 15/32-in OSB. Tests were performed with and without stucco exterior finish on the opposite face of the studs from the OSB. Stucco lath was connected with 3/8-in staples at 6-in centers. Specimens were subjected to cyclic loading protocols suggested by Krawinkler et al. (2001). Two relevant tests have superimposed vertical in-plane loading of 450 lb/lf, meant to simulate the bearing of a 2-story structure above the cripple wall.

Among the test results were the finding that the ultimate strength of the 2-ft x 12-ft specimen without stucco finish was approximately 10.1 kip (0.84 kip/lf) at 1.0 in displacement (4.2% drift). With stucco, ultimate strength was 14.4 kip (1.20 kip/lf) at 1.0 in displacement (4.2% drift), suggesting that stucco adds approximately 360 lb/lf of ultimate strength without significant change in ultimate displacement, consistent with the Pardoen et al. (2000) tests on a per-lf basis. Chai et al. (2002) also found a yield strength of 236 lb/lf (which Isoda et al., 2001, used). These values are used in the present study, with the exception that, as in Porter et al. (2002a), mean strengths under actual constructed conditions are assumed to be 20% less than under laboratory conditions, with a coefficient of variation of 0.36. Per the Chai et al. (2002) tests, initial stiffness attributable to the stucco is taken as 7.0 kip/in for a 12-lf segment, and scaled accordingly with length. Other hysteresis parameters are taken from Isoda et al. (2001).

Note that tests under the near-fault loading protocol recommended by Krawinker et al. (2001) produced similar results. The authors estimate an average increase in stiffness of 7 to 9 kip/in associated with adding stucco to a 12-lf segment of a 2-ft level level cripple wall (approximately 290 to 375 lb/in/sf of wall), or ¼ of the absolute stiffness associated with Pardoen et al.'s (2000) 8-ft-high specimens connected with 1-in crown staples, but roughly equal to on a per-square-foot basis. They attribute the addition of strength and stiffness to deformation of the staples.

Very recently, Arnold et al. (2003) completed an investigation of the force-deformation-damage behavior of woodframe shearwalls with 7/8-in stucco exterior finish and ½-in gypsum wallboard interior finish. Boundary conditions were consistent with the first-story of a two-story house, in particular, 450 lb/lf vertical in-plane loading, just as in the Chai et al. (2002) tests. Two pairs of specimens were tested; of interest here are specimens 1 and 2. Both specimens were 16 ft long, with different configurations of window and door openings: specimen 1 had two 4-ft x 3-ft windows; specimen 2 had one 4-ft x 3-ft window and one 2-ft, 8-in x 6-ft, 8-in door, the door located 2 ft from one end of the specimen. The Krawinkler et al. (2001) cyclic loading protocol was applied. The authors delineate response in four regimes.

(1) Up to 0.2% drift, response was nearly linear, force reached approximately 50% of ultimate, 0.05 in to 0.1 in of residual drift was observed, stucco cracks 1 ft to 2 ft long and short (a few inches) wallboard cracks appeared at window and door openings.

(2) At 0.4% drift, force reached 65% to 70% of ultimate, residual drift was 0.1 to 0.2 in, stucco cracks spanned approximately the height and width of specimens, wallboard cracks were still short, and finishes broke over 10 to 20 nail heads per 16-ft specimen.

(3) At 0.7% drift, force reached 90% of ultimate, residual drift reached 0.3% to 0.4%, stucco began to spall and to detach from the framing, gypsum wallboard core was crushed, and finishes broke over 30 to 40 nail heads per 16-ft specimen. The authors consider all damage up to and including this point as repairable.

(4) At ultimate, force was 30.1 kip for specimen 1 and 25.4 kip for specimen 2, both at approximately 1% drift. The authors consider failure as the point at which force drops below 80% of ultimate, which occurred at 1.7% to 2.0% drift. The authors consider damage to be non-repairable, but do not state whether the transition from repairable to non-repairable damage can be said to occur at closer to ultimate or failure. From the observation that stucco began to detach at 0.7% drift—which a contractor could detect by knocking on the wall and hearing a hollow sound—it seems likely that the transition is better assigned to the lower level of drift. At failure, corner studs twisted and stucco spalling extended approximately 1 ft or more along cracks at window and door corners.

Since Arnold et al. (2003) did not test specimens with stucco or gypsum alone, one cannot draw conclusions from these tests about the relative contribution to strength or stiffness from the stucco and gypsum wallboard. However, if one treats specimen 1 as a single perforated shearwall, the strength per linear foot of wall would be 1.88 kip/lf. If one treats specimen 2 as two piers: one 11.33 ft long, the other 2 ft long, and neglects the spandrel-like element above the door lintel, then its strength per linear foot is 1.90 kip/lf, essentially the same as specimen 1, which suggests a strategy for dealing with window and door openings when creating a structural model of stucco- or gypsum-wallboard-sheathed shearwalls.

Note that specimens 1 and 2 of the Arnold et al. (2003) tests of 8-ft-high walls achieved ultimate strength at 1-in drift, somewhat greater than the 0.6-in drift associated with ultimate in the 8-ft-high stucco-wall tests of Pardoen et al. (2000), and the same as 1-in drift at ultimate in the 2-ft walls testbed by Chai et al. (2001). These observations suggest that drift rather than drift angle is more closely associated with achieving ultimate strength in a stucco-finished wall. This is consistent with an assumption that the stucco behaves as a rigid body, that the principle deformation occurs in the connectors, and that the connectors tolerate up to 1 in of displacement of the wall's top edge relative to the bottom.

Because of the difference in connectors between the studies, and the fact that none of the studies tested stucco-finished cripple walls without structural sheathing, it is difficult to relate the behavior of 8-ft-high stucco walls with 2-ft-high stucco cripple walls.

B.3 SHEARWALLS SHEATHED WITH T1-11 SIDING

Texture 1-11 siding (usually referred to as T1-11) is a plywood product made in sheets 4 ft wide and 8, 9, and 10-ft long. As specified by APA (1999), T1-11 panels are nominally at least 19/32-in thick with grooves 3/8-in wide and ¼-in deep. Vertical edges have shiplap joints, which can cause strength problems. As SEAOC (2003 draft) has noted about T1-11 siding, "At the edges where two adjacent panels adjoin, each panel must be nailed to the wall stud with a separate row of nails…. A common, improper construction practices providing only one row of nails through both sheets (at the overlap). This creates a weakness as the plywood thickness is only one-half of its normal thickness at the overlap, and only half the number of nails is provided. Such practice led to failures in the 1984 Morgan Hill (California) Earthquake." The laps are ½-in wide, resulting in nail edge distances of ¼-in or less.

No laboratory test data on the force-deformation behavior of woodframe shearwalls sheathed with T1-11 siding were available, but one can estimate the force-deformation behavior of a shearwall analytically. As part of the CUREE-Caltech Woodframe Project, Folz and Filiatrault (2001) developed the CASHEW software (Cyclic Analysis of SHEarWalls) for modeling the force-deformation behavior of woodframe shearwalls. This finite-element software treats a woodframe shearwall as a collection of linear framing elements (studs and plates), rectangular shear panels (plywood or OSB sheets), and point connectors (nails, screws, etc.). Framing elements are treated as rigid elements. Shear panels are assumed to deform elastically. Connectors are treated as deforming nonlinearly.

Mechanical properties of 8d nails connectors are taken from Fonseca et al. (2002). That study does not include tests with the small edge distance of T1-11 nailed in the lap. Test 47 reflects 8d common nails in 3/8-in OSB nailed to DF-L with 3/8-in edge distance and shear perpendicular to the grain. To account for the smaller edge distance, all of test 47's parameters were scaled by the ratio of parameters from two similar tests, one with 3/8-in and one with ¼-in edge distance, respectively. These two latter tests were with 7/16-in OSB, DF-L, 8d cooler nails, and shear perpendicular to the grain. The results are shown in Table B-2.

Table B-2. Connector properties for T1-11 siding

	Unscaled	Scaled	Units
a	0.6000	0.6000	
b	1.1000	1.1000	
F_0	0.1506	0.1040	kip
F_I	0.0612	0.0397	kip
D_u	0.2076	0.1035	in
K_0	3.6695	2.9593	kip/in
r_1	0.0578	0.2061	
r_2	-0.0842	-0.3551	
r_3	1.9690	2.0653	
r_4	0.0791	0.2331	

These parameters are used in a CASHEW analysis of the T1-11 shearwall, with 19/32-in 4-ft x 8-ft sheathing, 8d nails at 6-in edge and panel, and 360 ksi elastic shear modulus of the sheathing. The shearwall spring is modeled with Stewart's (1987) degrading-stiffness hysteresis model (with pinching). Results are shown in Table B-3. Per Porter et al. (2002a), initial fracture of sheathing-to-framing connections (requiring re-nailing and putty) is assumed to occur when force reaches ultimate; irreparable damage (requiring replacement of the sheathing panel) occurs when force drops to 80% of ultimate.

B.4 PLYWOOD SHEARWALLS FROM INDEX BUILDING 3

CASHEW was used to model the behavior of these shearwalls. Connector properties were taken from tests by Fonseca et al. (2002) of 19/32 OSB nailed to DF-L with 8d common nails and 3/8-in edge distance and 7.8-in spacing at the edge and in the panel zone (this was the mean value actually measured in the field, although nominal might have been 8 or 9 in.). Results are shown in Table B-3.

Table B-3. Shearwall properties for T1-11 siding on IB6 and plywood sheathing in IB3

Parameter	**T1-11**	**IB3 10-ft wall**	**IB3 8-ft wall**	**Units**
F_I	0.076	0.0909	0.109	kip/lf
F_Y	0.355	0.2628	0.311	kip/lf
F_U	0.363	0.3537	0.414	kip/lf
K	1.185	1.2093	1.670	kip/in/lf
R_F	0.209	0.1100	0.111	
P_{TRI}	-0.895	0.2063	-0.222	
P_{UNL}	1.687	2.1480	2.176	
α	-0.694	1.1340	1.320	
β	0.809	1.1280	1.199	

C. CONSTRUCTION COSTS

This appendix contains professional construction costs estimates of the six index buildings, using construction costs in Santa Monica, CA, using nonunion labor. (Since all repair costs are normalized by construction cost, the seismic vulnerability functions and thus the EAL results are not sensitive to the precise location of construction.) It also includes repair-cost estimates for assembly types and damage states not already documented in Porter et al. (2002a). These cost estimates were prepared by Tom Boyd of Ray Young Associates.

Table C-1. Construction cost, index building 1

DIVISION	DESCRIPTION	DIVISION SUBTOTAL	DIVISION TOTAL
1	**GENERAL CONDITIONS**		**29,744**
	Personnel	14,400	
	Small Tools	500	
	Temporary Facilities	1,688	
	Temporary Utilities	2,900	
	Clean - Up	5,256	
	Dumpsters	2,400	
	Testing & Inspections	2,600	
2	**SITEWORK**		**7,050**
	Grading	7,050	
3	**CONCRETE**		**4,930**
	Foundations	4,130	
	Pad Footings	800	
4	**MASONRY**		**0**
	None Required	0	
5	**METALS**		**0**
	None Required	0	
6	**CARPENTRY**		**24,750**
	Rough Carpentry	18,492	
	Finish Carpentry	1,464	
	Cabinetry	4,795	
7	**MOISTURE PROTECTION**		**1,885**
	Insulation	552	
	Roofing	1,333	
8	**DOORS, WINDOWS, & GLASS**		**9,158**
	Wood Doors and Frames	2,325	
	Sliding Glass Door	736	
	Finish Hardware	612	
	Windows	5,486	
9	**FINISHES**		**19,947**
	Lath & Plaster	3,543	
	Drywall	4,511	
	Ceramic Tile	2,341	
	Carpeting	2,965	
	Vinyl Flooring	466	
	Painting	6,121	
10	**SPECIALTIES**		**196**
	Toilet Accessories	196	
11	**EQUIPMENT**		**1,196**
	Appliances	1,196	
12	**FURNISHINGS**		**0**
	None Required	0	
13	**SPECIAL CONSTRUCTION**		**0**
	None Required	0	
14	**CONVEYING SYSTEMS**		**0**
	None Required	0	
15	**MECHANICAL**		**7,240**
	Plumbing	6,112	
	HVAC	1,128	
16	**ELECTRICAL**		**4,640**
	Electrical Devices	4,640	
	SUBTOTAL	110,735	**110,735**
	Contractors overhead, profit, taxes, etc.		**16,610**
	TOTAL CONSTRUCTION		**127,345**
	Allowances:		
1	**Building Permit (0.75%)**		**955**
	TOTAL		**128,300**

Table C-2. Construction cost, index building 2

DIVISION	DESCRIPTION	DIVISION SUBTOTAL	DIVISION TOTAL
1	**GENERAL CONDITIONS**		**29,744**
	Personnel	14,400	
	Small Tools	500	
	Temporary Facilities	1,688	
	Temporary Utilities	2,900	
	Clean - Up	5,256	
	Dumpsters	2,400	
	Testing & Inspections	2,600	
2	**SITEWORK**		**7,050**
	Grading	7,050	
3	**CONCRETE**		**4,930**
	Foundations	4,130	
	Pad Footings	800	
4	**MASONRY**		**0**
	None Required	0	
5	**METALS**		**0**
	None Required	0	
6	**CARPENTRY**		**25,644**
	Rough Carpentry	19,386	
	Finish Carpentry	1,464	
	Cabinetry	4,795	
7	**MOISTURE PROTECTION**		**1,885**
	Insulation	552	
	Roofing	1,333	
8	**DOORS, WINDOWS, & GLASS**		**9,158**
	Wood Doors and Frames	2,325	
	Sliding Glass Door	736	
	Finish Hardware	612	
	Windows	5,486	
9	**FINISHES**		**19,947**
	Lath & Plaster	3,543	
	Drywall	4,511	
	Ceramic Tile	2,341	
	Carpeting	2,965	
	Vinyl Flooring	466	
	Painting	6,121	
10	**SPECIALTIES**		**196**
	Toilet Accessories	196	
11	**EQUIPMENT**		**1,196**
	Appliances	1,196	
12	**FURNISHINGS**		**0**
	None Required	0	
13	**SPECIAL CONSTRUCTION**		**0**
	None Required	0	
14	**CONVEYING SYSTEMS**		**0**
	None Required	0	
15	**MECHANICAL**		**7,240**
	Plumbing	6,112	
	HVAC	1,128	
16	**ELECTRICAL**		**4,640**
	Electrical Devices	4,640	
	SUBTOTAL	111,629	**111,629**
	Contractors overhead, profit, taxes, etc.		**16,744**
	TOTAL CONSTRUCTION		**128,373**
	Allowances:		
1	**Building Permit (0.75%)**		**963**
	TOTAL		**129,336**

Table C-3. Construction cost, index building 3

DIVISION	DESCRIPTION	DIVISION SUBTOTAL	DIVISION TOTAL
1	**GENERAL CONDITIONS**		**29,824**
	Personnel	14,400	
	Small Tools	500	
	Temporary Facilities	1,688	
	Temporary Utilities	2,900	
	Clean - Up	5,336	
	Dumpsters	2,400	
	Testing & Inspections	2,600	
2	**SITEWORK**		**7,660**
	Grading	7,660	
3	**CONCRETE**		**10,661**
	Foundations	3,875	
	Slab on Grade	6,786	
4	**MASONRY**		**3,844**
	CMU	3,844	
5	**METALS**		**0**
	None Required	0	
6	**CARPENTRY**		**39,939**
	Rough Carpentry	29,685	
	Finish Carpentry	6,356	
	Cabinetry	3,898	
7	**MOISTURE PROTECTION**		**4,788**
	Insulation	809	
	Roofing	3,979	
8	**DOORS, WINDOWS, & GLASS**		**11,878**
	Wood Doors and Frames	4,121	
	Garage Doors	940	
	Finish Hardware	1,253	
	Windows	5,564	
9	**FINISHES**		**28,731**
	Siding	5,820	
	Drywall	5,286	
	Ceramic Tile	3,061	
	Carpeting	3,970	
	Vinyl Flooring	536	
	Painting	7,021	
	Wallcovering	3,039	
10	**SPECIALTIES**		**571**
	Toilet Accessories	571	
11	**EQUIPMENT**		**1,845**
	Appliances	1,845	
12	**FURNISHINGS**		**0**
	None Required	0	
13	**SPECIAL CONSTRUCTION**		**0**
	None Required	0	
14	**CONVEYING SYSTEMS**		**0**
	None Required	0	
15	**MECHANICAL**		**10,459**
	Plumbing	8,203	
	HVAC	2,256	
16	**ELECTRICAL**		**6,525**
	Electrical Devices	6,525	
	SUBTOTAL	156,725	**156,725**
	Contractors overhead, profit, taxes, etc.		**23,509**
	TOTAL CONSTRUCTION		**180,233**
	Allowances:		
1	**Building Permit (0.75%)**		**1,352**
	TOTAL		**181,585**

Table C-4. Construction cost, index building 4

DIVISION	DESCRIPTION	DIVISION SUBTOTAL	DIVISION TOTAL
1	**GENERAL CONDITIONS**		**41,981**
	Personnel	20,800	
	Small Tools	600	
	Temporary Facilities	2,438	
	Temporary Utilities	3,900	
	Clean - Up	7,643	
	Debris Removal	4,000	
	Testing & Inspections	2,600	
2	**SITEWORK**		**8,500**
	Grading	8,500	
3	**CONCRETE**		**7,946**
	Foundations	6,646	
	Slab on Grade	1,300	
6	**CARPENTRY**		**68,319**
	Rough Carpentry	56,268	
	Finish Carpentry	2,308	
	Cabinetry	9,743	
7	**MOISTURE PROTECTION**		**8,305**
	Insulation	2,573	
	Roofing	5,732	
8	**DOORS, WINDOWS, & GLASS**		**11,799**
	Wood Doors and Frames	2,845	
	Sliding Glass Door	4,410	
	Garage Door	727	
	Finish Hardware	938	
	Windows	2,879	
9	**FINISHES**		**39,314**
	Lath & Plaster	8,258	
	Drywall	8,724	
	Hardwood Flooring	882	
	Ceramic Tile	7,925	
	Carpeting	4,932	
	Painting	8,593	
10	**SPECIALTIES**		**542**
	Toilet Accessories	542	
11	**EQUIPMENT**		**1,995**
	Appliances	1,995	
12	**FURNISHINGS**		**0**
	None Required	0	
13	**SPECIAL CONSTRUCTION**		**0**
	None Required	0	
14	**CONVEYING SYSTEMS**		**0**
	None Required	0	
15	**MECHANICAL**		**14,582**
	Plumbing	10,387	
	HVAC	4,195	
16	**ELECTRICAL**		**5,625**
	Electrical Devices	5,625	
	SUBTOTAL	208,907	**208,907**
	Permits		**1,802**
	Contractors overhead, profit, taxes, etc.		**31,336**
	TOTAL CONSTRUCTION		**242,044**

Table C-5. Construction cost, index building 5

DIVISION	DESCRIPTION	DIVISION SUBTOTAL	DIVISION TOTAL
1	**GENERAL CONDITIONS**		**41,981**
	Personnel	20,800	
	Small Tools	600	
	Temporary Facilities	2,438	
	Temporary Utilities	3,900	
	Clean - Up	7,643	
	Debris Removal	4,000	
	Testing & Inspections	2,600	
2	**SITEWORK**		**8,500**
	Grading	8,500	
3	**CONCRETE**		**7,946**
	Foundations	6,646	
	Slab on Grade	1,300	
6	**CARPENTRY**		**70,568**
	Rough Carpentry	58,518	
	Finish Carpentry	2,308	
	Cabinetry	9,743	
7	**MOISTURE PROTECTION**		**8,305**
	Insulation	2,573	
	Roofing	5,732	
8	**DOORS, WINDOWS, & GLASS**		**11,799**
	Wood Doors and Frames	2,845	
	Sliding Glass Door	4,410	
	Garage Door	727	
	Finish Hardware	938	
	Windows	2,879	
9	**FINISHES**		**39,314**
	Lath & Plaster	8,258	
	Drywall	8,724	
	Hardwood Flooring	882	
	Ceramic Tile	7,925	
	Carpeting	4,932	
	Painting	8,593	
10	**SPECIALTIES**		**542**
	Toilet Accessories	542	
11	**EQUIPMENT**		**1,995**
	Appliances	1,995	
12	**FURNISHINGS**		**0**
	None Required	0	
13	**SPECIAL CONSTRUCTION**		**0**
	None Required	0	
14	**CONVEYING SYSTEMS**		**0**
	None Required	0	
15	**MECHANICAL**		**14,582**
	Plumbing	10,387	
	HVAC	4,195	
16	**ELECTRICAL**		**5,625**
	Electrical Devices	5,625	
	SUBTOTAL	211,156	**211,156**
	Permits		**1,821**
	Contractors overhead, profit, taxes, etc.		**31,673**
	TOTAL CONSTRUCTION		**244,651**

Table C-6. Construction cost, index building 6

DIVISION	DESCRIPTION	DIVISION SUBTOTAL	DIVISION TOTAL
1	**GENERAL CONDITIONS**		**35,817**
	Personnel	17,600	
	Small Tools	500	
	Temporary Facilities	2,063	
	Temporary Utilities	3,400	
	Clean - Up	6,454	
	Debris Removal	3,200	
	Testing & Inspections	2,600	
2	**SITEWORK**		**12,000**
	Grading	12,000	
3	**CONCRETE**		**10,780**
	Foundations	4,410	
	Slab on Grade	6,370	
4	**MASONRY**		**3,144**
	Brick Fireplace	3,144	
5	**METALS**		**0**
	None Required	0	
6	**CARPENTRY**		**29,319**
	Rough Carpentry	19,385	
	Finish Carpentry	1,203	
	Cabinetry	8,731	
7	**MOISTURE PROTECTION**		**12,366**
	Insulation	2,706	
	Roofing	9,660	
8	**DOORS, WINDOWS, & GLASS**		**8,511**
	Wood Doors and Frames	3,480	
	Sliding Glass Door	2,205	
	Garage Door	727	
	Finish Hardware	511	
	Windows	1,588	
9	**FINISHES**		**28,798**
	Siding	4,467	
	Drywall	7,825	
	Ceramic Tile	2,515	
	Carpeting	4,611	
	Vinyl Flooring	1,116	
	Painting	8,265	
10	**SPECIALTIES**		**542**
	Toilet Accessories	542	
11	**EQUIPMENT**		**1,845**
	Appliances	1,845	
12	**FURNISHINGS**		**0**
	None Required	0	
13	**SPECIAL CONSTRUCTION**		**0**
	None Required	0	
14	**CONVEYING SYSTEMS**		**0**
	None Required	0	
15	**MECHANICAL**		**15,622**
	Plumbing	10,127	
	HVAC	5,495	
16	**ELECTRICAL**		**4,725**
	Electrical Devices	4,725	
	SUBTOTAL	163,468	**163,468**
	Permits		**1,410**
	Contractors overhead, profit, taxes, etc.		**24,520**
	TOTAL CONSTRUCTION		**189,398**

COST DATA SHEET 4.1.412.1460.08-Y

ASSEMBLY TYPE

4.1.412.1460.08, Wood siding w/2"x4" studs, 16"O.C., uninsulated wall, 5/8" redwood plywood with 1/4"x1/4" vertical kerfs at 2" OC (like T1-11, but with closer kerfs), gray paint finish. No interior finish. Unit: 64 sf (8 lf of 8' high wall)

DAMAGE STATE

Yield: some nails heads bend at the top or bottom edge of the sheathing panel. Studs, plates, and sheathing are intact.

REPAIRS RECOMMENDED

Re-nail at the bent nails and touch up paint as required.

LABOR

Minimum charge based on a 4 hour day x 80.00 per hour = $320.00

MATERIALS AND EQUIPMENT

1gallon of custom paint mixed = $25.00

TOTAL REPAIR COST AND DURATION

Mean cost, excluding paint:	$200.00
Mean duration, excluding paint:	2 ½ hours min.
Mean cost of painting:	$145
Mean duration of painting:	1 ½ hours

COMMENTS, REFERENCES

It may only take 20-30 minutes to re-nail the siding but a minimum charge would apply. 1 ½ hours for painting includes time to go to a paint supplier and get a custom mix for touch up. We are assuming the paint can be matched and that the painting will be done on the same day.

PORTER COMMENTS

Renail & putty, ignoring minimum charge: 0.42 hr * 80/hr = $34.00

COST DATA SHEET 4.1.412.1460.08-S

ASSEMBLY TYPE

4.1.412.1460.08, Wood siding w/2”x4” studs, 16”O.C., uninsulated wall, 5/8” redwood plywood with 1/4”x1/4” vertical kerfs at 2” OC (like T1-11, but with closer kerfs), gray paint finish. No interior finish. Unit: 64 sf (8 lf of 8’ high wall)

DAMAGE STATE

Strength: a few nails tear through the top or bottom edge of the sheathing panel. Studs, plates, and sheathing are otherwise intact.

REPAIRS RECOMMENDED

Re-nail at the bent nails, putty holes and touch up paint as required.

LABOR

Minimum charge based on a 4 hour day x 80.00 per hour = $320.00

MATERIALS AND EQUIPMENT

1gallon of custom paint mixed = $25.00

TOTAL REPAIR COST AND DURATION

Mean cost, excluding paint:	$200.00
Mean duration, excluding paint:	2 ½ hours min.
Mean cost of painting:	$145
Mean duration of painting:	1 ½ hours

COMMENTS, REFERENCES

It may only take 20-30 minutes to re-nail the siding but a minimum charge would apply. 1 ½ hours for painting includes time to go to a paint supplier and get a custom mix for touch up. The extra time to putty nail holes is minor and is absorbed into the minimum costs. We are assuming the paint can be matched and that the painting will be done on the same day.

PORTER COMMENTS

Renail & putty, ignoring minimum charge: 0.42 hr * 80/hr = $34.00

COST DATA SHEET 4.1.412.1460.08-C

ASSEMBLY TYPE

4.1.412.1460.08, Wood siding w/2”x4” studs, 16”O.C., uninsulated wall, 5/8” redwood plywood with 1/4”x1/4” vertical kerfs at 2” OC (like T1-11, but with closer kerfs), gray paint finish. No interior finish. Unit: 64 sf (8 lf of 8’ high wall)

DAMAGE STATE

Collapse: all nails tear through the top or bottom edge of the sheathing panel. Studs, plates, and sheathing are otherwise intact.

REPAIRS RECOMMENDED

Remove and replace 2 each 4’ x 8’ sheets of siding, replace building paper and paint siding.

LABOR

10.25 hours @ $80.00 per hour = $820.00

MATERIALS AND EQUIPMENT

Siding = $151.20 Paint = $25.00 for a total of $176.20

TOTAL REPAIR COST AND DURATION

Mean cost, excluding paint:	$811.20
Mean duration, excluding paint:	8.25 hours
Mean cost of painting:	$185.00
Mean duration of painting:	2 hours

COMMENTS, REFERENCES

Includes 2 hours to pickup siding materials as well as material markup. Hours for painting includes time to go to a paint supplier and get a custom mix. We are assuming the siding must be replaced and that the paint can be matched.

PORTER COMMENTS

Consider material pickup as included in overhead & minimum cost. Excluding these 2 hr, and excluding paint, labor = 6.25 hr @ $80/hr = $500.00 + $151.20 material = $651.20

COST DATA SHEET 4.1.412.1460.10-Y

ASSEMBLY TYPE

4.1.412.1460.10, Wood siding w/2”x4” studs, 16”O.C., uninsulated wall, 5/8” redwood plywood with 1/4”x1/4” vertical kerfs at 2” OC (like T1-11, but with closer kerfs), gray paint finish. No interior finish. Unit: 80 sf (8 lf of 10-ft high wall)

DAMAGE STATE

Yield: some nails heads bend at the top or bottom edge of the sheathing panel. Studs, plates, and sheathing are intact.

REPAIRS RECOMMENDED

Re-nail at the bent nails and touch up paint as required.

LABOR

Minimum charge based on a 4 hour day x 80.00 per hour = $320.00

MATERIALS AND EQUIPMENT

1gallon of custom paint mixed = $25.00

TOTAL REPAIR COST AND DURATION

Mean cost, excluding paint:	$200.00
Mean duration, excluding paint:	2 ½ hours min.
Mean cost of painting:	$145
Mean duration of painting:	1 ½ hours

COMMENTS, REFERENCES

It may only take 20-30 minutes to re-nail the siding but a minimum charge would apply. 1 ½ hours for painting includes time to go to a paint supplier and get a custom mix for touch up. We are assuming the paint can be matched and that the painting will be done on the same day. There will be no difference in costs compared to the 8’ high siding. The field of the siding panel is not affected and the additional 2’ of painting is inconsequential.

PORTER COMMENTS

Renail & putty, ignoring minimum charge: 0.42 hr * 80/hr = $34.00

COST DATA SHEET 4.1.412.1460.10-S

ASSEMBLY TYPE

4.1.412.1460.10, Wood siding w/2”x4” studs, 16”O.C., uninsulated wall, 5/8” redwood plywood with 1/4”x1/4” vertical kerfs at 2” OC (like T1-11, but with closer kerfs), gray paint finish. No interior finish. Unit: 80 sf (8 lf of 10-ft high wall)

DAMAGE STATE

Strength: a few nails tear through the top or bottom edge of the sheathing panel. Studs, plates, and sheathing are otherwise intact.

REPAIRS RECOMMENDED

Re-nail at the bent nails and touch up paint as required.

LABOR

Minimum charge based on a 4 hour day x 80.00 per hour = $320.00

MATERIALS AND EQUIPMENT

1gallon of custom paint mixed = $25.00

TOTAL REPAIR COST AND DURATION

Mean cost, excluding paint:	$200.00
Mean duration, excluding paint:	2 ½ hours min.
Mean cost of painting:	$145
Mean duration of painting:	1 ½ hours

COMMENTS, REFERENCES

It may only take 20-30 minutes to re-nail the siding but a minimum charge would apply. 1 ½ hours for painting includes time to go to a paint supplier and get a custom mix for touch up. The extra time to putty nail holes is minor and is absorbed into the minimum costs. We are assuming the paint can be matched and that the painting will be done on the same day. There will be no difference in costs compared to the 8’ high siding. The field of the siding panel is not affected and the additional 2’ of painting is inconsequential.

PORTER COMMENTS

Renail & putty, ignoring minimum charge: 0.42 hr * 80/hr = $34.00

COST DATA SHEET 4.1.412.1460.10-C

ASSEMBLY TYPE

4.1.412.1460.10, Wood siding w/2”x4” studs, 16”O.C., uninsulated wall, 5/8” redwood plywood with 1/4”x1/4” vertical kerfs at 2” OC (like T1-11, but with closer kerfs), gray paint finish. No interior finish. Unit: 80 sf (8 lf of 10-ft high wall)

DAMAGE STATE

Collapse: all nails tear through the top or bottom edge of the sheathing panel. Studs, plates, and sheathing are otherwise intact.

REPAIRS RECOMMENDED

Remove and replace 2 each 4’ x 10’ sheets of siding, replace building paper and paint siding.

LABOR

10.25 hours @ $80.00 per hour = $820.00

MATERIALS AND EQUIPMENT

Siding = $202.64 Paint = $25.00 for a total of $227.64

TOTAL REPAIR COST AND DURATION

Mean cost, excluding paint:	$862.64
Mean duration, excluding paint:	8.25 hours
Mean cost of painting:	$185.00
Mean duration of painting:	2 hours

COMMENTS, REFERENCES

Includes 2 hours to pickup siding materials as well as material markup. Hours for painting includes time to go to a paint supplier and get a custom mix. We are assuming the siding must be replaced and that the paint can be matched. Only the siding material costs have changed.

PORTER COMMENTS

Labor & siding, excluding material pickup, same as 4.1.412.1460.08-C but with $51.44 more material cost: $702.64.

COST DATA SHEET 6.5.100.1663.10-S

ASSEMBLY TYPE

6.5.100.1663.10, Philippine Mahogany interior paneling (also known as luan paneling), ¼-in x 10 ft 5d finish nails at 9-in centers. Unit: 80 sf (8 lf of 10-ft high wall)

DAMAGE STATE

Strength: some nail heads pull through at top or bottom plate. Panel edges are intact.

REPAIRS RECOMMENDED

Re-nail where nail heads have pulled through and putty holes.

LABOR

2 hours minimum @ $80.00 per hour = $160.00

MATERIALS AND EQUIPMENT

Putty stick- $2.55 ea

TOTAL REPAIR COST AND DURATION

Mean cost:	$162.55
Mean duration:	2 hours

COMMENTS, REFERENCES

2 hour minimum.

PORTER COMMENTS

Renail & putty, ignoring minimum charge: 0.42 hr * 80/hr = $34.00

COST DATA SHEET 6.5.100.1663.10-C

ASSEMBLY TYPE

6.5.100.1663.10, Philippine Mahogany interior paneling (also known as luan paneling), ¼-in x 10 ft 5d finish nails at 9-in centers. Unit: 80 sf (8 lf of 10-ft high wall)

DAMAGE STATE

Collapse: all nail heads pull through at top or bottom plate. Panel edges are intact.

REPAIRS RECOMMENDED

Re-nail where nail heads have pulled through and putty holes.

LABOR

2 hours minimum @ $80.00 per hour = $160.00

MATERIALS AND EQUIPMENT

Putty stick- $2.55 ea

TOTAL REPAIR COST AND DURATION

Mean cost:	$162.55
Mean duration:	2 hours

COMMENTS, REFERENCES

2 hour minimum. The damage state does not mention actual damage to the paneling other than nail holes which can be filled.

Special Note: If there are actual damages to the paneling that would require replacement, it would be unlikely that one or two sheet could be replaced and successfully matched to the existing paneling color. The entire wall or entire room of paneling may need to be replaced in order to match.

PORTER COMMENTS

Renail & putty, ignoring minimum charge: 0.42 hr * 80/hr = $34.00

COST DATA SHEET 6.5.100.1663.08-S

ASSEMBLY TYPE

6.5.100.1663.08, Philippine Mahogany interior paneling (also known as luan paneling), ¼-in x 8 ft, 5d finish nails at 9-in centers. Unit: 64 sf (8 lf of 8-ft high wall)

DAMAGE STATE

Strength: some nail heads pull through at top or bottom plate. Panel edges are intact.

REPAIRS RECOMMENDED

Re-nail where nail heads have pulled through and putty holes.

LABOR

2 hours minimum @ $80.00 per hour = $160.00

MATERIALS AND EQUIPMENT

Putty stick- $2.55 ea

TOTAL REPAIR COST AND DURATION

Mean cost:	$162.55
Mean duration:	2 hours

COMMENTS, REFERENCES

2 hour minimum. The damage state does not mention actual damage to the paneling other than nail holes which can be filled. There is no cost difference between 8’ and 10’ paneling.

Special Note: If there are actual damages to the paneling that would require replacement, it would be unlikely that one or two sheet could be replaced and successfully matched to the existing paneling color. The entire wall or entire room of paneling may need to be replaced in order to match.

COST DATA SHEET 6.5.100.1663.08-C

ASSEMBLY TYPE

6.5.100.1663.08, Philippine Mahogany interior paneling (also known as luan paneling), ¼-in x 8 ft, 5d finish nails at 9-in centers. Unit: 64 sf (8 lf of 8-ft high wall)

DAMAGE STATE

Collapse: all nail heads pull through at top or bottom plate. Panel edges are intact.

REPAIRS RECOMMENDED

Re-nail where nail heads have pulled through and putty holes.

LABOR

2 hours minimum @ $80.00 per hour = $160.00

MATERIALS AND EQUIPMENT

Putty stick- $2.55 ea

TOTAL REPAIR COST AND DURATION

Mean cost:	$162.55
Mean duration:	2 hours

COMMENTS, REFERENCES

2 hour minimum. The damage state does not mention actual damage to the paneling other than nail holes which can be filled. There is no cost difference between 8’ and 10’ paneling.

Special Note: If there are actual damages to the paneling that would require replacement, it would be unlikely that one or two sheet could be replaced and successfully matched to the existing paneling color. The entire wall or entire room of paneling may need to be replaced in order to match.

D. BASIS OF EQECAT CALIFORNIA EARTHQUAKE MODEL

This appendix was written by Andrew Cowell, EQECAT, Oakland, CA

D.1 FAULT MODEL

The principal source of fault data is the seismic hazard database that was compiled jointly by the U.S. Geological Survey (USGS) and the California Geological Survey (CGS) in 2002 and 2003 (Frankel et al., 2002 and Cao et al., 2003). This database was developed as part of the national and California seismic hazard mapping projects. In some regions of the state, this database was supplemented with additional state-of-the-art seismotectonic information. Data for some major faults were taken from consensus studies (WGCEP, 2003). Other public sources of earthquake, fault and soils data have been reviewed by EQECAT and in some instances this has resulted in the addition to or modification of the information contained in the principal sources of data described above.

D.2 EARTHQUAKE FREQUENCY

The recurrence frequency that EQECAT uses is based on the USGS/CGS model with the exception that time-dependant probabilities have been considered on those faults for which there is sufficient data to allow an adjustment for time dependence.

D.3 ATTENUATION RELATIONSHIPS

The attenuation relationships and the weightings specified in the USGS/CGS model of California have been adopted by EQECAT, with the exception that the attenuation relationships are those based on soil conditions rather than the rock condition equations used by USGS/CGS.

D.4 LOCAL SOIL CONDITIONS

The estimate of local hazard from the attenuation relationships are adjusted from a reference rock to local conditions based on the average shear-wave velocity in the top 30 m of the soil deposit ($V_{s,30}$). Each ZIP Code was assigned a population-weighted average of six soil categories based on $V_{s,30}$. Four of these categories are those in the 2003 *International Building Code* (IBC). The other two represent the boundaries between these four categories. The defined site categories cover a range of $V_{s,30}$ representing hard rock to soft soil. Nonlinear soil-amplification factors associated with each site category are based on the 2003 NEHRP Provisions (BSSC, 2004). IBC site classifications for California are inferred from the correlation between $V_{s,30}$ and different geologic units as displayed on the map by Wills et al. (2000).

D.5 VULNERABILITY FUNCTIONS FOR WOODFRAME HOMES

The claims data from insurance companies for the 1994 Northridge earthquake were used to develop the vulnerability function for wood frame buildings. The vulnerability have been updated to be functions of multiple spectral parameters.

D.6 DAMAGE AND LOSS COMPUTATION

The calculation of damage and loss includes a fully probabilistic treatment of variability in hazard, vulnerability function, and in the application of deductibles and limits.

REFERENCES CITED

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